Journal of Environmental and Public Health

Water Quality and Associated Health Risks

Lead Guest Editor: Muhammad Tayyab Sohail
Guest Editors: Malik Muhammad Akhtar and Shah Fahad

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Contents

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Retraction

Retracted: Assessment of the Impact of Higher Education on Environmental Quality in BRICS Economies Based on Sustainable Development Pathways

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The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Retracted: Green Supply Chain Management and Its Impact on Economic-Environmental Performance: Evidence from Asian Countries

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Retracted: Research on the Sustainability of Traditional Music and the Adaptability of Ecological Environment

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Retracted: Influence of HP Financial Economic Effect on Environmental Visualization under Sustainable Development

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Retracted: Political Will and the Impact Assessment of the New Crown Epidemic on Economic and Social Development and Countermeasures

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Retraction

Retracted: A Model for Evaluating the Effectiveness of Precise Governance of Social Assistance from a Management Perspective and Environment of Public Health

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In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

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Retracted: Does Income Inequality Harm Green Growth? The BRICS Experience

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Retraction

Retracted: Cognitive Attitudes of International Mainstream Media to China during the Contaminated Water and Human Health Under Big Data

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Research Article

Assessment of Bacteriological Quality and Physiochemical Parameters of Domestic Water Sources in Jenin Governorate: A Case Study

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Water quality of drinking water is a concern in Palestine due to possible pollution sources. There is a demand for investigating the quality of municipal water supply. This study aimed to assess the quality of domestic water in Jenin Governorate located in the north of the West Bank. The methodology of this research was based on field sampling and laboratory standard testing. The tested parameters included (1) physicochemical parameters of electrical conductivity, turbidity, total hardness, salinity, pH, and total alkalinity, (2) chemical contents including the contents of nitrate, nitrite, sulfate, chloride, sodium, potassium, aluminum, and fluoride, and (3) biological contents including total coliforms and fecal coliforms. The water quality parameters were compared with the acceptable limits set by local and international standards. The findings confirm that most of the values of the investigated parameters are within the acceptable standard limits. No pollution of heavy metals is detectable. On the other hand, there are limited pollution contents in terms of the total dissolved solid (TDS), total hardness, and calcium. Furthermore, the biological parameters indicate that there are low to very high risks in a fraction of the water quality samples in terms of total coliforms and fecal coliforms. This is believed to be due to the presence of septic tanks in the neighborhoods of the sampling locations. For these cases, biological disinfection treatments are recommended before human use with an essential need for the construction of urban sewer systems. Furthermore, water treatment for harness removal may be required.

1. Introduction

Water is a key component in human life either straight forwardly as drinking water or in a roundabout way as a constituent of food and is served in different utilizations in our everyday life [1–6]. Furthermore, water is an essential parameter in the public health due to possible transmission diseases [7]. The evaluation of water quality is an essential issue, and the security of water quantity is a critical point in the governmental plans and strategies [8]. Drinking water as well as entertainment and the natural life environment can be seriously influenced by contaminations [9, 10]. Chemical spills can intimidate water quality and human health.

Palestine and other countries in the Middle East suffer from water shortage due to predominantly semiarid to arid climatic conditions [11]. Water is a critical issue in the Middle East [12]. Water resources in Palestine are limited; hence, water shortage and water quality are imminent [13, 14]. There are three groundwater aquifer bowls in Palestine, which are situated in the West Bank, but controlled by Israel. An obvious lack of fresh water for domestic, industrial, and agricultural purposes was identified as one of the main issues in Palestine [15]. For example, the allowed daily consumption of water per capita in Hebron and Nablus cities in the West Bank of Palestine is nearly 50 L/day and the average daily consumption in the whole of the West Bank is

66 L/day [12, 16]. On the other hand, the WHO has set the minimum per capita daily consumption of 100 L/day [17]. Arid and semiarid areas suffer from scarcity of water resources, so the protection of existing resources is a priority for people. Water pollution occurs in the form of altering the composition of the watercourse components due to human activity, and then, the resulting water becomes less suitable for natural uses [18–23]. In the Gaza strip, a study of the quality of drinking water revealed low pH and TDS levels, while microbiological analyses showed that the total coliform for distribution points was 58 CFU/100 ml, and in the household storage tanks, it was found to be 171 CFU/100 [24]. The reduction in water quality locally and worldwide is considered one of the environmental challenges that requires urgent action [25, 26]. In fact, the decline in water quality is a reflection of poverty. Water quality is dependent on the logistics and practices of waste disposal and wastewater discharge [18, 27–31]. Municipal wastewater and waste are two of the pollution sources of water resources. The main problem of solid waste is the leaching of possible hazardous substances, the severity of which is dependent on horizontal distance to the water sources, temperature of the area, pollution content, and age [32]. The possible reasons for water pollution in the West Bank were identified to include the absence of sewage networks in many rural areas, the utilization of cesspits for domestic wastewater, and the inappropriate waste management [13]. Any released toxins can migrate into ground water resources where poisons interface with nature. Then, the ground water resources experience physical and substance changes, and they are consolidated into the earth resulting in changes in water quality [33–35]. In general, monitoring discharges of wastewater treatment plants (WWTPs) has many benefits for the protection of drinking water resources [36]. Chemical contaminations include nitrate content that may result from biological waste from humans and animals, plant debris, and seepage [37, 38]. Groundwater contamination with heavy metals, together with the geogenic presence of some toxic metals (e.g., arsenic and fluoride), is of increasing concern due to their severe ecological and public health impacts [39–41]. The main sources of heavy metal pollution are agricultural runoffs and uncontrolled discharges of wastewater from industries, including metal electroplating and mining [42]. Traffic is also an important source of heavy metal pollution [11, 43–45].

The pollution of water resources affects the quality of the municipal water supply. In addition, for municipal water supply, colored water may be obtained due to the deposited salts in the inner surface of network pipes. In the presence of manganese (Mn), there is a strong possibility for the formation of discoloration such as "black water." According to the United States Environmental Protection Agency, the limit value of manganese is 50 μg/L [46]. These pollutants in drinking water have various impacts on public health: Water hardness can cause kidney stone formation [47]. Water for human use must be free of microbiological contaminations that are pathogenic to humans [48, 49]. Water contamination with bacteria, protozoa, and viruses causes diarrhea, which can cause the death of infants (for example, cholera and hepatitis) [50, 51]. According to the World Health Organization (WHO), the diarrheal diseases globally were estimated at 3% in 2016 [40]. For noncleaned supplies, up to 10 fecal coliforms (FC) per 100 mL are permitted [52]. Sulfate content may have a laxative effect on humans, so the maximum contaminate level is 250 mg/L. Chloride concentrations above 250 ppm could affect the taste of drinking water [53]. Aluminum can lead to Alzheimer's disease [54]. The nitrate limit according to the WHO guidelines is 50 mg/L as NO_3 [55]. On the other hand, contamination with nitrite is more dangerous as a high concentration of nitrate can lead to methemoglobinemia [56]. High concentrations of salinity cause cholera, while small quantities of salt are essential for organizing the fluid balance of the human body [57]. The ammonia limit in groundwater according to the WHO [58] guidelines is 0.2 mg/L.

Water quality is usually monitored by measuring various parameters covering chemical, physical, and microbiological characteristics [59–61]. The physicochemical parameters include total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen, hardness, and chlorine and sodium contents [62]. High water turbidity may reflect the pollution of water from leaching of organic matters as well as domestic and industrial wastes. High electrical conductivity (EC) reflects a high concentration of soluble salts which makes water conductive for electric current [63]. Total hardness (mg/l) is the sum of calcium and magnesium hardness. The microbial parameters include total coliforms and fecal coliforms [15, 47, 64].

Little effort was made for assessing water quality in the West Bank areas [65, 66]. In a previous case study [66], the quality of drinking water obtained from local springs in the West Bank was evaluated. The previous study assisted in promoting the public use of the springs as a water supply. The publication of such case studies responds to a need for paving the road for performing similar case studies for other regions. This appears very obviously in the high citations of the previous case study [66] within a short time period from its publication date. There are concerns about the possible contaminations of municipal water supply that require the attention of the various authorities. The Ministry of Health is interested in assessing the quality of municipal water to prevent any potential impacts on human and public health. There is a knowledge gap in the published work on chemical, physical, and biological parameters for municipal water supplies. Currently, an ongoing international research project is concerned with the quality of water in schools for promoting public health. Consequently, perfuming case studies on the quality of municipal water supply can assist the authorities (water and health) in their planning and management efforts. Furthermore, the novelty of such a case study is concentrated in providing new information with more investigated parameters for better assessment of the water quality and providing a model approach for subsequent studies in other areas (generalization). Responding to these needs, the main research objectives are measuring the chemical, physical, and biological parameters for municipal water supply in the defined research area (Jenin district), as a case study, and evaluating the suitability of water quality for human use by comparing the measured parameters with the limits set by both national and international quality standards (the Palestinian standards (PSI) and the guidelines of the WHO). The research variables included pH, EC, total hardness, concentrations of nitrate, sodium ions, total chlorine, residual chlorine, turbidity, and total and fecal coliforms.

2. Methodology

2.1. Description of the Study Area. The domain of this study was Jenin Governorate located in the north of the West Bank. It is one of the 16 governorates of the Palestinian authority. The Jenin Governorate area comprises about 10.5% of the West Bank area and is considered one of the best agricultural areas in Palestine. Most of municipal administration of this governorate land is under the Palestinian authority. It is bordered by Nablus from the south and by Tulkarem from the southwest. Its location is between 90 and 750 m above sea level, and the highest elevation is at Jabal Hureish, while the lowest elevation is at El Mukhabba area [67]. Jenin Governorate is located above the Northeastern Groundwater Basins, the capacity of which is about 140 MCM/year [68]. Groundwater can be obtained at 50 m below the ground surface. The other sources of water include seasonal lakes such as Marj Sanur. The daily water consumption per capita in Jenin Governorate is about 50.2 L/day [69]. The projected mid-year population for Jenin Governorate in 2022 is 345875 persons [70].

2.2. Sampling. The sampling was performed during 2018 and 2019 from villages, towns, and cities in Jenin district in the West Bank of Palestine. The samples of drinking water were taken from wells, houses, restaurants, and others. The samples were collected by the Palestinian Ministry of Health to ensure the chemical, physical, and biological qualities of the drinking water. The samples were collected in pyrex-sterilized glass bottles (1000 mL), filtered through a 0.45 μm filter (Schleicher and Schuell ME 25, Taufkirchen, Germany), divided into two fractions, and stored at 4°C. Tables 1–3 list the distribution of samples based on the investigated parameters.

2.3. Analysis. Water samples were taken by field crew and were then transferred to the Palestinian public health laboratories where each parameter was analyzed. The physicochemical, chemical, and biological characteristics were measured according to the standard testing procedures. The tools used included a portable digital pH meter, an EC meter, a turbidity meter, inductively coupled plasma mass spectrometry (ICP-MS), and membrane filtration. The water samples taken for analyses of cations and trace metals were acidified ($pH < 1.5$) with analytical grade concentrated nitric acid.

The pH and conductivity were measured in the field immediately after or during sampling, using a portable HACHsensION1 multimeter, with a combined electrode, and a portable HACH conductivity meter (HACH, Loveland, CO, USA). The total dissolved solid (TDS) and the salinity were measured using a salinity meter, Hach CO150 (Hach Company, Loveland, Columbia, USA). The remaining physicochemical parameters were tested using a DR 2400 spectrophotometer as demonstrated elsewhere [71]. The concentrations of Ca, Mg, Al, Fe, K, Na, and Ag were analyzed using ICP-MS (Agilent Technologies 7500 Series, Agilent, Santa Clara, CA, USA). The total and fecal coliforms counts were measured by the membrane filtration technique [72]. The measured parameters for each of the collected samples were tabulated, and then, the mean values and standard deviations were estimated and compared with the limits set by the WHO and the PSI.

Table 1: Water samples for physiochemical and chemical parameters.

Parameter	Number of samples
Conductivity	26
Fluoride (F)	36
Nitrate	42
Nitrite	20
pH	40
Salinity (%)	26
Sulfate (SO_4)	26
Total dissolved solids (TDS)	41
Total hardness	27
Turbidity	26
Chloride (Cl)	34
Ammonia	30
Calcium (Ca)	26
Magnesium (Mg)	27
Sodium (Na)	26
Potassium (K)	26
Aluminum (Al)	11
Total alkalinity	6

Table 2: Water samples for testing heavy metals.

Heavy metal parameter	Number of samples
Ag	19
Cu	19
Zn	19
Fe	19
Pb	19
Cr	19

Table 3: Water samples for biological parameters.

Biological parameter	Number of samples
Total coliforms	2570
Fecal coliforms	2568

3. Results and Discussion

3.1. Physiochemical Parameters. The results of the physiochemical parameters of the drinking water in Jenin Governorate along with allowable limits of the PSI [73] standards and the WHO [58] guideline values are listed in Table 4.

Table 4 lists the range, the mean, and the standard deviation for each measured physiochemical parameter.

The values of electrical conductivity are within the range of 242–1833 μS/cm, and the mean value is 890 ± 302 μS/cm. Table 5 lists the classifications of water quality for various ranges of EC and the percentage of samples in each range. All measured values of EC were within the acceptable limit set by the WHO and PSI standards (2000 μScm^{-1}): the majority of the tested samples (77%) were classified as permissible, while 19.2% were classified as good and 3.8% were classified as excellent. Overall, 100% of the samples are within the PSI and WHO standards, and hence, there are no concerns regarding the soluble salts. The observed wide range of EC is an indication of the content of dissolved salts such as sodium chloride and potassium chloride. The values of the salinity are within the range of 0.01–0.050%, and the average value is 0.07 ± 0.10%. High concentrations of salinity lead to diarrhea and water-borne diseases such as cholera. Salinity is related to electrical conductivity. Thus, these two parameters are correlated well in this study. A wider range of EC (473–1406 μScm^{-1}) was reported for drinking water from natural springs in the study area as documented in a previous study [66], which was attributed to differences in geological structures, agricultural activity, and soil conditions within the study area.

The values of TDS are within the range of 36–1063, and the average value is 465 ± 192 ppm. It is obvious that 97.57% of samples are within the acceptable limits of the PSI and the WHO. Only 2.43% of samples have TDS values higher than the PSI acceptable limit, and hence, there are no major concerns regarding the dissolved solids. The TDS is correlated with turbidity: the values of the turbidity are within the range of 0.1–3.63 NTU, and the average value is 0.49 ± 0.76 NTU. All the samples are within the PSI and WHO standards, and hence, there are no concerns regarding the solids. A wider range of turbidity (0.05–9.9 NTU) was reported for drinking water from natural springs as documented in a previous study [66] which was attributed to human activities and an increase in the suspended particulate matter. However, a narrow range of 0–2 was reported for natural springs from other areas (Wadi Al Qilt springs) [74].

The values of the pH are within the range of 6.4–8.12, and the average value is 7.33 ± 0.37. All recorded values satisfy the PSI standards and the WHO [58] guidelines. The water quality in terms of pH is acceptable. These results are close to those reported for drinking water from natural springs [66]. The pH values are related to the total alkalinity. The values of the total alkalinity are within the range of 93.1–354, and the average value is 164 ± 206. This indicates that there are no alkalinity risks from industrial and chemical pollution.

3.2. Chemical Parameters. The results of chemical parameters of drinking water in Jenin Governorate along with allowable limits of the PSI [73] standards and the WHO [58] guideline values are presented in Table 6. Table 6 lists the range, the mean, and the standard deviation for each of the following ions: nitrate, nitrite, sulfate, chloride, fluoride, ammonia, sodium, calcium, potassium, and magnesium.

The values of nitrate concentration are within the range of 0–48 ppm, and the average value is 14.52 ± 11.54 ppm. All recorded values satisfy the PSI standards and the WHO [58] guidelines. Similarly, the values of nitrite concentration are within the range of 0–0.86 ppm, and the average value is 0.05 ± 0.03 ppm. All samples satisfy the WHO [58] guidelines. This obtained range for nitrate is narrower than that obtained previously for water from natural springs [66], with some groundwater resources contaminated with nitrate resulting from the penetration of nitrates from sewage and other wastes. However, the obtained range is close to that previously reported for water from springs in other areas (Wadi Al Qilt springs) [74]. Similarly, the values of the ammonia content are in the range of 0–2.63 ppm with an average value of 0.17 ± 0.5 ppm, which is lower than the WHO limit (1.5 ppm). This indicates that there are no risks from ammonia contaminations. Likewise, the values of sulfate concentration are within the range of 1.30–52.94 ppm, and the average value is 22.67 ± 12 ppm. All samples were within the limits of the PSI [73] and WHO [58] guidelines. This indicates that there are no risks from industrial pollution. Similarly, the values of fluoride concentration are within the range of 0.03–3.00 ppm, and the average value is 0.32 ± 0.05 ppm. All the samples are within the limits of the PSI [73] and WHO [58] standards.

Furthermore, the values of chloride concentration are within the range of 113.73–380.05 ppm, and the average value is 96.36 ± 97 ppm. All samples were within the limits of the PSI [73] and WHO [58] guidelines. These results are in line with the results for salinity as presented in Section 3.1 since salinity is correlated with the presence of sodium chloride that releases chloride ions and sodium ions. For a similar correlation, the values of sodium concentration are low, within the range of 9.551–108 ppm, and the average value is 43.42 ± 24.45 ppm. The values of potassium concentration are of ranges between 0.384 and 7.481 ppm, and the average value is 3.00 ± 1.77 ppm. All recorded values of sodium and potassium concentrations are within the limits of the PSI [73] and WHO [58] guidelines, and a previous study [66] indicated that the chloride and sodium contents of water from springs had wider ranges, with some values exceeding the permission limits according to the PSI and WHO.

On the other hand, the values of calcium concentration for 34.6% of the samples are over the PSI standard limits (for samples obtained from wells). The values of calcium concentration are within the range of 1.42–152.90 ppm, and the average value is 78.75 ± 40.20 ppm. The calcium content is dependent on the geological aspects. The contact of water with dolomite and limestone can lead to a high concentration of calcium [75]. High levels of calcium can lead to scaling [76]. These results are correlated with the obtained values of total hardness. Table 7 shows the water quality classification for various ranges of hardness. Most of the samples are classified as hard or very hard. This leads to the deposition of white scales on the piping systems and may cause kidney stone formation [47].

Table 4: Physiochemical parameters of drinking water in Jenin Governorate of the West Bank compared to allowable limits of the PSI standards and the WHO guidelines.

Physiochemical parameter	Range of measured values	Average ± standard deviation	PSI [73] standard limit	WHO [58] limit	Percentage of samples over MCL[a] of PSI (%)
Conductivity (EC) (μS/cm)	242–1833	890 ± 302	Up to 2000	Up to 2000	0%
Salinity (%)	0.01–0.5	0.1 ± 0.07	NA	NA	NA
Total dissolved solids (TDS) (ppm)	36–1063	465 ± 192	1000	1000	2.43%
Turbidity (NTU)	0.10–3.63	0.49 ± 0.76	5	5	0%
pH	6.40–8.12	7.33 ± 0.37	6.5–8.5	6.5–8.5	0%
Total alkalinity (ppm)	93.11–354	164 ± 206	NA	NA	NA

MCL[a]: maximum concentration limit according to the PSI [73]; NTU: nephelometric turbidity units; *NA: not available.

Table 5: Classifications of water quality for various ranges of EC in μS/cm at 25°C.

Range of EC (μS/cm)	Water quality classification [64]	Percentage of samples (%)
<250	Excellent	3.8
250–750	Good	19.2
750–2,000	Permissible	77
2,000–3,000	Doubtful	0
>3,000	Unsuitable	0

Table 6: Concentrations of ions in drinking water in Jenin Governorate of the West Bank compared to allowable limits of the PSI standards and the WHO guidelines.

Physiochemical parameter	Range of measured values	Average ± standard deviation	PSI [73] standard limit	WHO [58] limit	Percentage of samples over MCL[a] of PSI (%)
Nitrate (ppm)	0–48	14.52 ± 11.54	70	50	0%
Nitrite (ppm)	0–0.86	0.05 ± 0.03	NA	3	N.A
Ammonia (ppm)	0–2.63	0.17 ± 0.5	NA	1.5	N.A
Sulfate (SO_4) (ppm)	1.30–52.94	22.67 ± 12	200	250	0%
Fluoride (F) (ppm)	0.03–3.00	0.32 ± 0.05	1.5	1.5	0%
Chloride (Cl) (ppm)	13.73–380.05	96.36 ± 97	250	250	0%
Sodium (Na) (ppm)	9.551–108	43.42 ± 24.45	200	NA	0%
Potassium (K) (ppm)	0.384–7.481	3.00 ± 1.77	10	NA	0%
Calcium (Ca) (ppm)	1.42–152.90	78.75 ± 40.20	100	NA	34.61%
Magnesium (Mg) (ppb)	0.30–58.33	22.50 ± 15.84	100	NA	0%
Total hardness (ppm)	105.6–549.84	329.42 ± 109.64	500	500	3.7%

MCL[a]: maximum concentration limit according to PSI [73]; *NA: not available.

Table 7: Water quality classification for various ranges of hardness.

Total hardness (mg/L as $CaCO_3$)	Degree of hardness [63]	Percentage of samples (%)
0–75	Soft	0
75–150	Moderately hard	11
150–300	Hard	15
>300	Very hard	74

The results of the contents of heavy metals in drinking water in Jenin Governorate along with allowable limits of the PSI [73] standards and the WHO [58] guideline values are listed in Table 8. Table 8 lists the range, the mean, and the standard deviation for seven types of heavy metals. The concentrations of all heavy metals analyzed (Al, Zn, Fe, Pb, Cr, Ag, and Cu) are below the maximum limits set by the PSI [73] and WHO [58] standards. The concentrations of some heavy metals were found to be below the detection limit of the analytical methods applied. These results indicate that there are no risks associated with heavy metal contaminations.

Table 8: The concentrations of heavy metals in water samples in the study area.

Metal	Average concentration (μg/L)	WHO limit (μg/L)	Palestinian limit (μg/L)	Samples over MCL of PSI (%)
Al	2.79 – 54.13	17.20 ± 16.67	200	0
Zn	20.7 ± 18.2	3000	5000	0
Fe	2.74 ± 2.98	NA	300	0
Pb	0	10	10	0
Cr	0.03 ± 0.091	50	50	0
Ag	0	50	50	0
Cu	6.47 ± 28.21	2000	1000	0

Table 9: Distribution of the tested drinking water samples for total coliforms and their classifications according to their level of contamination and the recommended treatment procedure.

Recommended treatment procedure *	Range of total coliforms (CFU/100 mL)	Degree of contamination	Percentage of samples (%)
No treatment	0–3	0	85.53
Chlorination only	4–50	1	8.37
Flocculation, sedimentation, and then chlorination	51–50,000	2	4.40
Very high contamination, needs special treatment	>50,000	3	1.71

* [12].

Table 10: Distribution of tested drinking water samples for fecal coliforms (CFU/100 mL) and their classifications according to their degree of risk.

Range of fecal coliforms (CFU/100 ml)	Degree of risk*	Number and percentage of tested samples (%)
0	No risk	(2396) 93.30
1–10	Low risk	(74) 2.88
11–100	Moderate risk	(60) 2.34
101–1000	High risk	(23) 0.90
>1000	Very high risk	(15) 0.58

* [12].

3.3. Microbiological Parameters. Table 9 shows the analytical results of the microbiological parameters in terms of total coliforms, their classifications according to their level of contamination, and the recommended treatment procedure. It is clear that 85.5% of the samples satisfy the acceptable limits of the PSI standard. This means that no treatment is needed for this fraction before using for drinking or cooking. On the other hand, the remaining percentage of the samples (14.5%) is with values exceeding the acceptable limit, and thus, they are contaminated with microbiological pollutants. Among these contaminated cases, 8.71% must use chlorination, 4.4% need flocculation, sedimentation, and chlorination, and 1.71% need advanced treatment using special treatment [12].

Table 10 lists the distribution of tested drinking water samples for fecal coliforms (CFU/100 mL) and their classifications according to their degree of risk. A total of 2494 samples were analyzed for fecal coliforms, 93.30% of these samples possess no risk on health and 2.34% possess moderate risk, 0.9% possess a high risk, and 0.58% possess a very high risk based on the WHO guidelines and classification [12]. The results of total and fecal coliforms indicate that there are sources of microbial pollution, the presence of which is unacceptable for drinking. A previous study [77] indicated that only three communities in Jenin Governorate are connected to the public wastewater collecting system, while 80% of communities use a septic tank for the disposal of wastewater. In areas where there is a high concentration of septic tanks, it is possible for pathogenic organisms to penetrate into wells or nearby surface water [78]. All the polluted samples were taken from the wells and springs.

4. Conclusions and Recommendations

The findings of the study show that most of the water quality parameters are within the acceptable limits of the PSI and WHO standards. These include electrical conductivity, turbidity, salinity, pH, total alkalinity, and concentrations of nitrate, nitrite, sulfate, chloride, sodium, potassium, aluminum, and fluoride ions. Furthermore, the concentrations of heavy metals including Zn, Fe, Pb, Cr, Ag, and Cu are within the permission limits, and hence, there is no potential impact on human health. This indicates that there is no impact of industrial pollution or excessive use of fertilizers on water quality within the study area. The findings of the TDS analysis indicate that 97.57% of samples are within the acceptable limits, while only 2.43% are over the limit, which does not affect the human health but can cause the formation of scaling in water pipes, water heaters, and boilers. The findings of the total hardness indicate that the majority of samples are classified as very hard to hard water due to the presence of high amount of dissolved calcium salts. Moreover, 34.61% of calcium samples are over the limit of the PSI.

About 85% of the tested samples for TC show that there is no need for treatment before human use while the remaining percentage of samples are polluted and must be treated for safe use. On the other hand, 93% of the tested samples for FC indicate that there is no risk for human use. Wastewater discharging and unsafe disposal of wastewater are related to the microbial contamination content of TC and FC.

Based on the results of the study, the following recommendations are stated:

(i) Water treatment for harness removal may be required
(ii) Water disinfection is required for the removal of pathogens
(ii) There is an essential need for the construction of urban sewer systems
(iv) There is a need to increase the number of tests for heavy metals
(v) There is a need for closing the polluted water sources until treated especially in cases polluted with TC and FC
(vi) There is a need to increase the public awareness of people about the impacts of drinking polluted water

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Research Article

Drinking Water Sources along the Banks of Buriganga River of Bangladesh are Polluted and Possess Serious Health Risks: A Comprehensive In Vivo Analysis

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Background. The river Buriganga, one of the major dumping zones of industrial wastes in Bangladesh, is responsible for contaminating the drinking water sources along its length. This study aimed to assess the water quality from these sources by monitoring the changes in hematological, biochemical, and histological parameters caused in healthy rats due to their consumption. *Methods*. Using ethylenediaminetetraacetic acid (EDTA) as an anticoagulant agent, hematological and biochemical analyses of Sprague–Dawley rat models were executed in this study. Following blood sampling, the rats were sacrificed, and the heart, lungs, kidneys, liver, and spleen were separated to carry out the histological analysis. Later, to perform the statistical analysis, SPSS, V.25.0 was utilized. *Results*. A significant rise ($p < 0.02$) in body weight was recorded due to increased protein synthesis, inflammations; increased lymphocyte, white blood cell (WBC), and neutrophil count but hemoglobin (20.0 ± 1.39 g/dL vs. 15.25 ± 0.36 g/dL; p) and red blood cell (RBC) count ($(6.24 \pm 0.45) \times 10^6/\mu L$ vs. $(5.47 \pm 0.34) \times 10^6/\mu L$) decreased due to infections and hematopoietic stem cell poisoning by pathogens in water samples. Elevated ($p < 0.01$) serum urea, creatinine, alanine, and aspartate aminotransferase levels indicated kidney malfunction and hepatic tissue necrosis. Histological analysis revealed gross lesions, internal hemorrhages in the brain; inflammations, granulomas, migrating macrophages in the spleen; fibrosis (resulting in hypo-perfusion), and collagen formation in cardiac muscles. *Conclusions*. The findings in this study provide comprehensive evidence, based on *in vivo* analysis, that the water bodies around the Buriganga river are likely to be contaminated with toxic chemicals and microbial entities making them unfit for human consumption.

1. Introduction

Dhaka city, the capital of Bangladesh, is surrounded by four rivers. Balu on the east; Tongi Khal on the north; Turag on the west; and Turag-Buriganga on the south [1]. All of them are extensively polluted and have been charged with containing toxic effluents, chemical wastes, elevated levels of heavy metals, fertilizers, pesticides, and so on [1, 2]. The Buriganga River, regarded as the most significant of all, is considered Dhaka's lifeline. This 18 km long river, situated in the south of the city, has become the water source used by the city residents for bathing, drinking, irrigation, and industrial purposes [1]. However, parallel to domestic wastes, 627 dyeing, 343 tanneries, and 104 fertilizer industries discharge untreated industrial effluents daily, covering 5000 to 9000 m^2 of the river body [3, 4]. Because of a large number of pollutants discharged, the Buriganga River is getting worse. Furthermore, man-made activities such as cleaning, washing, bathing, and so on pollute the river's water. In recent years, many studies have shown widespread metallic water contamination with metals, including As, Fe, Mn, Cu, Cd, Cr, Pb, Ni, Zn, and others being found in the contaminated water in various concentrations [5]. Epoxy, polyurethane, enamel, ductile-silver white metal, hydrochloric acid, alkalis, lime, caustic soda, aluminum, zinc chromate, zinc phosphate, asbestos, and other toxic materials have all been identified in the effluents of the river water [4]. Chlorides, pH, dissolved oxygen, biological oxygen demand, and other water quality indicators seldom meet the requirements established by the Bangladeshi Department of Environment [6].

The Buriganga river was long ago designated as a "waste dump" that could not sustain aquatic life and whose water is exceptionally unsafe for home use. In addition, drinking water pipes are frequently leaking into the sewer systems in Dhaka, exposing millions of people to the river's contaminated water and seriously endangering their health [3]. Metals are regarded as poisons and eventually affect the body when consumed in higher than recommended amounts. Several metals such as lead, cadmium, chromium, and arsenic may not have any substantial benefits for the body, but they do directly harm the liver and kidney, and even at normal levels, they are highly nephrotoxic and hepatotoxic [7]. Besides, Lead intoxication can cause damage to the brain and nerves. It also slows enzymes and is harmful to many different metabolic processes [8]. Like this, manganese toxicity can cause manganism, a chronic neurological condition characterized by tremors, trouble walking, and facial muscle spasms. These symptoms are frequently followed by less severe ones such as aggression, impatience, and hallucinations. There is no doubt that industrial pollution and water contamination are related [9]. According to a recent health benefits assessment, industrial exposures may be responsible for up to 10% of end-stage renal disease and various liver illnesses [10]. Specifically, according to a recent study, the Buringa water had high levels of phosphate ($PO4^{-3}$), ammonia, organic matter, biological oxygen demand (BOD), and chemical oxygen demand (COD). The study also highlighted the serious risks to public health and the potential harm to the environment [6].

Due to several risk factors, research has long been interested in the Buriganga River's water quality and the water from nearby sources. Numerous studies have been conducted in these areas to estimate the physicochemical parameters, presence of toxic wastes, heavy metals in drinking water, and possible sources of contamination [1, 4, 9, 11, 12]. However, little effort has been put forth to examine the risk of long-term use of such polluted water using animal models.

Hence, in this present study, water samples from the major drinking outlets around the Buriganga river were collected and fed to Sprague–Dawley rats in the laboratory over 56 days. The animals were later sacrificed; blood and tissue samples were collected to investigate changes in biochemical, hematological, and histological parameters. These assessments could provide evidence that would clarify the impact of (if any) Buriganga river water on the health-related issues of the population living along the length of the river. Thus, the objectives of this study were to examine the hematological, biochemical parameters, and tissue histology of some major organs of Sprague–Dawley rats fed with the contaminated water and estimate the significance of the change in physiology made due to long-term exposure to the sampled drinking water.

2. Materials and Methods

Test water samples were randomly collected from different sites (Sadarghat, Tanti Bazar, Shakhari Bazar, Islampur, Nowab bari Ghat, and Badamtoli Bridge) covering the length of Buriganga, following the method of Sunjida, et al. 2016 [9]. At each point, a total of 10 samples were taken from chlorine-treated groundwater sources (tap water) and collected in double-capped polyethylene bottles previously washed with detergent, dilute $HNO_{3,}$ and Milli *Q* Water (MQW). A total of 12 healthy, eight weeks old, female albino, Sprague–Dawley rats, weighing 160 ± 25 g, were housed in plastic ($30 \times 20 \times 13$ cm) cages; kept at laboratories where room temperature and relative humidity (25°C, 60%) were strictly monitored. All experimentations associated with living subjects were performed according to the institutional guidelines for animal experimentation of the Department of Pharmacy, State University of Bangladesh. Besides, the Animal Ethics committee of the State University of Bangladesh has critically reviewed and approved the study protocols and detailed guidelines. The Federation of European Laboratory Animal Science Associations (FELASA) guidelines and recommendations were followed to reduce the pain and stress of the experimental animal. The subjects were kept for one week in order to settle into their new environment. Later, they were divided into two groups of 6 members, and all were fed and allowed to drink water ad libitum. Group 2 (the experimental group) received the sample water, while Group 1 served as the control group and was given normal drinking water. All the individual rats in both groups were marked (as I, II, III, IV, V, and VI) carefully on the tail for ease of identification and these identification marks were used to record the responses of an individual rat prior to and during the experiment. The experimental study was conducted for 56 consecutive days. The body weight of each rat in the treatment and control group was measured at the beginning of the experiment using an electronic analytical weight balance. Two times measurements of weight per week were recorded during the total exposure period. After 56 days of exposure, the rats were fasted overnight and weighed. Blood samples were collected from every individual rat through cardiac puncture using a 5 mL syringe with a 25 G needle and immediately transferred to a tube containing 8.5% of the anticoagulant ethylenediaminetetraacetic acid (EDTA) [13]. Samples were immediately transferred to anticoagulant-containing tubes and mixed with 8.5% EDTA. All the tubes were properly labeled and immediately transferred to the laboratory for hematological and biochemical analysis.

At the end of the experiment, an anesthesia overdose (Ketamine HCl (100 mg/kg) and xylazine (7.5 mg/kg) through the intraperitoneal route were given to the rat models followed by euthanasia [14]. The heart, lungs, kidneys, liver, and spleen from each rat were removed using a sharp blade and scissors, immediately rinsed with physiological saline, blotted, dried, and later weighed. The organs were separately preserved in 10% formaldehyde (pH 7.2 to 7.4), and sections of tissues were sliced later for histological analysis [15].

All the hematological and biochemical analyses were performed using the laboratory facility at the Pharmacology research laboratory, Jahangirnagar University, Savar, Dhaka. The hematological analyzed parameters were white blood cell (WBC) count, red blood cell (RBC) count, hemoglobin concentration (Hb), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and platelet count (PLT). The biochemical parameters were serum urea, creatinine, bilirubin, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels [16, 17].

For the histological evaluations, the organs were trimmed to 0.5 cm in thickness and placed in cassettes. The cassettes were submerged in 10% formalin solution overnight, before undergoing a series of dehydration processes for about 16 hr in an automated processor (Leica ASP300, Germany). The samples were then embedded with paraffin to form a block by a processor machine (Leica EG1160, Germany) and left to cool. The blocks were trimmed to about 3–5 μm in thickness using a sectioning rotary microtome (Leica RM2155, Germany) and directly placed in a 45°C water bath before mounting on slides. All the glass slides were labeled with a diamond pen and mounted on a hot plate (54°C) overnight. Finally, after staining with hematoxylin and eosin (H&E) the samples were examined under a light microscope at different magnifications, and images (1360 × 1024 pixels each image) were captured using 100 times magnification [18].

Statistical analysis was performed on a PC using SPSS, V.25.0. All the parameters were recorded in triplicates and expressed as mean ± SEM of n experiments (where n represents the number of animals used). Values between the control and the experimental group were compared using the t-test and p values lower than 0.05 were considered to be statistically significant.

3. Results

After 56 days, significant ($p < 0.001$) variations in body weight were found between the sample and control group. The mean body weight of the rats in the test group (137 ± 1.0 mg) was higher compared to the rats in the control group (121.8 ± 1.2 mg) (Figure 1).

Hematological analysis revealed a significant difference only in the hemoglobin level ($p < 0.01$) of the test animals which was 4.75 ± 1.75 mg higher than the control group. Other parameters such as the values of MCV, MCH, MCHC, and PCV were comparable in both groups. There was a reduction in the RBC and platelet count while the lymphocytes such as WBC, monocyte, eosinophil, basophil, and neutrophil counts increased (Table 1). In the biochemical analysis, significant variations were recorded in all the parameters being measured between the two groups of animals. Serum urea ($p < 0.01$) levels were 6.9 ± 2.04 mg/dL elevated and creatinine ($p < 0.05$) levels increased by 0.24 ± 0.09 mg/dL in the sample group animals. Both the concentrations of AST ($p < 0.01$) and ALT ($p < 0.05$) were found to be higher by 39.3 ± 13.8 and 5.92 ± 2.54 mg/dL, respectively, after the rats were in exposure to the sampled water (Figure 2).

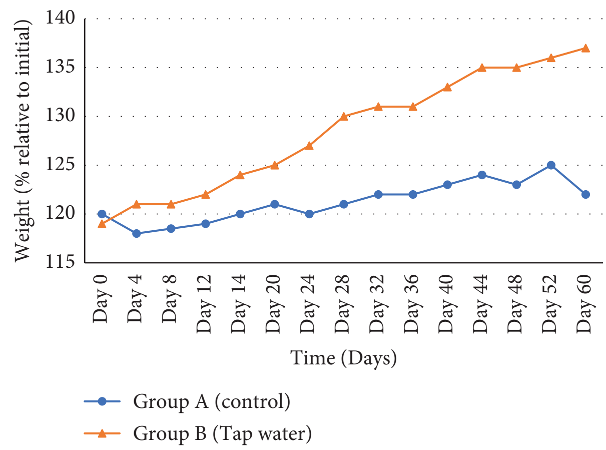

Figure 1: Effect of tap water (sample water) ($n = 6$) on body weight of Sprague–Dawley Rats compared to control groups (normal water) ($n = 6$). The weights of the rats were measured every four days for 56 days, and weight change was calculated relative to the initial weight at day 0.

Table 1: Hematological values (mean ± SEM) of Sprague–Dawley rats ($n = 6$) after 56 days of the experiment.

Sl. No.	Parameters	Group 1 (control)	Group 2 (sample water)
1	Hemoglobin	20.0 ± 1.39 g/dL	15.25 ± 0.36** g/dL
2	ESR	4.5 ± 1.1 mm/hr	4.5 ± 0.76 mm/hr
3	PCV	33.21 ± 1.13%	33.08 ± 2.13%
4	MCV	53.56 ± 0.69 fL/red cell	53.48 ± 0.70 fL/red cell
5	MCH	19.13 ± 0.38 pg/cell	18.38 ± 0.21 pg/cell
6	MCHC	33.83 ± 0.80 g/dL	33.8 ± 1.27 g/dL
7	RDW-SD	30.63 ± 1.56%	32.4 ± 1.44%
8	MPV	6.62 ± 0.080 fL	7.21 ± 0.27 fL
9	RDW-CV	16.67 ± 0.54%	16.22 ± 0.66%
10	WBC	4500 ± 295.52/µL	5350 ± 689.32/µl
11	RBC	$(6.24 \pm 0.45) \times 10^6$/µL	$(5.47 \pm 0.34) \times 10^6$/µL
12	Lymphocyte	77.83 ± 2.71/µL	81.83 ± 1.60/µL
13	Monocyte	1.50 ± 0.22/µL	2.0 ± 0.45/µL
14	Eosinophil	0.02 ± 0.0025l/µL	0.02 ± 0.0041l/µL
15	Basophil	2.83 ± 0.60/µL	3.03 ± 0.45/µL
16	Neutrophil	15.5 ± 2.96/µL	17 ± 1.03/µL
17	Platelet	539200 ± 8063.91/µL	528400 ± 20523/µL

All the values are expressed as mean ± SEM ($n = 6$). $p < 0.05$ significant when compared to the control group (normal water). Here, $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$ when compared with the control group. Here, ESR = erythrocyte sedimentation rate; PCV = packed cell

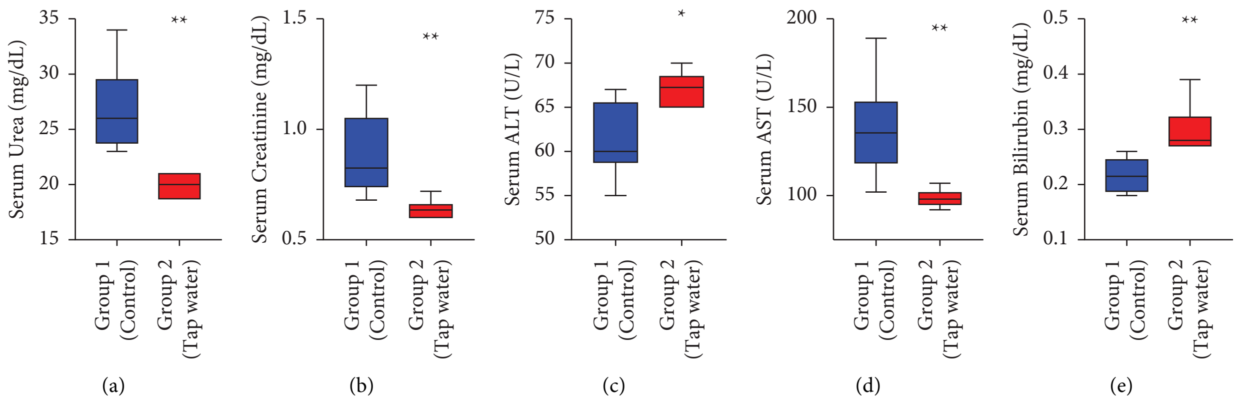

Figure 2: Biochemical changes of Sprague–Dawley rats after 56 days of exposure to different types of water (normal water (control) vs. tap (sample) water). (a) Changes in serum urea level; (b) Changes in serum creatinine level; (c) changes in serum ALT level; (d) changes in serum AST level; (e) changes in serum bilirubin level;** compared with the control group, $p < 0.005$;* compared with a control group, $p < 0.05$. Results are shown as mean ± SEM of $n = 6$ rats per group.

volume; MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin; MCHC = mean corpuscular hemoglobin concentration; RDW = red blood cell distribution width; WBC = white blood cell; RBC = red blood cell.

Histological analysis of the brain tissue revealed the presence of a gross lesion and mild-to-moderate focal hemorrhage in the sample group while the control group had normal brain histology (Figures 3(a) and 3(b)). Cardiac tissue from the rats receiving the sample water showed highly distorted cardiac muscle fibers with an increased collagen bundle (Figures 3(g) and 3(h)). Histological sections of the liver had sinusoidal dilatation, cytoplasmic vacuolation, and inflammation (Figures 3(c) and 3(d)). Renal tissue samples from the experimental groups had tissue degeneration at the glomerular tuft accompanied by lymphocyte infiltration. Additionally, the renal tubules were vacuolated and had lost their brush borders. The cells of both renal corpuscle and renal tubules lost a considerable amount of total protein as well. However renal tissue samples from the control group exhibited no such changes (Figures 3(i) and 3(j)). No visible changes were seen in the lung tissue sample from the two groups (Figures 3(e) and 3(f)) but a histological study of the spleen tissue revealed the presence of granulomas in the capsule and red pulp composed predominantly of infiltration of macrophages and rare lymphocytes and plasmacytes (Figures 3(k) and 3(l)).

4. Discussion

Globally, the supply of fresh water is being lowered continuously due to resource overuse, population growth, and rapid industrialization [19]. Industrialized countries have good monitoring and remediation initiatives to counteract these issues, and health hazards in developing countries are on the rise, due to fewer initiative programs and poor management by the authorities [20]. Nevertheless, there has been a recent upsurge in concern among the general population making river pollution one of the main topics in the environmental issue of urban Dhaka [9]. As a result, numerous investigations have been conducted to assess the quality of major water bodies around the country, especially in industrialized areas. All of these studies provide strong evidence that the water in the rivers around Dhaka, i.e., Buriganga, is highly contaminated containing toxic industrial wastes, heavy metals, etc., threatening the health of local communities [9]. Our present study has taken a newer approach of expanding the field of investigation by studying the long-term toxic effect of drinking water contaminated by the Buriganga river water, in an animal model. Our findings regarding the hematological, biochemical parameters, and histological observations corroborate previous in vitro studies conducted on the water from Buriganga and other surrounding sources and provide comprehensive evidence that the drinking water sources nearby Buriganga are highly polluted and unfit for human consumption.

Enhancement of body weight in test animals after treatment with polluted drinking water has been recorded in the previous report [9], but no plausible explanation was provided. However, drinking water contaminated with heavy metals and carcinogens such as arsenic, cadmium, lead, benzene, and trichloroethylene has been associated with the increased weight of organs such as the liver, spleen, pancreas, and heart in several studies [21]. Similarly, chronic infections (caused by pathogens present in the contaminated water in this case) have also been linked to inflamed liver and spleen along with increased protein synthesis by these organs [22]. This elevated number of tissue inflammation and protein synthesis of various organs as a measure to counteract the pathogenic infestations caused by consuming polluted water could add up to the increase in total body weight. Hematological changes similar to this study have been published in other studies where test animals were treated with polluted water or by water contaminated with industrial wastes containing toxic heavy metals [23, 24]. The intake of the polluted water could have had intoxicated the internal organs which were also evident in the histological tissue analysis. This might cause inhibition of erythropoiesis in the hemopoietic organs, decreasing the RBC, PCV, and Hb count resulting in an anemic condition in the rats [25].

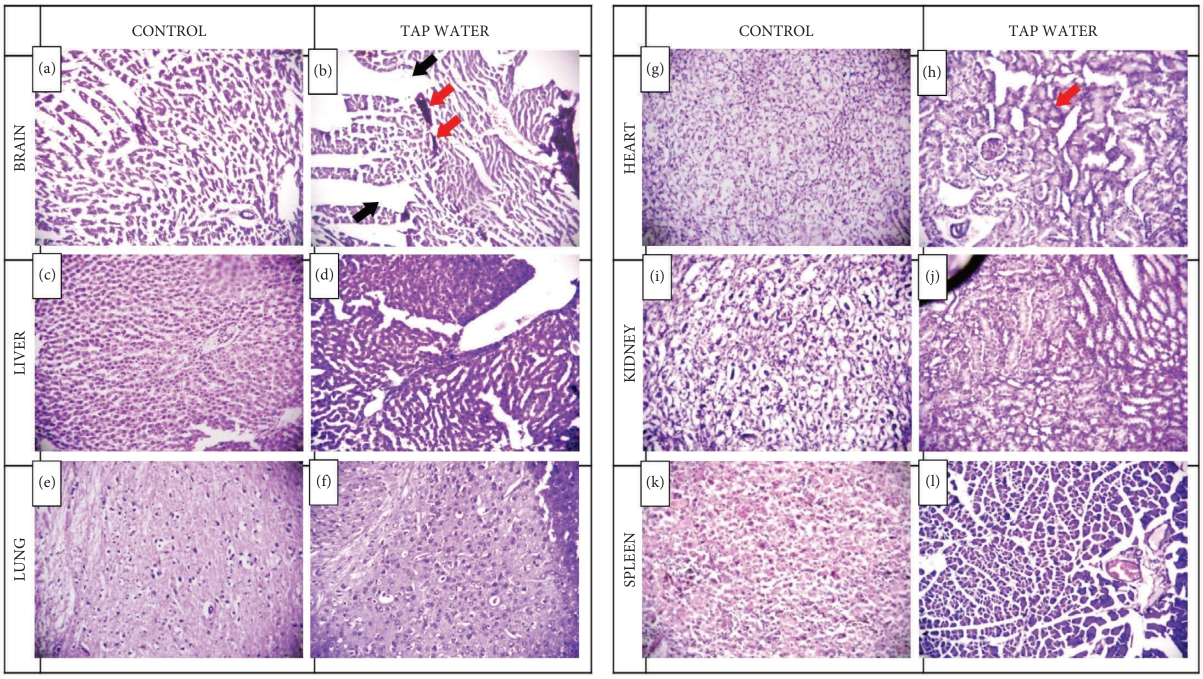

Figure 3: Representative photomicrographs of distal organs of rats after 56-day exposure to sample tap water. Photomicrographs of slices from the brain (a–b), liver (c–d), lung (e–f), heart (g–h), kidney (i–j), and spleen (k–l) stained with hematoxylin and eosin. (a) Normal brain architecture with well delineated cortical layers and neuronal cells; (b) in the experimental group (tap water), gross lesion (black arrow) and mild-to-moderate focal hemorrhage (red arrow) was observed; (c) normal liver architecture with normal hepatocytes and red cell stasis within the central vein and sinusoids; (d) experimental rat liver section showing sinusoidal dilatation, cytoplasmic vacuolation and inflammation; (e) sections of lungs of control rat; (f) sections lungs of experimental rats showed no differences; (g) well developed and normal distribution of cardiac muscle fibers; normal appearance of cardiac tissue of control rat; (h) highly distorted cardiac muscle fibers with increased collagen bundle (red arrow) observed in experimental group and the muscle fibers appears deformed due to adverse accumulation of collagen increasing tissue stiffness causing cardiac fibrosis; (i) normal histological features of kidney including glomerulus and tubules of control rat-glomeruli are normal and tightly filing the Bowman's capsule and renal tubules are lined with typical thick cubic epithelium; (j) kidney section of experimental groups had degeneration of the glomerular tuft with infiltration of lymphocytes and the renal tubules became vacuolated along with losing their brush borders; (k) normal histology of spleen, region of the periarterial lymphoid sheath of control rat; (l) spleen tissue sample of experimental rat revealed the presence of granulomas in the capsule and red pulp.

Hypoxic conditions could also result in the release of immature RBCs in the blood as a compensatory measure resulting in a decrease in MCV, MCH, and MCHC values [26]. The WBCs are the body's first line of defense against pathogens [27]. Elevated levels of these cells in the body indicate internal infections [28]. This infection could be initiated by pathogens entering the rats from the polluted drinking water. An increase in serum urea and creatinine level indicates an increase in the tubular reabsorption of urea and decreased creatinine clearance both caused by a reduction of renal blood flow also known as hypo-perfusion [29]. This reduction in blood flow could be the sign of any condition that leads to a decrease in effective circulating blood volume caused by any cardiac impairment (failure/injury) [30]. This cardiac injury was clearly evident in the histological analysis (Figure 3: H, red arrow). On the other hand, the increase in ALT ($p < 0.05$) and AST levels is directly related to progressive liver damage (Figure 3: C), tissue necrosis, or extensive breakdown of body tissue leading to the liberation of these enzymes into the blood [31]. The hemorrhage and the edema indicate a severe form of brain injury and tissue damage (indicated by an arrow in Figure 3: A). Furthermore, the hemorrhage could worsen the inflammation further contributing to brain injury [32–34]. This brain damage could be a result of increased oxidative stress in brain tissue. Oxidative stress could damage the membrane phospholipids and DNA nucleotides directly and also indirectly through the mediation of various cellular cascades [35–37]. Additionally, the large consumption of oxygen by brain tissues makes them more vulnerable to oxidative stress [36]. These reactive oxygen species (ROS) could enter the body through polluted water. In the brain, increased ROS causes oxidative damage to all cellular components. The muscle fibers appeared deformed due to adverse accumulation of collagen increasing tissue stiffness and causing cardiac fibrosis. This is characterized by decreased contractility and thereby impairing the overall performance of the heart [38]. Several mediators could be responsible for the induction of this collagen formation such as transforming growth factor-β1 (TGF-β1) and angiotensin-converting enzyme 2 (ACE2). [39, 40]. However, the relationship between cardiac fibrosis and contaminated water consumption could trigger those mediators, and still, further relationship needs to be established. All three of these observations have been linked with bacterial infection and provide evidence that the water samples were the primary source of pathogenic bacteria. For example, bacterial invasion results in inflammation due to immune response. In addition, sinusoidal inflammation is associated with inflammatory diseases [41]. Finally, cytoplasmic vacuolation is a very common morphological change undergone by cells after exposure to infectious pathogens [42]. The progressive damage of liver tissue is also supported by the elevated levels of ALT and AST in the blood serum mentioned previously. Chromium, arsenic, etc., very common in polluted water, have been found highly nephrotoxic and hepatotoxic even at normal levels [43]. The liver and kidney damage in the rats could be associated with these two heavy metals present in the drinking water samples. The formation of granulomas and migration of macrophages is a common response shown by the body when it tries to eliminate microbes or foreign matters [44]. These pathogens or foreign matters could easily invade healthy rats due to the consumption of contaminated water.

5. Conclusion

Interpretations of the physiological changes recorded in the current study suggest that the inhabitants living near Buriganga are at serious health risks such as respiratory infections, liver cirrhosis, renal impairment, various tissue necrosis, and toxicities. Long-term consumption could also give rise to health issues such as reduced immunity, anemia, and cardiac fibrosis as well as numerous tissue inflammations in humans. Even though some parameters, i.e., MCH, MCHC, and WBC count showed gradual changes for which general explanations have been proposed but these variations were not significant to draw any blatant conclusion. Therefore, this study also demands future in vivo studies with broadened sample area, size, and increased duration, in order to elucidate these changes, understand the mechanism of actions triggering them and clarify the public health associated risks due to exposure to this contaminated water. Furthermore, since the river is polluted from various sources, including domestic, industrial, and dyeing wastewater, it is essential to investigate the concentrations of primary pollutants, such as the kind and amount of dye, trace element types and amounts, and chemical and biological contaminants.

Data Availability

Further raw data will be found from the corresponding authors upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Climate Change and Water Crises in Pakistan: Implications on Water Quality and Health Risks

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Pakistan is vulnerable and most affected by adverse impacts of climate change. The study examines the impact of climate change on Pakistan during the year 2022, resulting into unprecedented heatwave and drought in summers followed by the abnormal rains and floods during monsoon season. Agriculture is the backbone of Pakistan's economy, which has been devastated by both drought and floods. While the flood water is gradually receding, the stagnant contaminated water is causing several health risks for the inhabitants. This research argues that water security is the emerging national security challenge for Pakistan. The article investigates the status of water availability vis-a-vis the burgeoning population, agriculture, and other uses of water. Impact of abnormal melting of glaciers, nonavailability of dams for storage of rainwater, and lack of smart means for agriculture water have been examined to empirically validate the arguments.

1. Introduction

Climate change has become international buzzword today and it is "no longer an unfamiliar term, which can be comprehended through personal knowledge, experience, and interactions" [1]. The phenomenon of climate change is largely attributed to human induced actions, more specifically in terms of emissions of greenhouse gases in the atmosphere [2]. Therefore, the phenomena of climate change are producing many threats on the Earth surface, ranging from droughts, heavy precipitation, and heatwaves to unprecedented tropical cyclones [3]. All these disasters have varying degree of impact over different geographical zones, resulting into environmental, health, economic, and social impact. There is no denying the fact that the world we live in today is far more vulnerable and affected by the negative impacts of climate change. However, the greatest health impact is being witnessed in the countries which have least share in greenhouse emissions [4]. There is also strong realization to attend to climate emergency, which is causing water security issues around the globe, and threatens food security, agricultural yield, food supply, and prices with serious implications on sustainable development, poverty, and inequality. The UNICEF warns about the availability and use of water in a nicely crafted statement that "the world needs to get water smart, and everyone has to realize that they have a role to play, and we cannot afford to wait" [5]. The "climate change is happening right now, and its effects are being felt around the world" [6].

Pakistan is vulnerable to the negative consequences of climate change, therefore, susceptible to unusual weather patterns, which can create strategic challenges [7]. The rising temperatures are causing rapid melting of glaciers in northern areas and unusual rains as seen in monsoon this year have created mayhem through floods, unprecedented in Pakistan's history in last 30 years. United Nations Secretary General Antonio Guterres stated that Pakistan is facing "the unrelenting effects of epochal levels of rains and flooding" [8]. The men and material losses are enormous and therefore, Pakistan is likely to face water crisis, food shortages, and serious implications for human security. Reacting to the recent flood situation in Pakistan, the Finance Minister Mr Miftah Ismail stated that "Pakistan is dealing with the worst effects of the climate change, which has caused over US$ 30 billion loss to Pakistan's economy and displacing 33 million people" [9]. This study explores the impacts of climate change on the availability, usage, and storage of water in Pakistan. The drought and floods of year 2022 have been taken as case study for analyzing the impacts of climate change across Pakistan by sampling both rural and urban areas. Figure 1 shows the sectoral usage of available water in Pakistan.

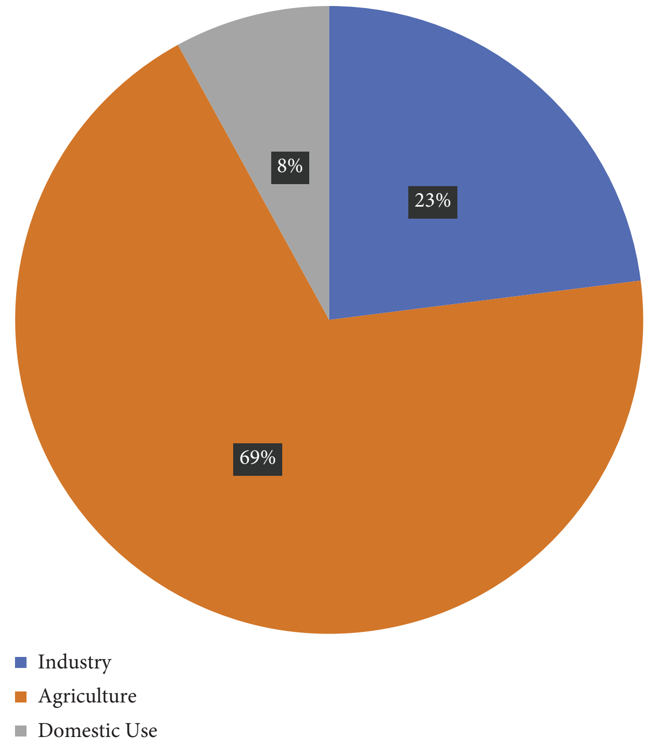

FIGURE 1: Sectoral distribution of water consumption in Pakistan.

2. Materials and Methods

The year 2022 is unprecedented in Pakistan's history of last three decades. The summers produced extreme temperatures which resulted in unusual melting of glaciers in northern areas of Pakistan resulting in partial collapse of bridge near Hassanabad in Hunza [10] as shown in Figure 2.

Later, the exceptional monsoon rains produced extraordinary floods across the country, with huge men and material losses. The evolving trends indicate that Pakistan is most vulnerable to climate change. The floods have devastated the agriculture, livestock, and infrastructure. The loss to national economy is estimated at US$ 30 billion [11]. The survey and data analyses of past two and half decades reveal that Pakistan confronted from absolute dry and drought situations to devastating floods to the extent of witnessing both phenomenon in one calendar year as happening in the ongoing year 2022. The study has been completed by considering drought and floods data from primary and secondary sources with particular focus on this year. The field visits to rural and urban areas of Sindh, Khyber Pakhtunkhwa (KPK), and Baluchistan were conducted for obtaining the first-hand information and data on the impacts of flood situation. The relevant officials in the ministry of climate change and meteorological offices were also interviewed and their views have been incorporated in the study for developing a comprehensive picture, conducting rationale analyses, and arriving at workable findings. The study is very contemporary and relevant and expected to provide valuable policy guidelines to relevant government ministries in Pakistan as they are grappling with the ongoing flood situation and rehabilitation process. Figure 3 highlights the vulnerability of Pakistan to climate change risks in the global context, which has been explored further in the study to empirically prove the vulnerabilities and risks.

3. Findings

3.1. Deciphering the Impact of Climate Change on Pakistan. Climate remains the most debated yet least addressed issue for decades. World leaders have often joined heads to tackle this global phenomenon but with little to no success. From motivational speeches to documentaries and movies on the effects of climate change on the Earth has been narrated time and again but to no avail [13]. The developed countries remain aloof of devastating effects of greenhouse gas emission is causing to the ozone layer. The growing depletion of the ozone layer is resulting in increased Ultraviolet (UV) radiations level on the surface of Earth, which has detrimental impact on human health resulting in cancer and weak immune system [14]. These UV radiations have devastating effect on the agriculture sector as well due to low yield of the crops [15]. Scientists have been talking about the infamous "black hole" in the Antarctic region for years. But the recent research in the year 2022 has discovered a hole in the Tropics (Tropics are the regions of the Earth near the equator) which is seven times bigger than the Antarctic region [16]. The more alarming situation is that, despite all this, the industrialized countries are less concerned by the deteriorating ozone and increase in global warming. Various protocols and initiatives like Kyoto Protocol, Copenhagen accord, and Paris accord had been initiated by the United Nations Framework on Climate Change (UNFCCC). Due to the Sovereign status of the global order, these agreements were not a binding, therefore, the industrial powers contributing the most carbon dioxide and greenhouse gases to the environment withdrew from these accords as it did not serve their economic interests. The major global contributors of the CO_2 emissions are given in Figure 4:

Figure 4 gives an account for the 10 most polluted countries in the world as of 2020. However, China remains leading in that aspect in the year 2022 as well. United States remain on second number with 4.4 billion tons of CO_2 emissions, while India is third producing 2.3 billion tons of CO_2.

According to Figure 5, the above countries might not appear as the top 10 global CO_2 contributors, but they fall in the top 10 per capita CO_2 contributors, due to their large-

Figure 2: Partial collapse of Hassanabad bridge.

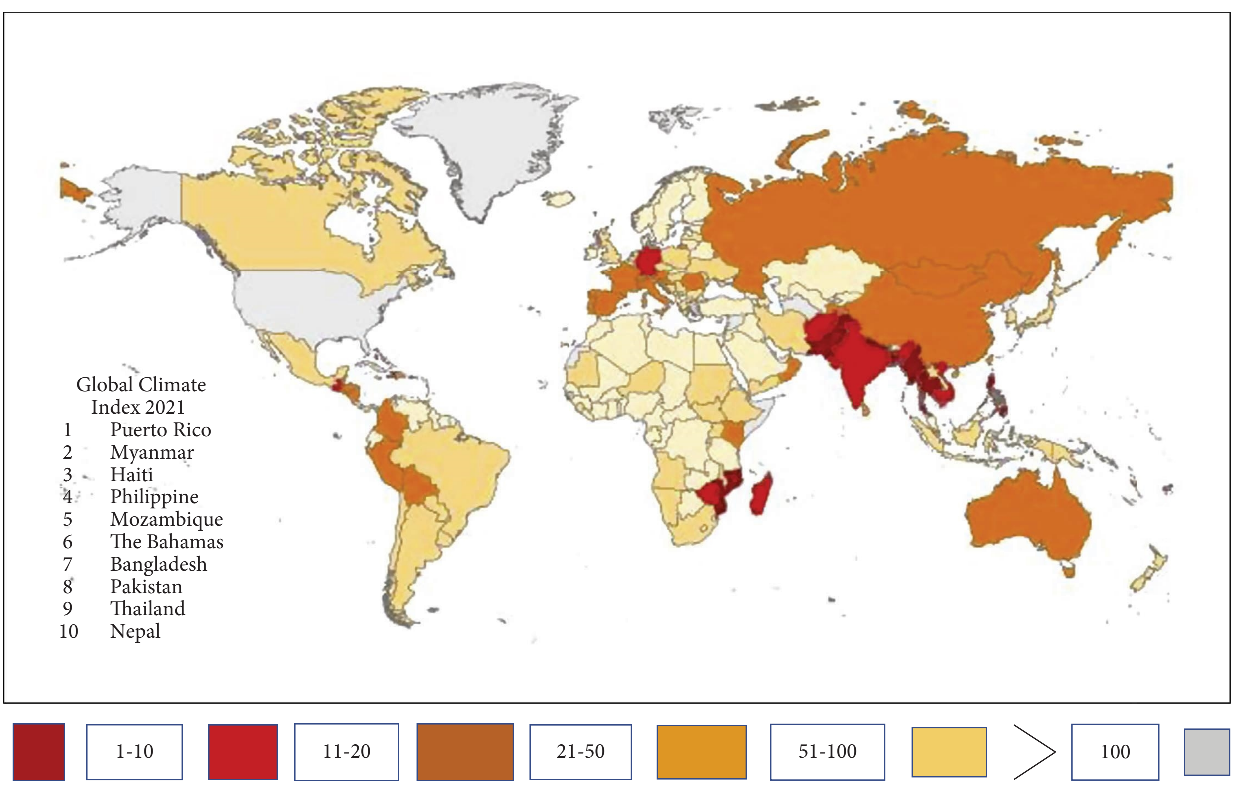

Figure 3: Climate risk indexing and Pakistan's vulnerability [12].

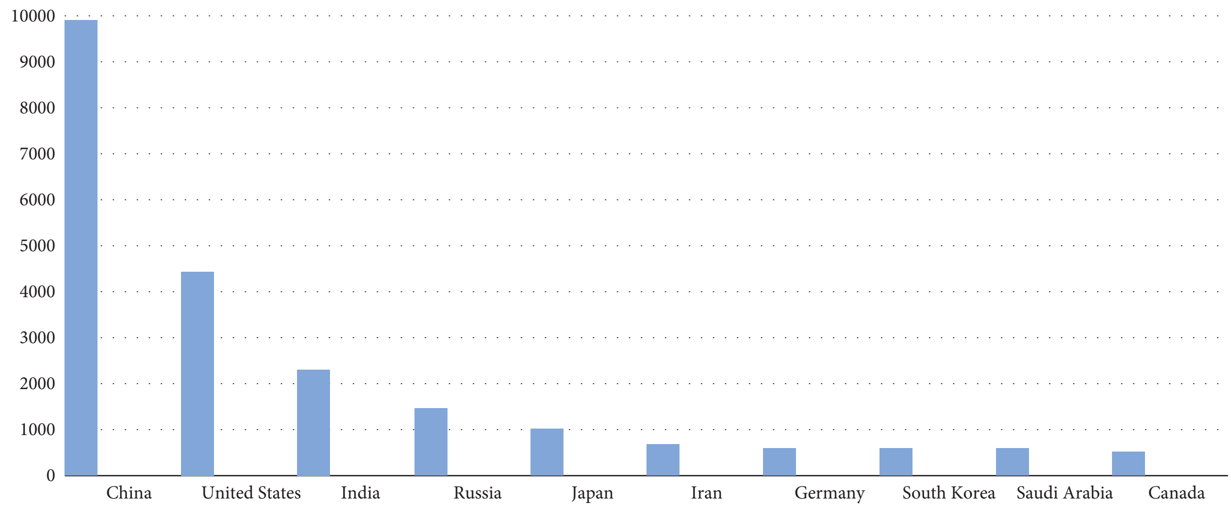

Figure 4: 10 most polluted countries as of 2020 [17].

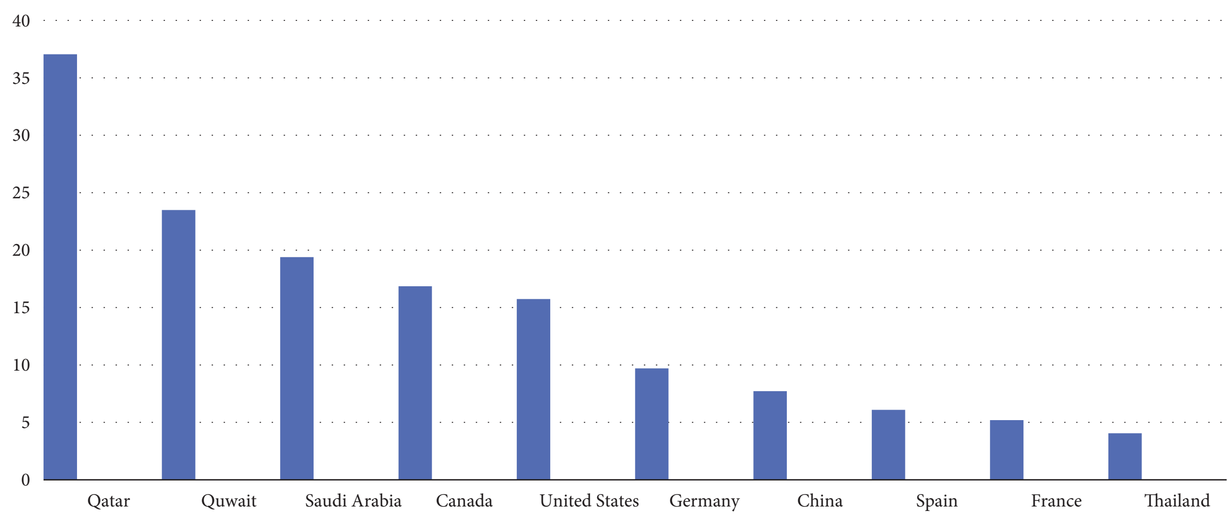

Figure 5: 10 most polluting countries per capita 2022 [18].

scale reliance on oil and small number of populations. United Nations Secretary General Mr Antonio Gutters paid an official visit to Pakistan on 9-10 September 2002 to show solidarity to flood victims and assess the devastations through field visits and official briefings. He stated that the "nature has attacked Pakistan, which contributes less than 1% of global emissions" [19] while facing the consequences of developed countries emissions and pollution of climate. He further added that "it was outrageous that action to reduce greenhouse gas emissions was being put on the back burner, today it is Pakistan and tomorrow, it could be your country" [20], pointing toward industrialized countries. The Global Climate Index (GCI) 2021 has also vindicated Pakistan's vulnerabilities to climate risks as shown in Table 1 below, where Pakistan stands number 8 [21] in the vulnerability Index. The analysis presented highlights the severe impacts of climate change on Pakistan ranging from extreme heat and drought to dreadful floods. [22].

3.2. Examination of Water Calamities in Pakistan. Water is an essential need for ecosystem and human life. In recent times, it has been a growing concern that "precious blue" is becoming inadequate resource for future of human survival [23]. The amount of fresh water has remained constant on Earth surface since last 100 years; however, the access to water resources is unbalanced [24] with the rapid population growth, urbanization, and deforestation. Similarly, other issues, such as technological waste, growing industrialization, global warming, and climate change, all are among the key contributing factors for extreme water scarcity [25]. Although the water scarcity has emerged as a global challenge today, it has severely hit the underdeveloped countries like Pakistan with serious implications on all sectors. Pakistan stands among top 10 severely "high water risk countries" with agriculture as most affected sector [26]. Moreover, roughly 80% of the population is facing grave shortage of water during at least 1 month in a year which is

Table 1: Global climate index 2021 [22].

Cri 2000 2019 (1999 2018)	Country	Cri score	Fatalities	Fatalities per 100000 inhabitants	Losses in millions US$ PPP	Losses per unit GDP in %	Number of events 2000–2019
1 (1)	Puerto Rico	7.17	149.85	4.12	4149.98	3.66	24
2 (2)	Myanmar	10.00	7056.45	14.35	1512.11	0.80	57
3 (3)	Haiti	13.67	274.05	2.78	392.54	2.30	80
4 (4)	Philippine	18.17	859.35	0.93	3179.12	0.54	317
5 (14)	Mozambique	25.83	125.40	0.52	303.03	1.33	57
6 (20)	The Bahamas	27.67	5.35	1.56	426.88	3.88	13
7 (7)	Bangladesh	28.33	572.50	0.38	1860.04	0.41	185
8 (5)	Pakistan	29.00	502.45	0.30	3771.91	0.52	173
9 (8)	Thailand	29.83	137.75	0.21	7719.15	0.82	146
10 (9)	Nepal	31.33	217.15	0.82	233.06	0.39	191

very alarming. Under scarce surface water, ground water resources (last resort to water supply) are being over utilized. If appropriate measures are not initiated in time with "whole of nation" and "whole of government" approach, the situation would get worse in time to come and the entire country will face the severe crises of water scarcity by 2025, by most projections "Pakistan could run dry" [27]. The evolving situation has serious implications on the national security of Pakistan, as it will create challenges for sustainable agriculture production which contributes around 23% of Pakistan's Gross Domestic Product (GDP) and creates job opportunities for around 42% of population [28]. According to the report published by Pakistan Institute of Development Economics (PIDE), Pakistan ranks 14th out of 17 very high-risk countries affected by water scarcity, as more than 1/3rd of available water is wasted due to bad management [29]. Since 1962, after the formalization of Indus Water Treaty (IWT) with India, per inhabitant water availability has plummeted from 5229 cubic meters to about 1187 in 2017, which is continuously on the downward slide [30]. The latest UN report on Pakistan's growing population indicates that by 2050, the population is likely to exceed 366 million [31], which will compound the water demand, which is predicted to reach 274-million-acre feet (MAF) by 2025 against available water supply of 191 MAF. This demand and supply gap would continue to grow year on year basis due to growing population and bad water management [32]. Figure 6 shows graphical representation of expected water situation in Pakistan by 2025 viz-a-viz the population [33].

3.3. Analysis on Flood Devastations in Pakistan in Year 2022. Most of Pakistan's economy is dependent on the agricultural sector; however, the industrial sector also contributes a great deal to the economic growth of Pakistan. The growing population is directly impacting the environment as the number of vehicles on roads and the number of industries to accommodate these individuals will also increase. The population of Pakistan at the time of independence was 32.5 million; however, as per the 2021 census, the population has increased to 225 million. Although, Pakistan remains significantly low on the global CO_2 emissions list, yet the effects of global warming have reached Pakistan in a sweeping manner [34]. The issue that industrialized countries failed to realize that the environment does not belong to a single country and when one country damages the ozone layer, the entire world would pay the price for that. The year 2022 was one such year for Pakistan when the effects of climate change brought heavy rainfalls in Pakistan resulting in major loss of lives, infrastructural damage, and massive economic losses to the tune of US$ 30 billion [35]. The NASA issued satellite imagery on the flood situation in Pakistan, which is given in Figure 7.

Torrential rainfall and flooding have wreaked havoc across Pakistan killing over 1600 people including children and destroying infrastructure. According to statement given by Sherry Rehman Minister for Climate Change: "One third of the country is literally under water, a catastrophe of unknown precedent" The data are given in Table 2 and Figure 8. Therefore, the devastating floods caused by unprecedented impact of climate change have hit Pakistan the most this year seriously impacting all the sectors of economy and society [36].

3.4. Analysis on Drinking Water Quality in Pakistan. The quality of available drinking water in Pakistan is in a dreadful state. Both surface and subsurface water sources are contaminated and disease prone [37] in major cities as well as rural areas. In the overall context, per capita the availability of water is decreasing precipitously in Pakistan, and the country is ranked as "water stressed" country and fast heading toward "water scarce" country in coming few years [38]. The evolving situation also creates challenges for availability of water for agricultural production, and daily usage requirements, therefore intensifying the human security issues in Pakistan [39]. Water pollution is the most common word today in Pakistan, which can be ascribed to numerous aspects affecting quality of available water [40]. The common causes are an upsurge in the atmospheric temperatures, with an inbuilt tendency to take heat to the threshold of drinking water, microbes, organic chemicals, nutrients, and heavy metals [41]· The research findings have discovered other factors as well affecting water quality,

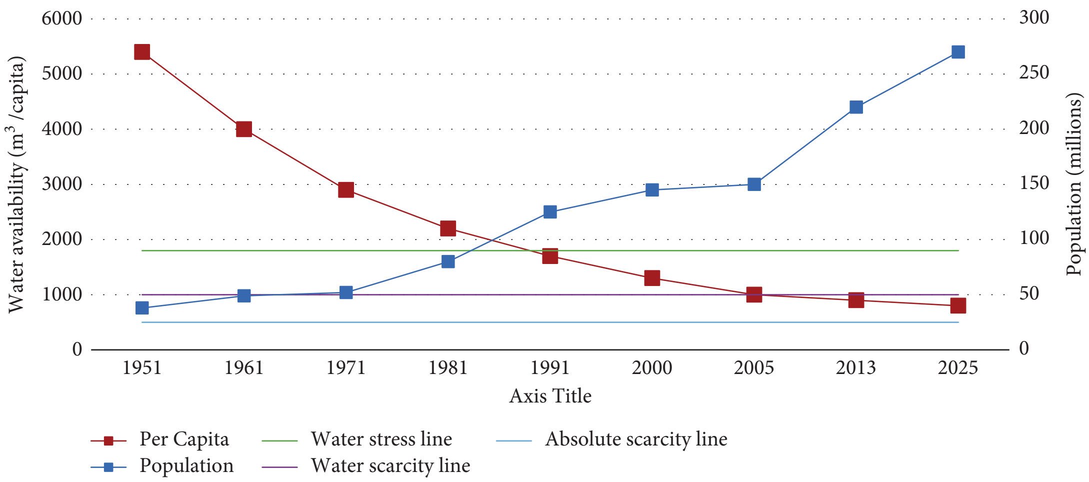

Figure 6: Water availability in Pakistan by 2025 taken from Dr Muhammad Ashraf's research report.

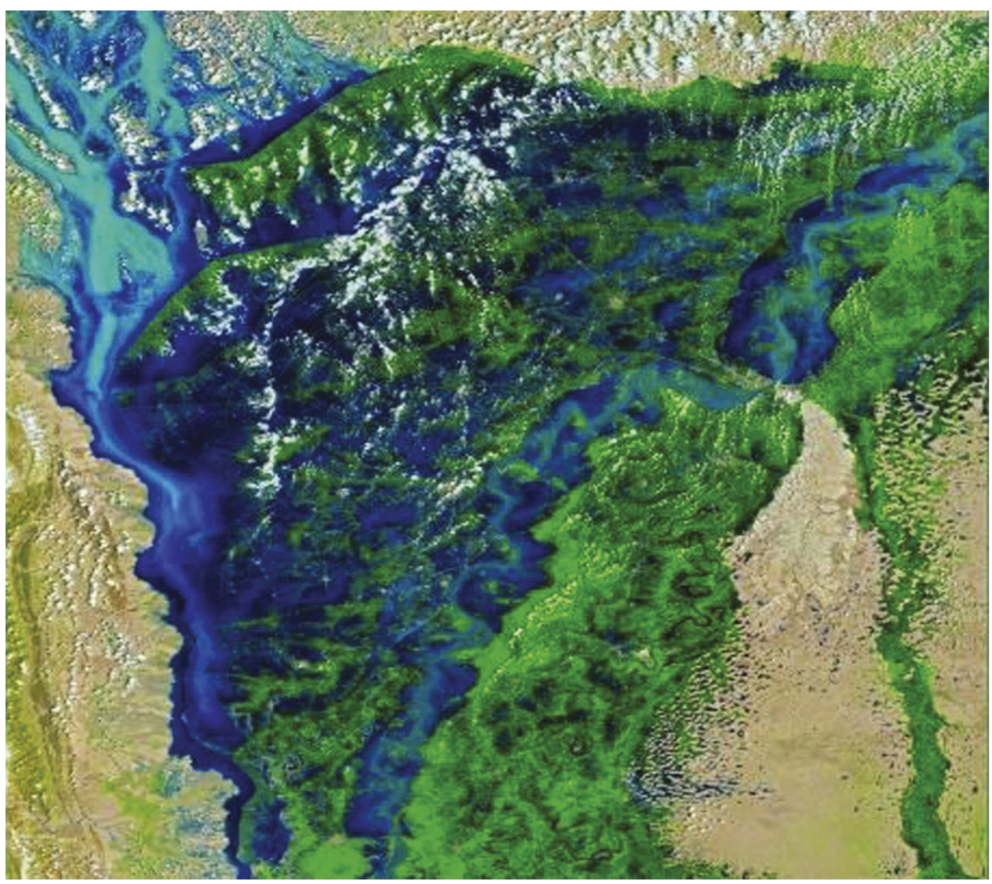

Figure 7: NASA satellite imagery of floods in Pakistan, September 01, 2022.

Table 2: Province wise loss suffered because of heavy rain fall [36].

Province	Death toll	Fully damaged	Injured	Economic loss
Punjab	188	16,590 houses	2023	Agricultural
Baluchistan	253	17,608 houses	164	Agricultural
Sindh	422	307,306 houses	1101	Agricultural
KPK	264	30,233 houses	327	Agricultural

Figure 8: Flood devastation in Swat (KPK) and Baluchistan.

which include surface debris, sporadic water supply, improper discharge of water supply, proximity of sewage water to drinking water lines, industrial waste which has now become very common in almost all major cities in Pakistan, discharge of untreated sewage water and highly incompetent technical workers and service providers on water disposal projects [42]. The pollution of water due to geological and natural factors depends on the presence of different chemicals and their concentration in the geological formations in selected areas, while anthropogenic pollution is caused by extensive use of herbicides and pesticides, coal mining, oil refining, careless disposal of garbage, and septic tanks [43]. Because of such developments, fresh drinking water is available to hardly 20% of population, while 80% population is content with drinking of contaminated water [44]. The recent floods have further aggravated the situation as vast swaths of land in Pakistan is still under water, which is now contaminated causing several health issues. The ongoing situation has also impurified subsurface drinking water due to seepage of contaminated flood water deep in Earth, and government's inability for effective disposal of sewage water.

3.5. Water Security. Food and energy security is directly influenced by water security for agrarian society like Pakistan, which contributes more than 23% in national GDP. Agriculture is the backbone of Pakistan as it employs more than 40 million population and guarantor of breadbasket of the country. Therefore, "the loss of major river systems in the past had a domino effect on the thriving civilizations, which became extinct one after the other" [45]. Pakistan is transitioning from water strained country with declining "per capita fresh drinking water, which is less than 1800 cubic meters per year (m^3/y) to water scarce country (per capita less than 1000 m^3/y)" projected by 2035 [46]. Similarly, river water also receding to 800 m^3/y is expected in 2026 due to growing population. Therefore, "water security is emerging threat for Pakistan" [47]. Pakistan is a lower riparian state reliant on the nature and other countries for river's water. India has constructed more than fifty big and small dams on the rivers coming to Pakistan, which are a constant source of irritation in the bilateral relations and vital for Pakistan's water and energy security. Similarly, Afghanistan is also considering construction of dams on Kabul River, which is likely to create two front dilemmas for Pakistan. The situation is even challenging when viewed in the context of availability of only two major dams in Pakistan, Tarbela, and Mangla which were constructed in late 1960s and 1970s; however, "their capacities are reducing due to silting." While construction of new dams is highly politicized, charged with massive outrage from political parties and masses, therefore, not likely to happen in near future. It is expected that the availability of less water is likely to increase food shortages and create conflict among the federating units and the federation. Similarly, the negative impacts of climate change can cause melting glaciers and unusual pattern of rains, which may lead to flooding as we are witnessing in year 2022.

3.6. Food Security. The Indus Basin, which is the bedrock of agriculture support in Pakistan is seriously threatened by the negative impacts of climate change. The changing weather patterns may result in the reduction of crops yield "(15–20% in cereals) and livestock (20–30%)" [48], impacting negatively the dairy and poultry as the agriculture and livestock sectors are the "backbone of Pakistan's economy, which contributes 23% to GDP and accounts 60% exports of country" [49]. The food security is vulnerable to climate change due to reduction in crops and adversarial influences on livestock. Reduced water in real harvesting season is changing the crops patterns and the lands are vulnerable to droughts and flooding as well, which also create massive migrations. The devastations of ongoing floods have created serious food shortages in Pakistan and inflation is also all time high. Pakistan's Prime Minister has already rung the alarm bells by stating that Pakistan is vulnerable to serious food shortage, and it is feared that essential food items may be imported this year and next year as all cultivable lands are under water [50].

3.7. Implications of Climate Change on the National Mosaic of Pakistan

3.7.1. Competition over Water Resources. Agriculture-based economies are heavily dependent on the natural resources of the state. This is extremely critical situation for the state to cope with the needs of the masses and economic challenges when there is a scarcity of sustainable renewable and nonrenewable resources. Countries like Pakistan where socioeconomic challenges, such as rising population, lack of political will, internal security issues, urbanization, lack of

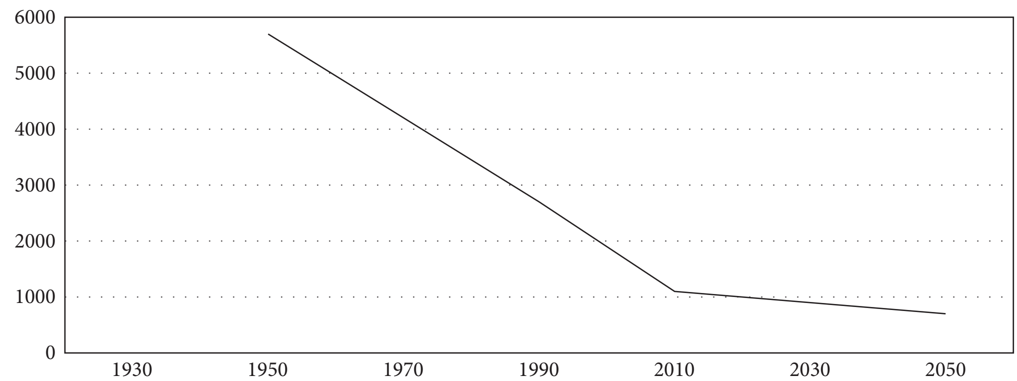

Figure 9: Per capita availability of water reservoirs in Pakistan [52].

public policies for managing population, and natural resources are growing at a faster pace as compared with its economic growth. Even the geographical position of the state near the equator is unable to supplement its growing needs and demands. It is an alarming situation for the Pakistan that in the presence of other socioeconomic challenges, the drastic impacts of climate change have also increased its economic and political challenges, while the insufficiency of water reservoirs is creating serious concerns of inter-provincial disharmony. The rising population has not only affected the quantity of water reservoirs but has also depleted the quality in the same manner. The increase in anthropogenic activities is causing water stress on natural reservoirs, while since independence in 1947, the country is facing persistent decline in the availability of water year on year basis due to multitude of factors examined above. According to the estimates of Mr. Jamshed Iqbal Cheema, Chairman Pakistan Agriculture Scientists Association (PASA), in 1947, the capita water availability was 5600 cubic meters, which decreased by 406% from 5260 cubic meters in 1951 to 1038 cubic meters in 2010 and 877 cubic meters in 2020. The PASA estimates that available water will further deplete by 2025 to a level of 660 cubic meters and by 2050 will reach 575 cubic meters as shown in Figure 9 below [51].

The causes of water shortages in Pakistan exist in two types: (a) incidental causes related to poor water management policies at local level, (b) operational causes include the political conflicts (over the water resources on provincial/institutional level) and the societal differences over water management and distribution. Water issue is not only related with the environmental degradation, but also linked with the social factors as abnormal population growth causes a rise in demand of clean water resources, disturbance of equilibrium between communities, provinces, and water resources distribution. As Pakistan consists of multiple ethnicities and diversified geographical terrain but competition over the access of water resources has often created tensions and conflicts among the federating units. The growing vulnerabilities of communities over the insufficiency of water reservoirs promote lawlessness, antistate sentiments and sense of deprivation among its own nationals. Due to lack of strong monitoring mechanism over channelization of available water, for creating a balanced approach between demand and supply of available water, the population is incentivized for illegal water proliferation. The tacit approval from the water management departments has resulted in water theft cases mostly in Southern Punjab and interior Sindh, as there are many illegal drillings, hidden pipelines, and unrecorded water connections from main supply lines. Such illegal water channels mostly exist adjacent to sanitation systems in cities and rural areas, contaminating the available water. The increase in anthropogenic activities is also causing water stress on natural reservoirs.

Another reason of growing water scarcity is unlawful construction and sanitation systems near or over the water channels, which continuously contaminate water, especially during floods blend these altogether. The role of administration is highly crucial in this matter to control such catastrophic constructions and lessen the pressure on water consumption. The unprotected constructions along rivers, lakes, and streams often cause blockage of natural water channels particularly in monsoon and rainy season resulting into loss of lives, roads network, and infrastructure damage as the enormity of flood damages to clean water channels is immeasurable. In 2010 floods, Pakistan witnessed unimaginable losses as around 20 million people were victims, 1.7 million died, 436 healthcare centers were devastated, 80% food reserves were smashed, 2.9 million households were severely damaged, nearly 1.1 million houses were damaged and $ 9.7 billion economic loss in 135 districts. While the issues of accessing the safe water channels was still in demand after flood (96.8% before vs 96.7%). In year 2022 floods, these losses have increased manifolds and caused unprecedented damages to natural water resources. Around 33 million people are direct victims, death troll rising above 1500, while 110 district of Baluchistan (Quetta, Pishin, Killa Saifullah, Nushki, Jaffarabad, and Washuk), Punjab (Koh *e* Suleman ranges, Rajanpur, D. G Khan), Sindh (Mirpur Khas, Thatta, Sajawal, and Shaheed Benazir Abad) and Khyber Pakhtunkhwa (Swat and lower/upper Dir) are declared as most calamity hit areas. While 30% water channels are severely affected, and 63% flood victims are struggling for sufficient clean water channels. The economic losses suffered have been estimated to the tune of US$ 30 billion. The analyses amply highlight the insufficiency of available water and demand, compounded by adverse effects of floods during this year.

3.7.2. Negative Impact on Agriculture Sector. Pakistan is heavily relying on agricultural sector for its international exports and domestic food demands, but in the presence of water crisis and conventional irrigation system for its agricultural production, the country will face severe challenges of water scarcity in times to come. According to Global Food and Security Index 2021, Pakistan ranked 80 out of 113 countries [53] and Global Food and Security Index 2022, it has further slipped by four numbers and now ranks 84 out of 113 countries [54]. Pakistan lags behind all South Asian countries in food insecurity. The lack of progress in agricultural sector is also linked with the mismanagement of land and water resources, unsatisfactory policies of water governance, exponential population growth, and the negative impacts of climate change. Pakistan has also failed to adopt new strategies like advanced water management in agricultural sector, usage of adaptation methods in yields productions to enhance water consumption in eco-friendly manner, educate farmers about the water recycling and water productivity techniques. While water scarcity is a highly charged political issue in Pakistan as there is a turf war between the provinces and the federation. However, Punjab government took good initiative and introduced national water policy of Pakistan to ensure regularization of water governance system in the country. In the presence of fragile agriculture sector development, climate degradation impacts have worsened the livelihood and yield production. Therefore, on a year-on-year basis, the agriculture yield is squeezing, demand of water is increasing, and unplanned urbanization is resulting into loss of precious agriculture land. The overall impact of these issues is creating negative repercussions on agriculture production and aggravating food security situation in Pakistan.

3.7.3. Water Quality and Public Health Risks. The availability of clean drinking water is biggest national security challenge for Pakistan today. The water proliferation and loss of water supply sources from government record is not only raising the administrative issues but also causing multiple public health problems. The contamination of water along with the presence of sanitary pipelines expose the population with the contagious and chronic diseases like diarrhea, cholera, jaundice, typhoid, hepatitis C, liver cancer, and gastrointestinal infections. The water scarcity in Pakistan has enormous impact on health care system as well as the country is struggling with the diseases that are almost nonexistential in developed countries. The significant findings of this study are that in Pakistan, 50% diseases spread through contaminated water and provide most suitable medium of spread and transfer various bacterial and viral infections from human to human or animals to human as the country is facing the 40% of mortality rate caused by the contaminated water intake, while the frontline victims of waterborne diseases are pregnant women, newly born babies, and early teenage groups. It is also important to note that the primary source of water in Pakistan is sub-surface water channels, which over a period have become the hub of different variants of pathogens. According to World Health Organization (WHO) report, approximately, 2.5 million deaths occur annually in Pakistan from widespread diarrheal diseases caused by bacterial and protozoan agents present in inferior quality of drinking water. Around 80% population is exposed to unsafe water as UNICEF Pakistan has also shared the alarming fact that the well-being and health standards of youngsters are at risk; therefore, each year, 53,000 children under the age of 5 years lose their lives due to unhygienic water as 70% of household work and domestic usage of water in Pakistan is dependent on bacterial water sources. The floods of 2022 have compounded the problems of availability and access to clean drinking water. The field visits to rural and urban Sindh, KPK, and Baluchistan vindicated scarcity and contamination of drinking water, which has been reported by several NGOs and media as well. The stagnant water has been contaminated due to mixing of sewage water and created ideal breading grounds for bacteria causing serious health risks. Nonavailability of compatible medical support, inaccessibility, and nondisposal of flood water have created many health risks and entire population in affected areas is vulnerable to adverse effects of contaminated water. In most areas, the disposal of flood water is left to the nature and the government agencies have demonstrated inability to manage it, therefore, spread of waterborne diseases will continue for prolonged period in future.

4. Policy Recommendations

4.1. Legislation for Interministerial Coordination. The ministry of climate change should take a lead role and coordinate with all the provinces on the issues of water security. All related agencies and departments should work in harmony with this ministry for synergetic response. Similarly, international engagements would be essential component for successful policy implementation; therefore, Ministry of Foreign Affairs and Ministry of Climate Change should remove overlaps and avoid duplications wherever required.

4.2. Proper Enforcement of Legislation. "Pakistan Water Apportionment Accord 1991" highlights the judicious distribution of Indus River System (IRS) water among the federating units of Pakistan. However, this accord was unable to deal with the conflicts arising due to unfair distribution of water at times. To resolve this issue, "Indus River System Authority" (IRSA) was established in 1992 [55], through an act of Parliament to work as an institution for Indus water resources regulation and monitoring in Pakistan. However, the problems related to fair water distribution, monitoring and installation system, and the treatment plants lagged during the implementation phase. There always remained issues between Punjab and Sindh regarding unfair water theft. Despite establishment of "Council of Common Interest" (CCI) to resolve the grievances of provinces, but issues persist due to weak implementation mechanism and weak governance. The devolution of power under 18th amendment of the constitution, devolved the water distribution among the rural and urban areas of each province as an internal matter of the provinces; however, water crises remain at large seriously impacting inter-provincial harmony. The Pakistan Council of Research in Water Resources (PCRWR) is assigned the task of ensuring clean drinking water across Pakistan. Implementation of water-related policies requires a great deal of realization and urgency on the part of the political elites of Pakistan. The gravity of the issue needs to be addressed as a national emergency, otherwise, Pakistan is vulnerable to water scarcity situations normally witnessed in African continent.

4.3. Judicious Distribution of Water. Being a lower riparian, Sindh is often complaining about the water shortage, especially in the pre-monsoon period each year. The claims made by Sindh government at numerous occasions regarding Punjab stealing its share of water have been denied by Indus River System Authority (IRSA). After the 18th amendment, the allocation of resources to the provinces has been ensured to be judicious; however, the internal distribution of these resources to the rural and urban areas is the responsibility of the provinces. The IRSA is mandated to address, regulate, and develop standard operating procedures (SOPs) for water allocation to the provinces. Regrettably, each province has its own peculiarities in terms of agricultural needs and population, therefore, making the interpretation and implementation of the accord more difficult. To resolve water distribution issues on sustainable basis, the "whole of government approach" is recommended along with on-site consultative visits by the representatives of provincial and federal governments and political leaders for expeditious resolution of conflicting issues. Creating unnecessary fault lines is detrimental to national integration, which should be avoided at all costs.

4.4. Water Treatment Plants and Recycling of Water. Pakistan is in dire need of installing treatment plants as every year, hospitals are flooded with patients, both adults and children suffering from diseases resulting from contaminated water. People living in both urban and rural areas are exposed to contagions and microbial bacteria, which enter the body through water, unsafe for drinking. Not everyone in Pakistan can afford bottled water, therefore, it is the responsibility of the state to provide its citizens with safe drinking water. As we know that Pakistan receives a major portion of heavy rains between the months of July to September, where majority of rainwater ends up in rivers, ponds, while the rest of it results in heavy floods of cities and inhabitants. The government through installation of treatment plants can filter clean drinking water for ensuring public health. Similarly, more wastewater recycling plants are the need of time, which should be installed at priority. In rural areas, wastewater treatment is almost nonexistent, leading to pollution of surface and groundwater [56]. The government should pay instantaneous attention to the evolving challenges of treatment of wastewater for sparing clean water for drinking purposes and balanced delivery of recycled water to other uses like irrigation.

4.5. Climate Emergency and Disaster Response Mechanism. Pakistan was successful in convincing the world leaders during recently concluded United Nations General Assembly (UNGA) sessions about vulnerabilities to climate risks and the unprecedented impact during year 2022. UN Secretary General Antoni Guterres and US President Joe Biden personally appealed for help for Pakistan to alleviate the suffering and quick rehabilitation of flood victims. It is suggested that Pakistan should consider climate diplomacy as an urgent priority and initiate the process of engagement at bilateral and multilateral levels with developed countries to reduce the vulnerabilities and risks of climate change. Additionally, the disaster response mechanism also needs to be re-energized with strong interagency coordination. The existing structure of national and provincial disaster management authorities should be reinforced through capacity building and professional training. Appropriate equipment for rescue and relief operations also needs to be provided at vulnerable sites for immediate response to save maximum lives. The infrastructure development in flood affected areas should be expedited for which essential resources should be mobilized well in time. Such preparations should be done and rehearsed every year during pre-monsoon season for synergetic and a befitting response to minimize reaction time and save maximum lives.

5. Conclusion

Climate change is the evolving global threat, and Pakistan is most vulnerable from its negative impacts. The year 2022 witnessed extreme drought on one hand, followed by unusual floods over the short span of 2-3 months. Therefore, for Pakistan, alarm bells are ringing to take the holistic stock of situation by declaring climate emergency and adopt "whole of nation" and "whole of government" approaches for a comprehensive response ensuring strong interagency cooperation and capitalizing on the synergetic application of all Elements of National Power (EoNP) for optimum results. It is essential to integrate the respective departments under the umbrella of national and provincial disaster response agencies for harmonious functioning, coordination, and execution. There is dire need to create strong national realization to "conserve, preserve, and proportionally distribute existing water resources" [57]. Moreover, smart means for spending agriculture water and recycling of water for uses other than drinking would be helpful as such practices have been adopted by most of developed countries. The construction of more water reservoirs is the need of time and current floods across Pakistan are the testimony of this fact. It is felt that this study shall help the relevant government ministries as an academic policy input for addressing water security issues in Pakistan on sustainable basis.

Data Availability

The data used to support the findings of this study are included within this article.

Conflicts of Interest

The authors declare no conflicts of interest.

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Retraction

Retracted: Does Income Inequality Harm Green Growth? The BRICS Experience

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Research Article

Does Income Inequality Harm Green Growth? The BRICS Experience

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Green growth plays a vital role in ensuring sustainable development. Managing economic growth without disrupting the environment is considered the need of the present time. Therefore, the empirics have turned their attention toward finding the determinants of green growth. Hence, we aim to investigate the impact of income inequality on green growth in BRICS economies from 1993 to 2020. Findings of the panel autoregressive distributed lag (ARDL) model confirm that the long-run estimate attached to GINI is negatively significant, implying that higher inequality in the BRICS economies lowers the rate of green growth. The country-wise results highlighted the negative impact of GINI on green growth in India and China only and insignificant in other countries. In the short run, the estimates are inconclusive and mixed, be it group-wise or individual estimates. Our findings imply that the target of lower inequality and environmental sustainability can be achieved simultaneously.

1. Introduction

Sustainable development of ecological, social, and economic life for forthcoming generations necessitates the right decision-making from today. In this perspective, endorsing sustainable growth has become a fundamental objective for all economies. In order to attain sustainable growth, 129 member states of the United Nations (UN) designated "2030 sustainable development strategy" in 2015 [1]. This strategy aims to achieve several objectives such as the establishment of strong institutions, enhancement of environmental quality, and reduction in inequalities and poverty. Furthermore, it aims to solve fundamental environmental, social, and economic issues [2]. It is frequently revealed that deteriorating environmental quality and income inequality are two imperative complications to sustainable growth [3]. The United Nations also emphasizes that inequalities and environmental degradation are the two most important matters of the current time, and solution for these issues on a priority basis is necessary for sustainable green growth [4].

Sachs [5] highlighted that the global economy has attained substantial achievement in endorsing economic development but has not obtained the same achievement in terms of environment and welfare distribution. Consequently, it can be claimed that income inequality is a fundamental hindrance to the development of harmonious societies. Since 1980s, the speedy worsening of income distribution has become the main socioeconomic issue [6]. The speedy worsening of income distribution led to an increased investigation of the dynamics of income inequality in developing and developed economies. Most specifically in the OECD economies and in US, income inequality has deteriorated speedily since the last few years [7]. This speedy deterioration of income inequality has influenced the wealth distribution dynamics. For instance, the share of the upper 0.1 percent cluster in total wealth enlarged from 7 percent in 1987 to 22 percent in 2012 in the USA. Additionally, deterioration in income distribution has also been observed in developing economies as well during the neoliberal era. For example, Banerjee and Piketty [8] conveyed that the share of the upper 1 percent cluster in total wealth has enlarged during the period of economic liberalization in India. In the recent era, income inequality has significantly increased in China [9].

Another reason behind unsustainable development is a deterioration of environmental quality [10]. The global rise in consumption and production has increased energy consumption and natural resource consumption. The increased consumption of fossil fuels, the more globalized economic relations, and the increased world population have raised environmental pressure and instigated fundamental changes in the ecosystem. An increase in consumption of fossil fuels such as natural gas, coal, and crude oil accounts for approximately 75 percent of energy use, which mitigates the efficiency of energy and causes major environmental problems [11]. An increase in greenhouse gas emissions in the form of CO2 from the consumption of fossil fuels is the main determinant of environmental deterioration, such as climatic change and global warming. Global CO2 emissions are rising rapidly in recent years, and it is predicted that the climatic pressure will raise more if CO2 emissions could not be controlled [12]. For this reason, the needs for green growth, energy efficiency, and CO2 emission reduction have become tactical determinants for attaining sustainable development objectives.

Due to the upsurge in environmental disasters, green growth has become a strategic choice for the attainment of sustainable development [13]. The green growth concept has motivated widespread concerns and is considered an effective source of saving resources, raising growth, and mitigating environmental issues [14]. Research organizations have developed proper definitions for green growth and considered it a strategic idea [15]. Loiseau et al. [16] identified the characteristics and dimensions of green growth and examined the association between economic sustainability and green growth. There are several other studies discussing the concept of green growth. Musango et al. [14] claimed that conversion towards green growth can save natural resources and reduce CO2 emissions. Reilly [17] revealed that job creation, protection of the environment, and economic growth are three core purposes of green growth. Additionally, Bagheri et al. [18] investigated green growth potential for Canada, Ma et al. [19] explored green growth efficiency for China, and Yang et al. [20] investigated green growth differences for various resource-intensive regions of China.

In recent years, increasing concern over income inequality and environmental degradation has raised a new aspect to the literature of environmental issues by linking socioeconomic inequalities with environmental problems [21, 22]. Under this perspective, it has become an imperative research query whether income inequalities influence environmental degradation. Within this context, researchers aim to search the impact of income inequalities dynamics on indicators of the environment such as air pollution, water pollution, ecological deficit, and CO2 emissions and added new dimensions to the literature [23]. Although several studies have been done on this area, but no empirical and theoretical consensus has been gained yet. Baek and Gweisah [24] and Uzar and Eyuboglu [22] reveal that environmental issues are social issues stemming from power and income inequalities; however, few researchers such as Grunewald et al. [25] describe that income inequality has no impact on environmental quality.

It can be observed that there exists vast literature elaborating on the connection between income distribution and environmental quality. However, the effect of income distribution on green growth which imperative catalyst in improving environmental sustainability and reducing carbon dioxide emissions has been neglected in the literature. In fact, in the modern era, initiatives to classify the main factors of green growth have increased speedily. In literature, it is observed that political, environmental, and economic variables such as education [26], technology [27], green finance [28], trade openness [29], R&D [30], environmental regulations [31], and fiscal spending [32] are considered as primary determinants of green growth. However, current literature neglects a fundamental determinant of green growth such as income inequality which causes the socioecological part of the energy and environmental studies. From this perspective, the present study aims to identify the impact of income inequalities on green growth in the case of BRICS economies for time period 1993-2020. This study answers the question “is the income inequality harms green growth?” As far as the authors’ knowledge is concerned, this is the first study to investigate the influence of income inequality on green growth in the context of BRICS. This study employs the ARDL-PMG approach to capture long- and short-run nexus between income inequality and green growth. The results of this study will benefit in designing environmental sustainability policies.

2. Model and Methods

Theoretically, income inequality may have a negative or positive effect on CO2 emissions, which may have an impact on the sustainable economic development of the economy. The income inequality estimate on environmental quality mainly depends on the nexus between demand-income. In the case of the linear relationship between demand-income, any transfer of money from poor to rich will not have any impact on the environmental quality [33, 34]. On the other side, if the demand-income relationship follows a convex path, then a single penny transfer from poor to rich will significantly impact the environmental quality [35]. If income inequality strongly impacts CO2 emissions, we believe that it also affects production-based CO2 emissions, i.e., green growth [36, 37]. Hence, we have developed the following model.

$$\begin{aligned}\mathrm{GG}_{\mathrm{it}} = \varphi_0 + \varphi_1 \mathrm{GINI}_{\mathrm{it}} + \varphi_2 \mathrm{EI}_{\mathrm{it}} + \varphi_3 \mathrm{Education}_{\mathrm{it}} \\ + \varphi_4 \mathrm{GS}_{\mathrm{it}} + \varphi_5 \mathrm{FD}_{\mathrm{it}} + \varepsilon_{\mathrm{it}},\end{aligned} \tag{1}$$

where green growth (GG) is a dependent variable, which is determined by income inequality (GINI), environmental innovations (EI), average years of schooling (Education), government spending (GS), financial development (FD), and error term ($\varepsilon_{\mathrm{it}}$). Equation (1) presents only long-run

Table 1: Definitions and data sources.

Variable	Symbol	Definitions	Sources
Green growth	GG	Environmentally adjusted multifactor productivity	OECD
GINI	GINI	Gini index	World bank
Educational attainment	Education	School enrolment, secondary (% gross)	World bank
Environmental innovation	EI	Development of environment-related technologies, % all technologies	OECD
Government spending	GS	Government final consumption expenditure (% of GDP)	World bank
Financial development	FD	Domestic credit to private sector (% of GDP)	World bank

Table 2: Descriptive statistics.

	Observations	Mean	Median	Max	Min	S.D.	Skewness	Kurtosis
GG	140	5.096	4.930	13.13	-6.233	3.313	-0.513	3.930
GINI	140	1.652	1.612	1.812	1.501	0.100	0.289	1.491
Education	140	1.909	1.958	2.041	1.634	0.114	-1.047	2.905
EI	140	9.174	9.271	16.80	3.730	2.561	0.230	2.447
GS	140	16.25	16.98	21.07	9.802	3.185	-0.692	2.239
FD	140	1.760	1.743	2.261	0.456	0.329	-0.951	4.268

Table 3: Unit root tests.

	LLC		IPS		ADF-fisher	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
GG	-0.231	-4.056***	-0.012	-4.078***	-0.012	-4.187***
GINI	-2.198**		-0.178	-2.055**	-0.254	-2.879***
Education	0.102	-3.587***	1.821	-3.875***	1.954	-3.897***
EI	-1.023	-6.023***	-1.654*		-1.534*	
GS	-2.356***		-3.452***		-3.321***	
FD	-0.345	-3.875***	0.402	-5.345***	0.465	-5.012***

Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. Source: Author estimations.

estimates. The short-run effects are also equally important to explore. To this end, we follow Pesaran et al. [38] error correction format:

$$\begin{aligned}\Delta \mathrm{GG}_{\mathrm{it}} = \varphi_0 &+ \sum_{i=1}^{p} \pi_{1k} \Delta \mathrm{GG}_{\mathrm{it}-i} + \sum_{i=0}^{p} \pi_{2k} \Delta \mathrm{GINI}_{\mathrm{it}-i} \\ &+ \sum_{i=0}^{p} \pi_{3k} \Delta \mathrm{EI}_{\mathrm{it}-i} + \sum_{i=0}^{p} \pi_{4k} \mathrm{Education}_{\mathrm{it}-i} \\ &+ \sum_{i=0}^{p} \pi_{5k} \mathrm{GS}_{\mathrm{it}-i} + \sum_{i=0}^{p} \pi_{6k} \mathrm{FD}_{\mathrm{it}-i} + \varphi_1 \mathrm{GG}_{\mathrm{it}-1} \\ &+ \varphi_2 \mathrm{GINI}_{\mathrm{it}-1} + \varphi_3 \mathrm{EI}_{\mathrm{it}-1} + \varphi_4 \mathrm{Education}_{\mathrm{it}-1} \\ &+ \varphi_5 \mathrm{GS}_{\mathrm{it}-1} + \varphi_6 \mathrm{FD}_{\mathrm{it}-1} + \lambda.\mathrm{ECM}_{\mathrm{it}-1} + \varepsilon_{\mathrm{it}}.\end{aligned} \tag{2}$$

Equation (2) is called the ARDL-PMG framework and was proposed by Pesaran et al. [38]. The panel cointegration test is used to examine long-run relationships among economic variables. Pesaran et al. [38] proposed the F-test and ECM test for cointegration. The panel ARDL has several benefits. This method is more feasible at different orders of integration, such as I(0), I(1), or a mix of both types of variables (Bahmani-Oskooee et al., 2020). So for that, our study has used LLC, IPS, and ADF unit root tests. Panel ARDL also accommodates small samples. The panel ARDL simultaneously estimates both short- and long-run effects. The long-run effects are derived from $\varphi_2 - \varphi_6$ by normalizing on φ_1, while the short-run effects in the above-mentioned Equation (2) are identified by first-differenced signs. The ARDL panel technique takes into account the endogeneity and serial correlation issues.

The study explores the impact of income inequality on green growth in the case of BRICS economies. The impact of income inequality on green growth is determined by controlling the effect of education, environmental innovation, government spending, and financial development. The details regarding variables' definitions, symbols, and data sources are given in Table 1. Green growth (GG) is measured through environmentally adjusted multifactor productivity. Income inequality is determined through the GINI index. The control variables are selected based on previous green growth literature [27, 39]. Secondary school enrolment is taken to measure education. Environmental innovation is measured via the development of environment-related technologies as percent of all technologies.

Table 4: Green growth estimates.

Variable	BRICS Coefficient	BRICS t-stat	Brazil Coefficient	Brazil t-stat	Russia Coefficient	Russia t-stat	India Coefficient	India t-stat	China Coefficient	China t-stat	South Africa Coefficient	South Africa t-stat
Long-run												
GINI	-3.126*	-1.726	1.813	0.963	1.042	1.093	-0.828**	-2.511	-1.974**	-2.428	-0.114	-1.088
Education	2.678***	4.360	2.899	0.799	1.835	0.658	1.498**	2.285	1.308**	2.281	2.915	1.126
EI	0.187**	2.082	0.136	0.284	1.492***	4.049	0.483	1.277	1.140*	1.701	0.358*	1.695
GS	0.103	0.579	0.477	0.651	1.485***	5.005	1.482***	3.170	0.684*	1.878	-0.590	-0.930
FD	1.629*	1.705	1.424**	2.335	1.550	0.919	1.372*	1.910	4.875	1.379	1.809	0.587
Short-run												
D (GINI)	-2.050	-0.971	0.608	0.988	1.827	1.136	-0.353*	-1.914	0.935***	2.783	-1.455	-0.125
D (GINI (-1))	1.137	1.064					-0.007**	-2.267			-1.043	-1.098
D (GINI (-2))	0.070	1.189					-0.744	-1.380			-1.801	-1.570
D (Education)	-1.333***	-4.808	-1.327	-0.679	1.467	0.677	1.082***	3.338	0.598	1.589	0.553	1.111
D (Education (-1))	-0.513	-1.161	-1.088	-0.508					0.147	1.149	0.437	1.250
D (Education (-2))	-0.549**	-2.151	0.245**	2.259					0.091***	3.130		
D (EI)	0.304*	1.769	0.568	1.120	0.261	0.797	-0.289	-0.830	0.210***	2.709	0.090	0.713
D (EI (-1))	0.152	0.781	0.143	0.256	0.659**	2.350	0.217	0.942				
D (EI (-2))	0.127	0.550	0.599	1.358	0.994***	3.792	0.618**	2.301				
D (GS)	-0.221	-0.565	-0.609	-0.668	-0.546	-1.464	-1.998**	-2.106	-0.953	-1.253	0.262	0.447
D (GS (-1))	-0.116	-0.421			-0.359***	-3.053	0.316	0.255	0.912	1.075	-0.555	-0.905
D (GS (-2))	-0.125	-0.690					-2.257***	-2.644	-0.985	-1.487	0.918	1.654
D (FD)	1.235*	1.808	1.582**	2.367	1.089	0.871	1.623***	3.159	2.405**	2.184	1.237	0.608
D (FD (-1))	1.158***	5.774					0.305***	2.589	1.842	0.546	2.016**	2.126
D (FD (-2))	0.080	0.012					0.597	0.948	1.726**	2.475	2.796**	2.332
C	3.210***	3.447	6.390	1.111	3.324**	2.397	5.998**	2.329	2.463***	3.112	3.247*	1.949
Diagnostics												
F-test	6.554***		6.542***		10.02***		6.645***		7.023***		2.754	
ECM (-1)	-0.651***	-3.658	-0.568**	-2.126	-0.546**	-2.141	-0.314***	-8.624	-0.498***	-8.773	-0.523***	-5.010
LM			1.023		0.655		2.002		0.987		1.875	
Reset			0.987		0.775		1.012		1.987		0.879	
CUSUM			S		S		S		S		S	
CUSUM-sq			S		S		S		S		S	

Note: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Source: Author estimations.

Government spending is taken as general government final consumption expenditures as percent of GDP. Financial development is taken as domestic credit to private sector as percent of GDP. The data for the empirical analysis is taken from OECD and the World Bank. The mean (S.D) of GG, GINI, Education, EI, GS, and FD are 5.096% (3.313%), 1.652 (0.100), 1.909% (0.114%), 9.174% (2.561%), 16.25% (3.185%), and 1.760% (0.329%), respectively (Table 2).

3. Results and Discussion

To make and perform an empirical task, our study employed panel and time-series ARDL techniques for panel-wise and economy-wise analysis. As a first step, it is essential to check the stationarity properties of variables. In Table 3, according to LLC unit root test, it is found that GINI and GS are integrated at I(0) while GG, education, EI, and FD are integrated at I(1). However, IPS and ADF-Fisher tests produce similar results. It is found that EI and GS are stationary at I(0) and GG; GINI, Education, and FD are stationary at I(1). Table 4 displays the economy-specific and panel-specific results of long-term and short-run parameters of green growth models.

In the panel-specific model, the findings infer that an increase in GINI tends to reduce green growth, depicting that increase in income inequality results in reducing green

Table 5: Results of causality test.

Null hypothesis:	BRICS		Brazil		Russia		India		China		South Africa	
	F-stat	Prob.	*F*-stat	Prob.	*F*-stat	Prob.	*F*-stat	Prob.	*F*-stat	Prob.	*F*-stat	Prob.
GINI → GG	4.480	0.013	2.277	0.127	0.984	0.391	2.955	0.074	4.702	0.021	2.174	0.139
GG → GINI	0.090	0.914	0.042	0.959	0.153	0.859	0.945	0.405	0.631	0.542	0.226	0.799
EDUCATION → GG	2.961	0.074	1.809	0.188	1.097	0.352	3.114	0.065	2.583	0.099	2.022	0.157
GG → EDUCATION	2.181	0.117	0.503	0.612	0.531	0.596	2.734	0.088	2.757	0.087	0.387	0.684
EI → GG	2.879	0.060	2.505	0.106	8.301	0.002	0.518	0.603	0.701	0.507	0.114	0.893
GG → EI	0.477	0.622	0.246	0.784	0.305	0.740	3.262	0.058	2.315	0.123	0.615	0.550
GS → GG	8.451	0.000	0.042	0.959	4.277	0.028	1.607	0.224	0.868	0.434	3.793	0.039
GG → GS	1.492	0.229	0.659	0.528	0.852	0.441	1.575	0.231	2.944	0.075	1.785	0.192
FD → GG	1.141	0.323	0.739	0.490	0.462	0.636	2.483	0.108	0.387	0.684	4.716	0.020
GG → FD	0.465	0.629	1.201	0.321	0.056	0.945	3.854	0.038	10.74	0.001	0.094	0.911
Education → GINI	3.327	0.039	1.003	0.384	3.129	0.065	0.499	0.614	1.081	0.358	0.921	0.414
GINI → Education	1.652	0.196	0.035	0.965	6.153	0.008	5.491	0.012	1.333	0.285	1.262	0.304
EI → GINI	0.479	0.620	1.298	0.294	0.662	0.526	2.265	0.129	0.933	0.409	0.523	0.600
GINI → EI	2.896	0.059	3.522	0.048	1.410	0.266	10.97	0.001	0.873	0.432	3.210	0.061
GS → GINI	2.417	0.093	0.304	0.741	0.302	0.742	0.376	0.691	0.583	0.567	2.077	0.150
GINI → GS	1.684	0.190	0.242	0.788	0.913	0.417	1.378	0.274	0.084	0.919	2.380	0.117
FD → GINI	2.124	0.124	0.646	0.534	1.434	0.261	2.184	0.138	1.117	0.346	2.630	0.096
GINI → FD	1.407	0.249	7.335	0.004	2.839	0.081	4.336	0.027	0.236	0.792	4.268	0.028
EI → Education	0.045	0.956	0.408	0.670	0.703	0.506	0.243	0.786	0.187	0.831	0.501	0.613
Education → EI	2.621	0.077	0.437	0.652	5.924	0.009	7.809	0.003	0.190	0.829	0.367	0.697
GS → Education	0.020	0.981	0.129	0.880	0.532	0.595	1.941	0.169	0.610	0.553	0.590	0.563
Education → GS	2.921	0.058	0.314	0.734	0.165	0.849	1.049	0.368	2.862	0.080	5.808	0.010
FD → Education	3.532	0.032	0.306	0.740	0.805	0.460	10.13	0.001	2.325	0.122	0.465	0.635
Education → FD	0.109	0.897	0.533	0.595	0.062	0.940	2.257	0.129	3.506	0.049	1.007	0.382
GS → EI	0.669	0.514	1.184	0.326	0.539	0.591	1.954	0.167	2.017	0.158	1.020	0.378
EI → GS	1.327	0.269	0.553	0.584	1.123	0.344	1.061	0.364	0.508	0.609	1.529	0.240
FD → EI	0.589	0.556	3.721	0.041	0.036	0.965	13.86	0.000	0.189	0.829	0.821	0.454
EI → FD	0.507	0.603	3.230	0.060	1.247	0.308	5.233	0.014	0.742	0.488	3.420	0.052
FD → GS	1.241	0.293	9.499	0.001	0.447	0.645	1.900	0.175	2.585	0.099	9.282	0.001
GS → FD	0.311	0.733	1.658	0.215	0.105	0.901	0.592	0.562	0.063	0.939	0.137	0.872

Source: Author estimations.

growth in the panel of BRICS economies. It reports that a 1% upsurge in GINI causes 3.126% reduction in green growth in the long-term. The empirical analysis confirmed that higher income inequality leads to low green growth. Some other findings, such as Hallegatte et al. [40], Fay [41], and Kim et al. [42], also suggest that lower-income inequality means low emissions of CO2 during production activities. However, some other empirical suggests otherwise. For instance, Liu et al. [43] and Huang and Duan (2020) confirm that higher income inequality leads to low CO2 emissions during production and consumption activities. Empirical evidence suggests that the environmental impacts of income inequality are more prominent in developing economies than the developed economies. This is because the higher income inequality in developing economies is a barrier to the ubiquity of innovation, which hinders the development of green technological innovation.

Furthermore, the wide gap between the poor and the rich in developing economies induces policymakers to divert the flow of resources from research and development activities to the social security benefits programs. As a result, the firms have to rely on obsolete methods of production that take the economy further away from the target of green growth [44]. Moreover, the higher gap between rich and poor people also leads to a low literacy rate in developing economies, which means less awareness about the harmful impact of environmental degradation [45] and green growth. In developed economies, the income distribution is more equitable, which is suitable for developing environment-related technologies and green products. Besides, it also helps to introduce more relevant environment-related regulations [44]. The impact of the GINI coefficient is not significant on the CO2 emissions in developed economies; however, in the countries where per capita income is too high, evidence suggests a negative correlation between the GINI coefficient and environmental quality. Conversely, McGee and Greiner [46] demonstrated that income inequality might help reduce CO2 emissions during industrial and manufacturing activities in smaller developed economies.

Education reports an increasing impact on green growth in the long-term, confirming that an increase in education escalates green growth in BRICS economies. A 1% increase in the level of education causes 2.678% upsurge in green growth. Environmental innovation raises green growth in the long-term, displaying that increase in eco-innovation is useful to attain green growth in BRICS economies. It reveals that 1% rise in environmental innovation increases green growth by 0.187% in the long-term. In the long-term, government spending does not report a significant association with green growth in the BRICS economies. Conversely, financial development increases green growth, confirming that access of financial resources significantly contributes in increasing green growth in BRICS economies. It reports that 1% expansion in financial development causes 1.629% upsurge in green growth in the long-term. The short-term results show that GINI does not report a significant association with green growth. However, education, environmental innovation, and financial development report significant increases in green growth in the panel of BRICS economies.

In the economy-specific models, the long-run findings reveal that GINI reduces green growth in two economies of BRICS, depicting that increase in income inequality leads to a reduction in green growth in the long-term. A 1% increase in GINI causes a decline in green growth by 0.828% in India and 1.974% in the long-term. However, education enhances green growth in two of BRICS economies, describing that increase in level of education tends to improve the green growth in BRICS countries. A 1% improvement in education causes increase in green growth by 1.498% in India and 1.308% in China. Environmental innovation also results in the enhancement of green growth in three of BRICS countries. It confirms that eco-innovation acts as a vital measure that improves green growth in BRICS economies. It shows that a 1% increase in environmental innovation tends to enhance green growth by 1.492% in Russia, 1.140% in China, and 0.358% in South Africa. Government spending shows a positive enhancement in green growth in three BRICS economies in the long-term, confirming the significant role of government spending in enhancing green growth. It displays that a 1% rise in government spending ensures an upsurge in green growth by 1.485% in Russia, 1.482% in India, and 0.684% in China. In the end, financial development enhances green growth in two economies only displaying that 1% upsurge in financial development increases green growth by 1.424% in Brazil and 1.372% in India in the long-term. The short-run findings describe that GINI reduces green growth in India and China, confirming the negative association between income inequality and green growth. Education is positively attached with green growth in India only in the short-term. Environmental innovation increases green growth in China only. Government spending tends to reduce green growth in India only in the short-term. Financial development enhances green growth in Brazil, India, and China in the short-term.

In the end, some diagnostic test results are given, which are required to confirm the validity of ARDL results. The *F*-test and ECM test confirm the cointegration association among variables in the long-term. The stability condition is fulfilled through the both CUSUM tests. Finally, in Table 5, the results of the causality test for the BRICS nations panel and economy-wise show that unidirectional causality exists between GINI and GG in BIRCS, India, and China, while causality does not exist from GINI to GG in Brazil, Russia, and South Africa.

4. Conclusion and Implications

Environmentalists have observed that the increase in worldwide production and consumption activities has contributed massively to climate change due to emissions of greenhouse gasses. Over the past few decades, the world has witnessed unprecedented changes in the climate, including high temperatures, melting glaciers, storms, floods, and droughts. Such climate changes have rung the alarm bells for this generation and the upcoming generations. Therefore, the issue of climate change and global warming has become the buzzword in the 21st century and the most debated topic at international conferences. In this regard, the world community has signed treaties. The main crux of such treaties is preserving the environment for future generations by controlling CO2 emissions. As a result, the concept of green growth has emerged, which decouples economic growth from CO2 emissions. Recently, the empirics have turned their attention towards finding the determinants of green growth. However, the impact of income inequality on green growth is yet to be explored. Hence, we aim to investigate the impact of income inequality on green growth in BRICS economies.

To investigate empirically, we have first applied unit root tests, including LLC, IPS, and ADF-Fisher, which imply that series are a mixture of I(0) and I(1). Findings of the ARDL-PMG model confirm that the long-run estimate attached to GINI is negatively significant and implies that higher inequality in the BRICS economies lowers the rate of green growth. The country-wise results highlighted the negative impact of GINI on green growth in India and China only and insignificant in other countries. Among the control variables, the estimates of Education, EI, and FD are positively significant, suggesting that education, environmental innovations, and financial development promote green growth in the long run. In the short run, the estimates are inconclusive and mixed, whether group-wise or individual.

In order to reduce environmental pollution, we can propose some policy recommendations. Our findings suggest that high-income inequality in BRICS economies is detrimental to green growth. Therefore, we can confer that lower-income inequality and environmental sustainability targets can go side by side in BRICS economies. Therefore, policymakers should try to promote policies that can bring more income equality by taking various steps, such as social security benefits to the poor, tax policy reforms, and creating employment opportunities for a deprived faction of the society. All these policies not only help to reduce income inequality but also help in environmental sustainability as well green growth.

Since the analysis has contributed to the literature in many ways, it still has shortcomings. First, the analysis only covers BRICS economies, and the inference drawn from the study is only valid for developing economies. However, the issue of income inequality is more severe in less developing economies; therefore, the empirics should investigate the analysis for underdeveloped economies in the future. Moreover, the empirical research does not account for the cross-section dependence, and future studies should consider the techniques that can handle the issue of cross-sectional dependence.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Does Public Awareness Matter to Achieve the UN's Sustainable Development Goal 6: Clean Water for Everyone?

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United Nations set a Sustainable Development Goal to provide clean water for everyone (SDG 6). The successful implementation of SDG 6 is still miles to go. Public awareness's role as a key factor in achieving Sustainable Development Goal 6 is vital but received less attention from researchers in the past. To understand the role of public awareness and other relevant factors in achieving SDG 6, we have collected a cross-sectional dataset from a developing country and applied a partial least square structural equation modelling approach. The results revealed that willingness to pay for clean water, social influence, and facilities provided by the government, public awareness, and knowledge about contaminated water positively influence the households' intentions to use clean water. We also found that public awareness partially mediates relationships. Study results have useful policy implications for governments, NGOs, and other stakeholder organizations working on achieving SDG 6 in developing countries.

1. Introduction

The United Nations General Assembly in 2015 established 17 Sustainable Development Goals, one of which is "Ensure availability and sustainable management of water and sanitation for all." The official phrase for this goal is "Ensure availability and sustainable management of water and sanitation for all [1]." Clean water and sanitation should be accessible to everyone everywhere, which is the focus of Sustainable Development Goal 6 (SDG 6 or Global Goal 6). There are eight subgoals that need to be accomplished by the year 2030. Eleven different indicators will be used to determine how much progress has been made towards the objectives [1].

Drinking water that is safe and affordable; ending open defecation and providing access to sanitation and hygiene; improving water quality, safe reuse, and wastewater treatment; increasing water-use efficiency and ensuring freshwater supplies; implementing integrated water resource management; and protecting and restoring water-related ecosystems are the six "outcome-oriented targets" that have been established. Expanding aid for clean water and sanitation infrastructure in developing nations and bolstering community participation in water and sanitation management are the two "ways of getting there" that are referred to as "means of attaining" goals [2].

In 2017, 2.2 billion people did not have access to drinking water managed properly, and 4.2 billion people did not have access to sanitation managed securely [3]. Three billion people around the globe do not have access to even the most basic handwashing facilities in their homes [3]. Around the globe, two out of every five healthcare facilities lack soap and water and alcohol-based hand rubs (2016) [3]. The COVID-19 pandemic has increased the significance of this aim in a significant way [4]. On the other hand, this epidemic might make it more difficult for water companies to achieve their goal by increasing the amount of income they lose, which is money that would normally be invested [5].

There is a strong connection between SDG 6 and the other Sustainable Development Goals (SDGs). For instance, making progress towards SDG 6 will enhance health (part of SDG 3) and increase school attendance, reducing poverty. In April 2020, António Guterres, the Secretary-General of the United Nations, made the following statement: "Today, Sustainable Development Goal 6 is badly off track." He also stated that this "is hindering progress on the 2030 Agenda, the realization of human rights, and the achievement of peace and security around the world [6]."

Previous studies in this regard studied the threat to SDG 6 from urban drought [7], educational and citizen initiatives to support SDG 6 [8], assessing transformed urban agglomerations from the viewpoint of the water planetary boundary for SDG 6 [9], and water governance and SDG 6 achievability in India [10]. Still, ignoring the end-users' perspective that is the essential part of achieving SDG 6, none of the past studies focused on willingness to pay for clean water (WPCW), social influence (SI), facilitation provided by the government (FPG), knowledge about contaminated water (KCW), public awareness (PA), and intention to use clean water (IUCW). Neither have they explored the mediation role of public awareness in this context.

In addition to this, several studies have been conducted in countries where the education level and per capita income are stable, such as the BRICS Group: working towards actualization SDG 6 [11], UAE's commitments towards SDG 6 [12], but the successful achievement of UN's SDG 6 and factors influencing its implementation is unexplored in the countries where political instability, poverty, unemployment, education, and health are major hurdles in its way. We have selected Pakistan as a sample and collected a cross-sectional dataset to measure the influence of factors influencing the public intentions to use clean water. With this research gap, the following research questions are ones that we have suggested to answer in our study.

RQ1: How far do personal and economic factors and facilities provided by governments influence public intentions to use clean water?

RQ2: Does public awareness plays any role as a mediator in public intention to use clean water?

To answer these research questions, we have proposed a model presented in Figure 1 and collected the cross-sectional dataset from urban and rural residents of Pakistan. We have used the partial least square structural equation modelling approach to conclude our results for the above-mentioned research questions. Results revealed that all five factors significantly influence Pakistani residents' intention to use clean water. In addition, public awareness partially mediates the understudy variables (WPCW, SI, KCW, and FPG) and the end-users' intention to use clean water. Policy-makers may use the study's findings to inform their efforts to accomplish Sustainable Development Goal 6, while researchers can use them to comprehend better the attitudes and actions of people living in developing nations with respect to this same United Nations initiative.

2. Literature Review and Hypothesis Development

To answer the proposed research questions, we have proposed a research model presented in Figure 1. In this model, we have incorporated the economic, personal, and social factors and facilities provided by governments to assess their influence on the public intention to use clean water. We got inspiration from the theory of planned behavior to propose the following model. It explains that "Intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert to perform the behavior. As a general rule, the stronger the intention to engage in a behavior, the more likely should be its performance" [13]. Hence, we believe that the willingness to pay for clean water (WPCW), social influence (SI), facilitation provided by the government (FPG), knowledge about contaminated water (KCW), and public awareness (PA) will influence public intentions to use clean water (IUCW) and be helpful in achieving UN's SDG 6.

2.1. Willingness to Pay for Clean Water. When it comes to deciding what to buy, customers are often persuaded in their decisions by a number of different economic concerns. It is well established that customers' income levels play a significant role in their choices on whether or not to make purchases [14, 15]. Paying for clean drinking water in the form of mineral water, tap water, and installing water filtration plants or water treatment plants are some common examples involving money, and it all depends on the household income [16, 17]. We expect that households' willingness to pay for clean water will positively influence their intention to use it. When individuals think about their health and associated health risks and compare them with the cost and possible reasons behind these health risks, they often go to pay for safe alternatives and adopt precautions. Hence, we proposed the following:

H1: Willingness to pay for clean water will positively influence household intention to use clean water, which will help achieve SDG 6.

2.2. Social Influence. People's perceptions of what others believe about the appropriateness of using a certain service, technology, or activity provide the foundation for forming normative beliefs [18–20]. When society decides whether or not to adopt emerging innovations, social influence plays a role. The research results indicate that it is an accurate predictor, yet there are circumstances in which it does not affect a person's decision. According to the findings of certain researchers, social factors are a significant factor in the adoption of environmentally friendly items [20], e-commerce [21], and 5G technology [22]. It has been shown that subjective standards significantly impact the amount of customer satisfaction that may be attained [17]. We hope that as a result of this, customers in developing nations will be motivated to adopt and use clean water, which will assist in the construction of a sustainable healthy society and prevent viral infections and eventually help in attaining SDG 6. Even

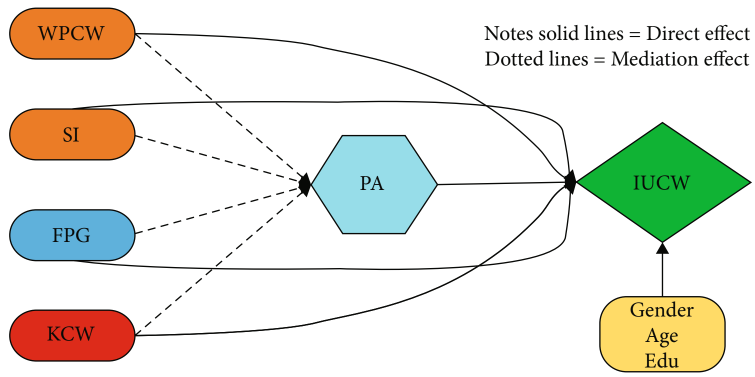

Figure 1: Conceptual framework. Note: WPCW: willingness to pay for clean water; SI: social influence; FPG: facilitations provided by the government; KCW: knowledge about contaminated water; PA: public awareness; IUCW: intention to use clean water.

while there is a lot of societal pressure on individuals to drink groundwater, it is almost always harmful, particularly in industrialized regions [16, 23, 24]. Hence, we expect that social influence will positively influence users' intention to use clean water and will be a key pillar in achieving SDG 6.

H2: Social influence will positively influence household intentions to use clean water and will be a helping hand in achieving SDG 6.

2.3. Facilitations Provided by the Government. To attain UN SDG 6 and provide basic facilities to the subjects, every government is providing facilities to its subjects. These facilities contain water supply, education, electricity and awareness or help in achieving a better lifestyle. The better infrastructure a government can provide its citizens directly influences their lifestyle [4, 24, 25]. The term "facilitating conditions" [5] is used to describe the methods and assets that are put into play in order to take advantage of a newly developed technology or product [20]. Hence, it is expected that governments and semigovernment institute initiatives and facilities will influence households' intentions to use clean water.

H3: Facilitations provided by the government will positively influence public intentions to use clean water that will be helpful in achieving SDG 6.

2.4. Knowledge about Contaminated Water. Human activity is responsible for polluting many of the world's water sources, including lakes, rivers, oceans, aquifers, and wells. This phenomenon is widespread across the world's waterways. Because of human intervention, water's physical, chemical, and biological properties have been altered, and the resulting water is toxic to all life forms. People who drink contaminated water or swim in filthy water run the risk of developing skin rashes, as well as cancer, reproductive disorders, typhoid fever, and stomach illnesses [26, 27]. People are more likely to avoid the usage of harmful products and prefer to use those products that can help them maintain good health and avoid health risks if they are informed about the benefits of a particular technology or product as well as the risks associated with using it, as this is the case when they have knowledge about the contaminated water and risks associated with its use. Knowledge about the advantages and related health risks is important in moulding human behavior towards modifying the human lifestyle and eating or drinking habits. This knowledge may either improve or harm a person's health. It has also been shown that providing individuals with environmental knowledge may enhance their views of environmental danger, environmental difficulties, and green purchasing patterns [18, 20, 22, 28]. Hence, we propose the following:

H4: Knowledge about contaminated water and the risks associated with its use will influence households to use clean water, and it will be a key determinant in achieving UN's SDG 6.

2.5. Public Awareness. A person's degree of awareness, which can be described as their grasp or acknowledgement of the advantages and downsides of the innovation, plays a significant role in determining whether or not they would accept an innovation, product, or activity in society [18, 22, 28]. A considerable percentage of individuals have a poor grasp of the benefits of utilizing clean water as a cure to prevent illnesses caused by polluted tap water, as shown by various research results. In the past, academics have seldom concentrated their study on investigating this aspect of customers' propensities to use clean water as their primary beverage [29, 30]. Researchers have claimed that users who are aware of some issues have the capacity to make better decisions compared to those without knowledge and awareness about the issues [18, 28]. Hence with this literature, we propose the following:

H5: Public awareness positively influences users' intentions to use clean water that will help achieve the UN's SDG 6.

2.6. Public Awareness as a Mediator. Public awareness is a strong predictor that plays a role in shaping consumers' behavior towards certain decision-making. We assume in our model that public awareness has also played its role as a mediator apart from the direct influence of the understudy variable. Previous studies have found that public awareness is influenced by age, education level, social status, recycling knowledge, public behavior, and willingness to participate in household waste treatment [31, 32]. Our understudy variable inserts their indirect influence with the mediation of public awareness; i.e., willingness to pay for clean water will increase public awareness. It will enhance the intention to use clean water. When consumers interact with each other, their awareness will also influence. The same is the case with facilitation provided by the government. As much as the government provides facilitations to facilitate citizens, it will enhance the awareness that leads to the intention to use clean water. Hence, we propose the following:

The relationship between WPCW (1a), SI (2a), FPG (3a), KCW (4a), and IUCW is mediated by public awareness.

3. Methodology

3.1. Data Collection. In order to acquire a dataset, we relied on a proven construct derived from earlier research. Table S2 in Supplementary Materials presents the detailed measurement items of the construct utilized to obtain the sample response. We have made some minor alterations to the phrasing of the measurement items in order to ensure that we get accurate responses and that they are the best fit for our study. The revised version of the construct was accepted by two academics in order to move forward with the study. First, we did some preliminary research in the form of a pilot study, and then, we moved on to the more extensive survey. For this aim, ten households and fifteen students at the master's level were chosen to assess the finalized questionnaire's readability and determine how long it took respondents to respond. The individuals who took part in the pilot study and the preliminary findings of the pilot study presented positive indicators that more research should be conducted [33]. Because of the potential for bias, the respondents from the pilot study were not included in the final sample.

We have decided to collect data through the use of an online survey so that we can eliminate the possibility of human error in the data handling process. We have segmented our population into two clusters depending on the literacy level, population concentration, and other facilities (rural and urban). Within these clusters, we used a method called systematic sampling to select one shopper from every ten who went to the supermarkets to do their grocery shopping. One of the most effective methods for obtaining responses from a diverse community is using this method [22, 34]. With the support of Google Forms, both the administration of the survey and the collection of responses were successfully carried out. In order to prevent having to make several attempts, for the purpose of data cleansing and to gather follow-up replies, respondents needed to enter their mobile phone numbers. The survey was carried out over two weeks, beginning in the third week of April 2022 and ending in the fourth week of the same month.

Before collecting any information or responses from any of the respondents, the researchers made sure to explain the goal of the study to each one of them and get their agreement. For the purpose of measuring the reaction, we have used a Likert scale of seven points, with "1 indicating strongly disagreeing and 7 as strongly agreeing." According to the findings of the aforementioned research, the Likert scale with seven points is superior to higher-order alternative scales since it is more accurate and simpler to use [35]. A total of 600 questionnaires were dispersed. Four hundred twenty-three valid responses were collected for a response rate of 70.5%. The sample size is substantially larger than the minimum requirement of 10 times for each construct component in order to do statistical analysis [36].

3.2. Demographics of Respondents. To better comprehend our study sample and its characteristics, we have collated the participant's age, gender, education level, occupation, and residency status. Information about the demographics of our whole sample (423 people) is provided in Table 1.

3.3. Common Method Variance. The common method variance (CMV) approach is a method that can be utilized to mitigate the impact of the social desirability effect. If the data for the study came from a single source and if the first element accounted for more than forty percent of the total variation, then the CMV may be a major issue for any study [37]. In the current investigation, a single component analysis developed by Harman was utilized as a statistical technique to account for the likelihood of common method bias. The results of an exploratory analysis of factors using the principal axis factors approach revealed that a single factor accounted for just 31.05% of the variation across measurements. This figure is lower than the determined cut-off value, which was 50%.

Consequently, this demonstrates that the risk of CMV is reduced in this research. However, to provide further evidence in support of the process described above, another method, which controlled for the effects of a single unquantified latent approach component [37], was used. It was discovered that the measurement factor loading for the common latent component was 0.47, which indicates that the common factor accounted for just 27.04% of the variation across measurements. This score is below the criterion of 50%, indicating that the data are free from any potential biases of a subjective norm or shared variation among the variables examined.

3.4. PLS-SEM. PLS-SEM was the method we decided to go with since it is frequently suggested for use in research projects that aim to anticipate and examine the dependent variables to explain the most practical variation. As a result, we decided to utilize it for our research. As a consequence of this, the PLS-SEM technique is the most effective way of creating forecasts [20, 38]. In addition to this, it is able to deal with the measurement (outer) and structural (inner) models simultaneously. When employing the PLS-SEM method, it is feasible to get more precise conclusions while having a smaller sample size. As a consequence of this, it seems that the PLS-SEM approach is the most appropriate one for this investigation. Recent research has shown an increase in interest in making use of the PLS-SEM methodology due to the potential benefits it offers in the field of management science [28, 39].

Table 1: Demographic characteristics.

Characteristics	Range	Frequency	Percentage
Gender	Male	241	57%
	Female	182	43%
Age	18-25 year	109	25.8%
	26-35 year	147	34.8%
	36-45 year	115	27.2%
	>45 year	52	12.3%
Education	High school or less	31	7.3%
	Bachelor	151	35.7%
	Master	240	56.7%
	Doctorate	1	0.20%
Occupation	Student	106	25.1%
	Govt. employee	96	22.7%
	Private company employee	132	31.2%
	Businessman/women/other	89	21.0%
Residential status	Urban	297	70.2%
	Rural	126	29.8%
Access to clean water	Yes	333	78.7%
	No	90	21.3%

PLS is more conducive to finding. Covariance-based SEM is more suited to testing and verification of well-established theories. The time to choose PLS is when your theories are still immature. As distinguishing between confirmatory and exploratory studies is not as easy as it may seem, this criterion requires further consideration. The consideration of data dispersion is another subject. Covariance-based SEM requires properly distributed data. PLS-SEM, on the other hand, makes no assumptions about the underlying data distributions. There is also the issue of sample size; covariance-based SEM studies need far more data than previously collected and analyzed. However, lower sample numbers are sufficient for PLS-SEM to converge.

PLS-SEM makes implementing formative measurement models simpler and more intuitive than covariance-based SEM. An additional factor is that PLS-SEM can simply and effectively manage increasingly complicated models. As such, PLS-SEM should be considered as the preferred option if formative measurement approaches are to be used.

In the process of PLS path modelling, the indicators of the constructs are evaluated in two different ways to ensure that they are reliable and accurate: (a) "the measurement model evaluation ensures the consistency and validity of the outer mode," and (b) the structural model estimation helps to identify the inner model or connection among the latent components. These assessments are performed to ensure that the indicators are reliable and accurate [36].

3.5. Multivariate Assumptions. According to [15, 20], it is required to evaluate the multivariate assumptions of multicollinearity, homoscedasticity, and linearity before doing any multivariate testing. This must be done before performing any multivariate tests. During the survey phase, when the data was being collected, we ensured the respondent's anonymity and made it apparent that there was no correct or incorrect answer. We followed the lead of other researchers and used the Kolmogorov-Smirnov test to determine whether or not the data distribution was normal; however, the results indicated that it was not [40, 41]. In terms of linearity, the nonlinear and linear interactions between independent and dependent constructs are confirmed in Supplementary Materials (Table S3). In order to determine whether the model suffered from collinearity, the VIF scores were examined. According to [36], VIF values lower than 5 suggest that the data acquired does not include any problems related to collinearity. All of the indicators have VIF scores lower than 5, as shown by the outcomes of this study. Therefore, the fact that there is no collinearity issue with the dataset is evidence that the model is resilient.

As the last step, we generate a scatter plot of the regression normalized predicted value, and the residual value shows that the data are consistent with this hypothesis. This was accomplished by following the methodology of past research [14, 42]. The loadings, as well as the crossloadings of the indicators, may be found in Supplementary Materials (Table S1).

3.6. Measurement Model. According to the research that was conducted by [43], the reliability of a measurement model is determined by both its discriminant and convergent validity. Indicator loadings and Cronbach's alpha (α) were used in the analysis to determine the instrument's level of dependability. The indicators of the constructs were evaluated using convergent validity to see whether or not they were able to measure the variables under investigation accurately. When expressing the total variance in the indicators, Average variance extracted (AVE) is used, while composite reliability (CR) is utilized to demonstrate the dependability of the

Table 2: Reliability and validity analysis.

Constructs	Items	Loadings	T statistics	VIF	α	CR	AVE
Facilitations provided by government	FPG1	0.922***	122.519	2.818	0.953	0.966	0.877
	FPG2	0.936***	148.248	2.978			
	FPG3	0.933***	138.331	2.902			
	FPG4	0.954***	191.423	3.77			
Intention to use clean water	IUCW1	0.894***	56.443	2.305	0.885	0.929	0.813
	IUCW2	0.912***	84.802	2.776			
	IUCW3	0.899***	62.512	2.593			
Knowledge about contaminated water	KCW1	0.878***	59.981	2.633	0.91	0.937	0.787
	KCW2	0.896***	68.147	2.916			
	KCW3	0.883***	59.238	2.778			
	KCW4	0.891***	67.704	2.807			
Public awareness	PA1	0.745***	24.148	1.437	0.765	0.85	0.587
	PA2	0.753***	25.23	1.447			
	PA3	0.777***	32.338	1.553			
	PA4	0.787***	36.329	1.498			
Social influence	SI1	0.790***	26.822	2.08	0.785	0.859	0.605
	SI2	0.732***	19.014	1.906			
	SI3	0.758***	21.753	1.518			
	SI4	0.827***	47.967	1.688			
Willingness to pay for clean water	WPCW1	0.875***	44.132	2.498	0.873	0.913	0.725
	WPCW2	0.880***	40.609	2.667			
	WPCW3	0.852***	24.497	2.438			
	WPCW4	0.795***	20.505	1.884			

Notes: $\alpha > 0.7$; CR > 0.7; AVE > 0.5; VIF < 5; ***significant at $p < 0.001$.

variables (Table 2). The model has component factor loadings of at least 0.6, which was the minimum required for inclusion (Figure 2). The assessed values of α are much higher than the cut-off value of 0.7, the CR for all variables is more than 0.7, and the AVE was discovered to be significantly greater than 0.50, a suggested number by specialists (Table 2). These findings provide evidence that the construct investigated in this research may be trusted [36, 43, 44].

In conclusion, the Fornell-Larcker criteria were used so that we could ascertain the discriminant validity of the research instrument before continuing to the next stage. It has been shown that a strong discriminant validity exists. The results of using the Fornell-Larcker criteria are shown in Table 3.

3.7. Structural Model Assessment. The PLS-SEM assessment procedure continues with the following stage, which is the structural model evaluation. Components of the structural path model assessment include assessing the predictive relevance of the model, the multicollinearity, the empirical significance of the path coefficients, and the degree of confidence in the results [21, 36, 43]. Following a predetermined protocol, the findings of this investigation were broken down and analyzed in order to draw conclusions. The R^2 value of the first model (Table 4) for direct effect analysis on intention to use clean water is 0.755 ($Q^2 = 0.606$), while R^2 for the mediating variable public awareness is 0.433($Q^2 = 0.348$).

We have run 5000 resamples of bootstrapping (Figure 3) by following the earlier researcher [21, 22]. The direct path results in model 1 revealed that all the independent variables positively influence the dependent variable with p value less than 0.001, i.e., PA -> IUCW ($\beta = 0.312$, $T -$ value $= 8.027$, p value < 0.001), FPG -> IUCW ($\beta = 0.148$, $T -$ value $= 4.326$, p value < 0.001), KCW -> IUCW ($\beta = 0.338$, $T -$ value $=$ 6.496, p value < 0.001), SI -> IUCW ($\beta = 0.209$, $T -$ value $=$ 4.603, p value < 0.001), WPCW -> IUCW ($\beta = 0.12$, and T $-$ value $= 4.427$, p value < 0.001). In contrast, the control variables gender, age, and education were found insignificant in model 1 (Table 5). With these results, we have accepted hypotheses H1-H5.

3.8. Mediation Analysis. In addition to the direct path assessment in the model, we have run model 2 with the same bootstrapping sample and accessed the mediation effect of the public awareness (Table 6) between FPG, KCW, SI, and WPCW on IUCW. The model 2 analysis results revealed a decrease in the β value for direct relations. The specific indirect effects are as follows: KCW -> PA -> IUCW ($\beta = 0.134$,

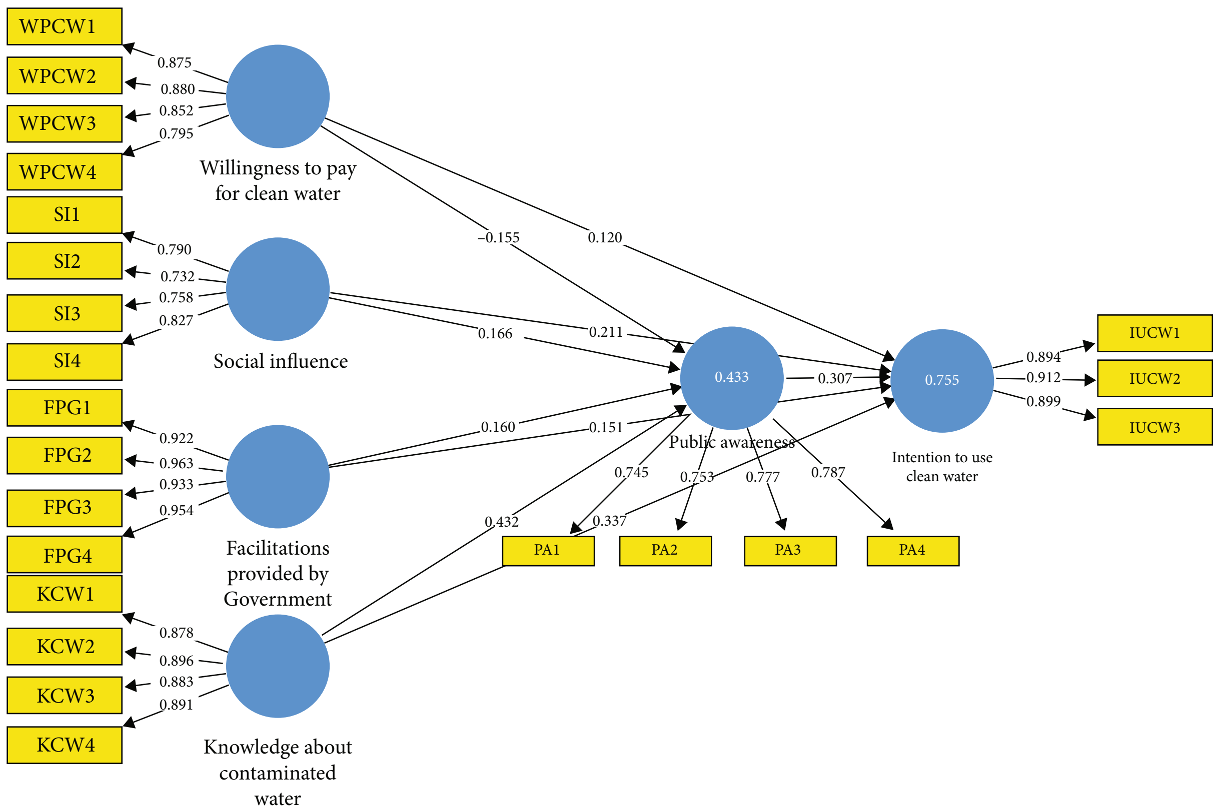

Figure 2: Measurement model.

Table 3: Fornell-Larcker's criteria (discriminant validity).

	Mean	Std. dev	FPG	IUCW	KCW	PA	SI	WPCW
FPG	5.15	1.34	0.936					
IUCW	4.94	1.44	0.599	0.902				
KCW	4.88	1.32	0.57	0.799	0.887			
PA	4.60	1.39	0.461	0.698	0.617	0.766		
SI	4.52	1.34	0.462	0.724	0.762	0.545	0.778	
WPCW	4.35	0.97	0.148	0.246	0.215	-0.011	0.162	0.851

Note: WPCW: willingness to pay for clean water; SI: social influence; FPG: facilitations provided by the government; KCW: knowledge about contaminated water; PA: public awareness; IUCW: intention to use clean water.

Table 4: Coefficient determination and blindfolding results.

Exogenous constructs	Overall model	
	R^2	Q^2
IUCW	0.755	0.606
PA	0.433	0.348

$T-\text{value}=4.959$, p value <0.001), WPCW -> PA -> IUCW ($\beta=-0.048$, $T-\text{value}=3.893$, p value <0.001), FPG -> PA -> IUCW ($\beta=0.05 T-\text{value}=3.253$, p value $=0.001$), and SI -> PA -> IUCW ($\beta=0.051$, $T-\text{value}=2.437$, p value $=0.015$). Hence, the mediation results presented in Table 6 revealed a partial mediation of public awareness. The effect of understudying independent variables is passing through the mediator of public awareness. Public awareness as a mediator explains the independent variables' influence on the dependent variable.

With these results, we have accepted the hypotheses H1a-H4a.

4. Discussion

This study is conducted to understand the influential factors that influence the household intentions to use clean water and can be helpful in achieving the united nations Sustainable Development Goal 6. Based on the theory of planned behavior, we have proposed a model and collected a cross-sectional dataset from Pakistan, one of the underdeveloped countries facing economic, political, and infrastructural issues as hurdles in achieving UN Sustainable Development Goals. Our study access the economic, personal,

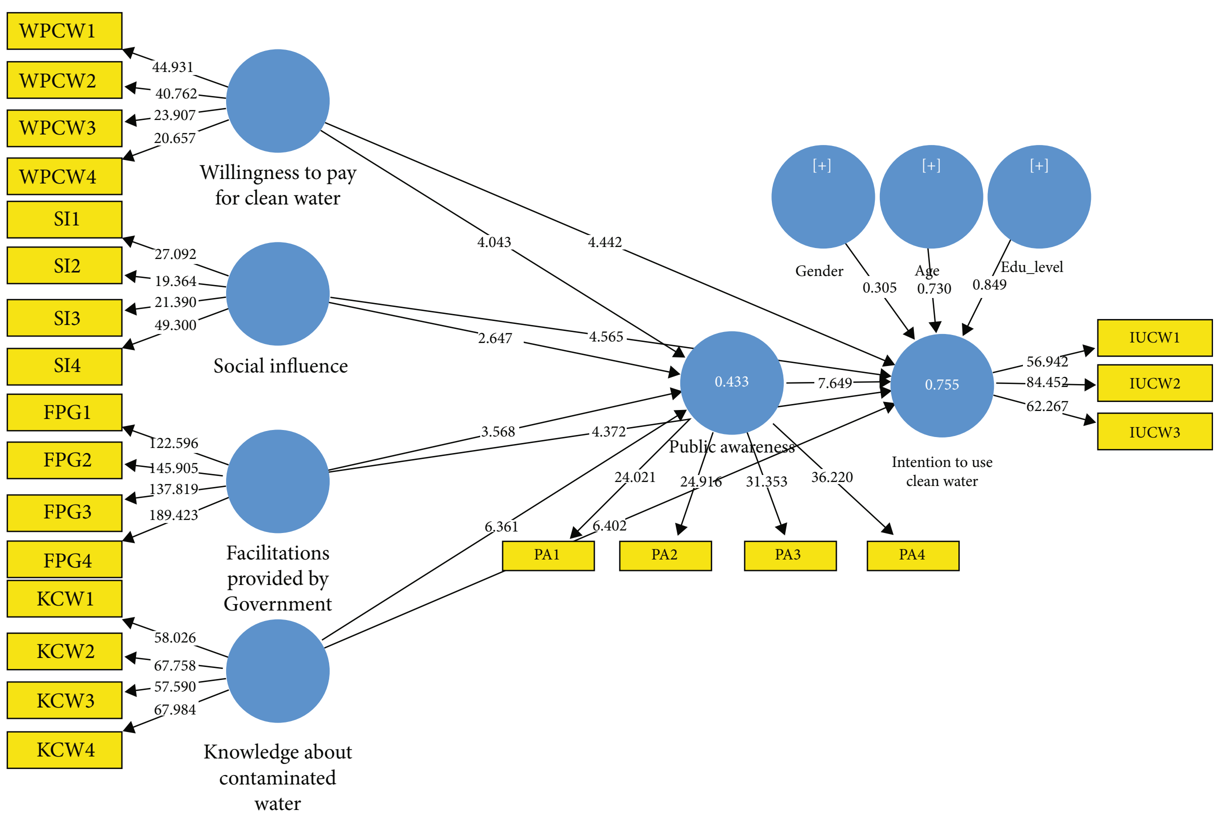

Figure 3: Path model.

Table 5: Direct paths.

Paths	Effects	Model 1			
		β	SD	T-value	p value
WPCW -> IUCW	(H1)+	0.12	0.027	4.427	***
SI -> IUCW	(H2)+	0.209	0.045	4.603	***
FPG -> IUCW	(H3)+	0.148	0.034	4.326	***
KCW -> IUCW	(H4)+	0.338	0.052	6.496	***
PA -> IUCW	(H5)+	0.312	0.039	8.027	***
		Control variables			
Gender -> IUCW		0.007	0.024	0.305	0.76
Age -> IUCW		-0.017	0.023	0.752	0.452
Education -> IUCW		0.021	0.026	0.839	0.402

Note: ***significance at level $p \leq 0.001$.

and infrastructural barriers and households' perception of these factors and how these factors influence shaping their behavior in using clean water, which is necessary to avoid health risks.

We have presented two research questions to study the topic and hypotheses 1-5 to answer research question 1 and hypotheses 1a-4a to answer research question 2. H1-H5 access the direct effect, and H1a-H4a access the mediation effect of public awareness. We have used the PLS-SEM approach to conclude our results.

Results revealed that willingness to pay for clean water significantly positively influences the intention to use clean water (H1) and public awareness mediates the relationship (H1a), but the mediation magnitude is negative (competitive mediation). It means households who are willing to pay for clean water are inclined to use clean water. But if they are aware of the cost because of the low-income country, they hesitate to pay for it and need it as a complimentary from the government. Although the relationship in H1 is positive, its magnitude ($\beta = 0.072$) is minimal when a mediator of public awareness is exposed in the model. In mediation, public awareness further weakens the relationship influence. In addition, it implies that households in developing countries are less concerned about the awareness and possibly

Table 6: Mediation analysis.

Paths	Effects	Model 2			
		β	SD	T-value	p value
WPCW -> IUCW	(H1)+	0.072	0.026	2.762	0.006
SI -> IUCW	(H2)+	0.260	0.049	5.293	***
FPG -> IUCW	(H3)+	0.198	0.036	5.500	***
KCW -> IUCW	(H4)+	0.473	0.056	8.520	***
WPCW -> PA -> IUCW	(H1a)-	-0.048	0.012	3.893	***
SI -> PA -> IUCW	(H2a)+	0.051	0.021	2.437	0.015
FPG -> PA -> IUCW	(H3a)+	0.05	0.015	3.253	***
KCW -> PA -> IUCW	(H4a)+	0.134	0.027	4.959	***

Note: ***significance at level $p \leq 0.001$.

the cost factor to overcome the awareness and direct care of their health and associated health risks. However, if households are aware of the price and associated health risk and prevention costs, they are not conscious about caring about their health issues. Because they live in a low-income country and possibly have low income, they are hesitant to pay for clean water and expect the government to provide it free of charge. Social influence (H2) positively influences the IUCW, and it is also positively mediated by public awareness (H2a) (complementary mediation). The possible reason behind it can be that people are socially influenced; if someone from the community is concerned about their health and use clean water for drinking and sanitation, fellow community members will start following it. Furthermore, when community members interact, they argue about the benefits and drawbacks of using clean water and the associated health that increase public awareness among individuals and as a whole society that leading to the intention to use clean water [16, 18, 23].

FPG (H3) has a significant positive influence on IUCW, and this relationship is also mediated by PA (H3a). The possible reason behind this relationship is that government facilities influence citizens as it is the outcome of their direct and indirect taxes that they pay for necessities. Although this is one of the basic responsibilities of government to provide clean water to all citizens, international organizations such as the United Nations, World Bank, and Asian development bank provide funds to developing countries to meet the Sustainable Development Goal 6. Hence, infrastructure and other facilities provided by the government aligned with United Nations' Sustainable Development Goal 6 positively influence and increase public awareness about the benefits of using clean water.

Knowledge about contaminated water (H4) positively influences the intention to use clean water, and public awareness mediates (H4a) the relationship between KCW and IUCW. It means as much as an individual knows about the use of contaminated water and its hazardous outcomes or benefits using clean water, as much as they will be inclined to use clean water and avoid contaminated water. Knowledge about contaminated water is a direct component of public awareness; as much an individual has the knowledge, they will be aware of the consequences and vigilant. Hence, the mediation of public awareness between KCW and IUCW is obvious. It is consistent with the previous studies that knowledge about a certain issue enhances awareness [20, 22].

Public awareness (H5) has a significant factor behind the use of clean water and a significant mediator in the process. The possible justification is awareness urge human to act wisely and smartly and pick whatever is right for them. Hence, if we have to pursue Sustainable Development Goal 6, we must create public awareness and engage individual efforts to accomplish the goal on a large scale.

We also observed that the demographic factors incorporated as control variables, gender, age, and education, have no substantial influence on our study. It contradicts the results of the previous studies that claim age and education are determinantal factors in shaping household awareness and behavior [31, 32].

5. Policy Implications

The job of the government and nongovernmental organizations is to build large-scale awareness campaigns on the need for good hygiene, including the points that water that seems clean may still be dangerous and that there is a requirement for household water treatment. Instead of using health concerns as a justification to get families to buy a filter, try appealing to their aspirations, using social stigma, and building trust. In addition, the government should make it possible for families unable to pay the whole cost upfront to make payments using their mobile phones or microcredit. The government and nongovernmental organizations can provide one-time financial assistance to low-income families. Filters, whether they are free or subsidized, should not disrupt markets but rather assist supply chains. One option is to provide free vouchers, which a family may use to "purchase" a filter from a retailer of their choosing. It is vital for governments and nongovernmental organizations [45] and the corporate sector to collaborate in order to scale up household water treatment and safe storage, and it is also essential that regulations be in place.

We also suggest considering building a piped infrastructure with home connections rather than community water tap points in communities with at least 500 people since this will eliminate the need for individuals to walk to get the water supply. Consumers are generally willing to pay for a service, such as water delivery to their homes, even if it costs more. Keeping in view the income level of rural and urban areas, it may be possible to slightly raise the price of water in metropolitan areas, and the additional revenue might then be used to support water provision in rural regions. People should be given support to put adequate infrastructure in areas where the cost of providing water access per person is very high because there are no low-cost options available (places with extensive water layers or very rough terrain).

In general, for developing countries and specifically for Pakistan, UN has its setup with the name of UNDP (Pakistan). This setup organized by UN actively participates in developing nations and helps to achieve sustainable growth and UN goals set for 2030. A model of 80-20 public UNDP partnerships can help in establishing a well-organized structure to achieve SDG6. We suggest UN make UNDP more deep routed and provide clean water facilities with the cooperation of local communities rather than providing funds to NGOs and other local bodies. We strongly encourage the involvement of local community organizations and social communities in providing clean water in underdeveloped areas such as Thar in Sindh and the South Punjab region.

6. Limitations

We tried to overcome the possible limitation by implying procedural and statistical instruments; still, our study lacked in some areas. These limits can be used as a possible future research avenue for researchers. Firstly, we only gathered data from one nation for our sample; a potential selection bias affects our findings' generalizability. Researchers are strongly urged to confirm the findings by researching in many countries simultaneously. Researchers can compare developed nations with underdeveloped nations and underdeveloped nations with others by distinguishing the geographic borders of the countries being compared, for example, Asian countries and African countries. Second, we did not assess the household earnings in our sample population. The degree of a consumer's income may have an impact on the process, and the priorities of customers might shift depending on their level of money. In further research, we recommend including the impact of one's income level. Thirdly, as a control variable, we look at the level of education. Future scholars will be able to investigate the profound impact of educational levels, in which the literate and uneducated members of the community can be crosscompared, and offer strategy statements to educate the masses about ecological problems and encourage people to use clean water to avoid health risks.

7. Conclusion

In response to the results revealed from our work, we concluded that public awareness about the use of clean water among developing countries' residents is limited. It needs to improve if the successful implementation of Sustainable Development Goal 6 needs to be achieved by 2030. We have also found that if households have awareness about the use of clean water and the risk associated with the use of contaminated water, the influence of willingness to pay for clean water, facilities provided by the government, social influence, and knowledge about contaminated water is more when they do not have any awareness. Hence, public awareness is a determinantal factor in achieving United Nations SDG 6. Our study results are also helpful in understanding the barriers to implementing SDG 6 in developing countries where infrastructure and economic and political instability are hurdles in development.

Data Availability

The dataset used in the study is available from the corresponding author at a reasonable demand.

Conflicts of Interest

The authors who contributed to this article have no financial or professional conflict of interest to disclose.

Supplementary Materials

Further details of crossloading, measurement construct, and correlation among variables can be found in Supplementary Materials as Table S1, Table S2, and Table S3. *(Supplementary Materials)*

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Retraction

Retracted: A Model for Evaluating the Effectiveness of Precise Governance of Social Assistance from a Management Perspective and Environment of Public Health

Journal of Environmental and Public Health

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] J. Li, "A Model for Evaluating the Effectiveness of Precise Governance of Social Assistance from a Management Perspective and Environment of Public Health," *Journal of Environmental and Public Health*, vol. 2022, Article ID 2635144, 9 pages, 2022.

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Research Article

A Model for Evaluating the Effectiveness of Precise Governance of Social Assistance from a Management Perspective and Environment of Public Health

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The research study describes the assessment model and its effect of precise governance of social assistance related to management's perspective. This research study was conducted in Chinese organizations which are related to the precise governance of social assistance. This research study is based on primary data analysis for gathering the data using specific questions related to social assistance and management. In this research study, the precise governance of social assistance is considered an independent variable, and management's perspective is the dependent variable. The planning, designing, leading, the growth of the organization process, and system control are all subparts of management's perspective. To measure the data, this study used 100 plus respondent persons who know social assistance related to governance and management. To measure the data, smart PLS software, and AMOS software and run informative results included growth curve model, the smart algorithm model, the regression weighted analysis, the correlation, covariance, minimization history, and assessment of normality. The overall result found that precise governance of social assistance shows positive and significant effects in the management perspectives.

1. Introduction

Among the numerous meanings of "governance" that exist, the one that is more suitable from the perspective of the bank is " where the strength is rehearsed in the organization of a country's monetary and social resources for development." On this significance, the general possibility of an organization is related straightforwardly with the administration of the growing interaction that includes people from both the private and government areas. It incorporates the working and capacity of the people and the guidelines and foundations that make the structure for the performance of both the general people and personal business, comprising responsibility for monetary and monetary execution and administrative systems, identifying organizations, enterprises, and collaborations [1]. Governance is all about the conventional climate where people can interface with themselves and other government administrations or institutions from a comprehensive perspective. The limit of the institutional climate is significant for the improvement since it decides the effect accomplished by the monetary arrangements taken on by the public authority. It has also been noticed that numerous states have embraced comprehensively comparative change bundles that resulted in fundamentally changed consequences across the boundaries. In the past few years, the debate on governance has increased tremendously, and the stress and concern on this topic have been raised. This issue has been considered in the ongoing discussion inside the bank on the destinations and methods of dealing with its functional endeavor and ways of managing its practical venture. For model, it got the awareness: at the critical conversations prompting the fifth renewal of the Asian Development Fund also written as ADF V stated that governance is the imperative association among correspondent. This framework is based on policy management and the functional and reasonable movement concerning the economy to explain the specific circumstances. The testimonial assertion was purposely added to the requirement for "deliberative and vote-based structures" and significantly reinforced "nearby general set of laws and administrative offices." A few investigations checked out the connection linking the executive pay and the company's deals. Despite diminishing the extent of chief compensation, the existence of exterior chief causes a rise in the level of value-based remuneration.

According to the administration, a fundamental problem that emerges is the legitimate job of government in monetary administration. With state-run administrations having restricted admittance to data, the developing agreement efficiently markets most of the dispensed assets. Notwithstanding, state running administration is standard, and this administration has to play out specific essential capacities, specifically (a) keeping up with macroeconomic steadiness, (b) creating a framework, (c) giving public products, (d) forestalling market disappointments, and (e) advancing equity. Mostly the policies that the government is adopting are decided by the government too. Once these policies are chosen, the next step is to make sure that these policies should work under good governance. There is compatibility linking possession fixation as well as incorporation as restraining gadgets. To ensure the prosperity of bank projects and their investments, crucial attention should be paid to the working of institutional systems in creating nations and on arbitrary execution.

Many organizations paid stress the role of governance in growing and progress of any field or industry. The methodology of the World Bank is generally essential. In the viewpoint of the bank of the world, the critical elements in any administration include general public regions, the executives, and responsibility; the legitimate structure for advancement; and data and straightforwardness. The contrast of thoughts in political history results in the evolution of the political organization and intellectual diversity in Asia and the Pacific area of the world. Out of these, none can sensibly profess to have any relative benefit according to the administration's perspective. It can be, appropriately, be numerous institutional choices for dealing with the improvement interaction adequately. The bank will consider every country's qualities, abilities, and circumstances while applying the standard for good governance. By creating a framework, legislatures can make practical terms for private interest in business exercises. The primary role of the private area in foundation advancement is probably going to increment. The test for states is to devise an approach and institutional structure that permits more extensive support to the private area in framework development and the board and also at the same time defends the public interest. Death wishes hurt objective investors by lessening the likelihood of takeovers. The incorporators play the role of replacing exterior chiefs, as there can be a significant control on technique when fewer or a few exterior chiefs are available on the project .

Communal items are the products mutually requested, and their usage by any one individual does not diminish the availability for other people. The most common form of public goods is education and health. In many nations, states accept accountability for the arrangement of public products, also with the financial assets being directed in a unique way to guarantee their inventory. This is also important for maintaining equality in the field of the economy. In a fully market-based economy, the public authority commits to make sure that merchandise works productively and that the battleground is level for all members [2]. It demands versatility of growth elements, free progression of data in regard to costs and innovation, and contest among purchasers and vendors. Merchandise guidelines by the public authority ought to guarantee that the working principles are not segregating between individual members or respected parties. This suggests excellent exposure for validation and traditional standards and their reasonable and straightforward petition. A vital obligation of government is guaranteeing that the advantages of economic development are evenhandedly conveyed all over the community. Tax collection and use measures are critical points regarding this. Also, it should be made sure that the assessments ought are reasonable. The taxes should be gathered adequately to provide adequate income for fundamental administrations (and assist with keeping up with financial balance). The last thought is that the additional necessitates of public spending will be kept away from excessive obligation administration weights, and appropriations for low need exercises will be progressively eliminated. This highlights the cozy connection between value and macroeconomic strength. In any case, excellent governance is needed to ensure that executions are viable and predictable.

2. Literature Review

A social benefit evaluation is a procedure of examining, planning, and managing social change resulting from plans, developments, and projects. An SIA focuses on the substantial consequences of projects and enhancements beyond the effects on typical assets. Social consequences include how people live, work, play, and interact with one another daily. A person's lifestyle is defined by their commonalities in religious beliefs, cultural practices, and language. Those who belong to this group have a sense of loyalty, stability, character, administration, and office. People's ability to make decisions in life, the degree of democracy taking place, and the resources made available as a result are all reflected in their political frameworks [3].

There is one primary health care unit with six staff people. This unit close by a dispensary gives all expansive prosperity organizations to the space typical ailments consolidate digestive infection, bronchitis, stomatitis, the runs, and detachment of the insides. In case debilitated, individuals should make an excursion outside the town to Kivunge Cottage Hospital or Zanzibar Town. The Zanzibar government cultivated the target of appropriating enlightening workplaces inside a 5 km range. A public primary school is available where area kids go to classes. There could be no middle schools in the brief locale. There are, moreover, five Quran schools open, four mosques, and four Madrasa locally. Major money-related activities in the space consolidate fishing, kelp developing, cultivation, unimportant trade, and animal cultivating. Amazingly, fish stocks have been declining throughout the long haul, notwithstanding a powerless economy based on the resource [4]. Cultivating is also a fundamental piece of the economy. It contains cassava, mango, maize, sorghum, and other yearly reaps produced for individual usage, with a little piece being sold on the close-by market. Likewise, animals are raised for individual usage.

State-run management regularly have legally binding associations with suppliers that move part of the hazard of accomplishing results to specialist organizations. Agreements that pay suppliers for conveying a certain number of management (output-based) move with little danger. They boost the supplier to convey a set number of administrations [5, 6]. Social help programs have as a rule been outlined to assist individuals to adapt to their troubles and sudden emergencies.

In-country ranges, social assurance can contribute to progressing versatile capacities where employments are influenced by climate alter. It must back agrarian enhancement and move forward versatility through complementary components of social help programs that give back for common asset administration and feasible nourishment frameworks [7].

National and global economies rely heavily on social assistance programs to illustrate the progress of local and national governments since they form a significant part of the organization's overall budget. Concern over the need for social collaborators has led to political meetings and discretionary procedures over the years [8]. Still, it has also led to the development and use of financial methodologies for tracking, directing, and ultimately reducing the number of socioeconomic collaborators to reduce the budget burden. Social help indicates to approaches to avoid and decrease deprivation, powerlessness, and social avoidance; throughout the lifecycle, it can fortify requests, boost utilization, and contribute to financial development [9]. Amid retreats, social assurance investing can offer assistance revive economies and satisfactory work.

Social help may be a principal component of the modern welfare state. Concretely, social help is the "last security net," that is, a last-resort wage bolster program to which citizens can turn when they have depleted all other alternatives [10]. Since the early 1980s, social help has been the protest of considerable rebuilding beneath the drive of effective elemental powers such as the relative development of the benefit segment, increment in female business, globalization, and populace maturing [11, 12]. The maintained budget shortfalls have driven to an environment of "permanent austerity."

Destitute birth results are a critical worldwide open wellbeing issue [13, 14]. Social help programs that give cash or in-kind exchanges, such as nourishment or vouchers, hold the potential to move forward birth results, but the proof on their viability has not been surveyed. For example, before 1989, childless social help beneficiaries got much lower benefits than beneficiaries over 30. Legislative issues are critical within the rise of social help programs in creating nations within the final decade. It finds that this is often a two-way handle. Legislative issues are significant to the selection, plan, and usage of social help programs. They, too, have a critical impact on the neighborhood and national legislative issues [15, 16].

Benefits related to health and nutrition might include access to appropriate medical care. The Supplemental Nutrition Assistance Program (SNAP) or food stamps may make it easier for people in need to get their hands on food. The humanitarian advantage to others, building nobility for everyone, social equality, and better grounded human relationships are at the heart of social work's core ideals. The importance of social work today is based on the ideals social workers promote, which significantly impact individuals, groups, and civilization [17–19].

Welfare changes frequently center on effectively work among advantage beneficiaries, based on the hypothetical instrument that the execution of moo salary work will serve as a venturing stone towards money-related self-sufficiency [20]. Research in that setting contains an essential part to play. Be that as it may, much work is still required to get better the long-term welfare and redistributive impacts of social help and their interaction with labor and protection markets and charge approaches. Research believes that considering this supplement will contribute to the struggles around making strides in the viability of social help .

2.1. Methodology. This research study presents the assessment model of the effect of precise governance of social assistance from management's perspective. Based on the primary data analysis for measuring the data, this research study used different questions related to the variables, including independent and dependent variables. Furthermore, this research study presents that governance of social assistance in management for data analysis used smart PLS software and AMOS software and run results models.

2.2. Participants. This research study presents that primary data for gathering the data used almost 100 plus respondent persons and collected data from these respondents—the data collected from different organizations related to the governance of social assistance and management as shown in Table 1.

2.2.1. Variables

2.3. Precise Governance of Social Assistance. When confronted with occasions that cause a shock to household earnings, social assurance programs assist families with trying not to need to sell resources that they depend on professionally or pull out kids from school. Social assurance programs often focus on ladies. Social security arrangements and projects diminish destitution and weakness by empowering proficient work markets, lessening individuals' openness to chances, and working on their capacity to oversee financial and social dangers like joblessness, avoidance, infection, inability, and advanced age. People and families in need are helped by a social government assistance framework, which incorporates projects like medical care help, food stamps, and joblessness pay [21–23]. Calamity help and instructive help are two lesser-known parts of a social government assistance framework. In this research study, the

Table 1: Dependent and independent variables.

Sr. no	Descriptions	Notations
1	Independent variable	IV
2	Precise governance of social assistance	PGSA
3	Dependent variable	DV
4	Perspective of management	PM
5	Planning and guiding organizational processes	PGOP
6	Planning, design and leading	PDL
7	System controller	SC

precise governance of social assistance is considered as independent variable for measuring the performance of social assistance related to the management perspectives.

2.4. The Perspective of Management. Acquiring the abilities and procedures of excellent management is what is going on from the board's viewpoint. It is finding out about the cycles that add to the accomplishment of any association, straightforwardly or in a roundabout way. Accordingly, the course is popular and extends to unique open positions. It is characterized as a particular interaction comprising arranging, putting together, acting, and controlling to accomplish expressed objectives [24]. As per this perspective, its capacities are arranging, putting together, staffing, planning, and coordinating to accomplish the association's objective. The management perspective helps settle on everyday choices and create business techniques. The executives are worried about task appointments and the shuffling of assets like cash, supplies, and staff. However, it can be considered a strategy for convincing administrators and chiefs to work with worker execution. The perspective of management is considered as dependent variable for measuring the research related to the social assistance in governance performance.

2.5. Planning and Guiding Organizational Processes. Arranging, such as arranging, requires a thoroughly examined and carried out process. This cycle involves figuring out what work is needed to accomplish the objective, allocating those assignments to people, and sorting out those people into a dynamic system (traditional design)—utilizing consistent, systematic, and deliberate methodology to accomplish objectives. To accomplish objectives, successful preparation and association require the capacity to plan and carry out coherent, precise cycles. The method involved with considering the exercises needed to accomplish an ideal objective is known as arranging. Prescience, the principal limit concerning mental time travel, fills in as the establishment for arranging. The advancement of planning, or the capacity to prepare, is thought to have been the main impetus in human development. The planning and guiding organizational processes are also consider as dependent variable and its part of management.

2.6. Planning, Design, and Leading. Arranging is an administration work that involves setting targets and deciding a strategy to accomplish those goals. Arranging requires monitoring the environmental conditions facing their association just as determining future conditions [25]. It also requires that chiefs use wise judgment. Arranging is a cycle that incorporates a few stages. Natural checking is the initial phase, which implies that organizers should know about the basic possibilities that their association faces regarding monetary conditions, contenders, and clients. From that point onward, organizers should endeavor to conjecture future conditions.

Driving involves utilizing social and casual wellsprings of impact to rouse others to make a move. Administrators who are viable pioneers will move their subordinates to strive to accomplish hierarchical objectives. The social sciences have made various commitments to our comprehension of this administration work. Character exploration and occupation mentality studies give primary data regarding how directors can most adequately lead subordinates. For instance, as this review indicates, directors should initially comprehend their subordinates' characters, qualities, mentalities, and feelings to be compelling pioneers. The planning, designing, and leading this are also considered as dependent variable and its part of the management for measuring the effect of precise governance social assistance.

The model as shown in Figure 1 represents that the smart PLS algorithm model between dependent and independent variables such as the precise governance of social assistance is independent. On the other hand, management's perspective is a dependent variable that included planning, designing, and leading; planning to guide the organization process; and system control. The model presents 0.301 positive relations with each other; it shows that 0.450, 0.720, and 0.358 all present positive relationship with the perspective of management.

Table 2 presents the colinearity statistical analysis of each variable; the VIF values are 1.018, 1.024, 1.000, and 1.042, respectively. The result shows a colinearity relation, which means each variable is correlated with positive relationships.

The model as shown in Figure 2 presents the growth curve model with the help of ICEPT and SLOPE values; the model presents that each variable results in the form of a curve model; the ICEPT value is 1.92 to −0.09, and the SLOPE value are 0.87 to −0.05. Thus, the model presents a significant relationship with each other.

2.7. Assessment of Normality (Group Number 1). Table **3** result presents the assessment of normality test analysis with the help of different variables. The result presents that minimum value, maximum value, and skew value also show the kurtosis values of each variable. The overall minimum value is 1.000, and the overall maximum value is 5.000. The result presents that planning, designing, and leading are part of management; its shows that the skew value is 0.135, the C.R. value is 0.549, and the kurtosis rate is −0.961, respectively. The result presents that planning growth of organization process is also part of dependent variable; its skew value

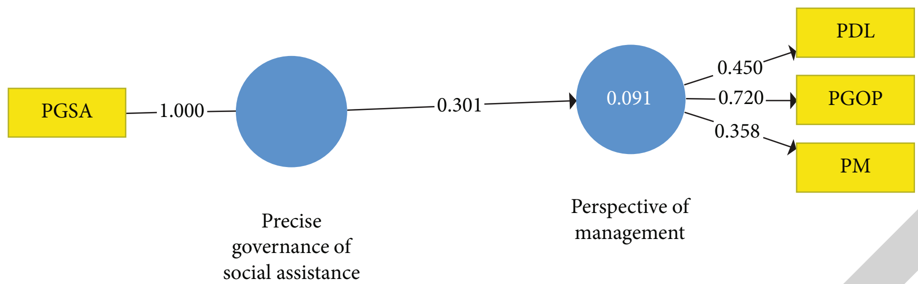

Figure 1: Smart PLS algorithm model.

Table 2: Colinearity statistical analysis.

Description	VIF
PDL	1.018
PGOP	1.024
PGSA	1.000
PM	1.042

is 0.460; its C.R. value is 1.870, and its kurtosis value is −0.422, respectively. The perspective management is the primary dependent variable; its skew value is −0.084, is C.R. value is −0.341, and its kurtosis rate is −1.252. Finally, the precise governance of social assistance is considered an independent variable. It shows that the positive skew value of each factor is as follows: its minimum value is 1.000, its maximum value is 5.000, and its skew rate is 0.517, and its C.R. rate is 2.101, respectively.

2.8. Sample Covariances (Group Number 1). Table **4** result describes the sample covariance in between each variable. The planning, designing, and leading show 1.3000 covariances with each other. On the other hand, the planning growth of the organization process presents 0.016 covariance with PDL and shows 1.179 covariances with each other. The perspective management presents that negative covariance with dependent variables rate is −0.114, −0.127, respectively. The result indicates that the precise governance of social assistance presents 0.126 level of covariance with planning, designing, and leading, and it shows 0.187 level with planning growth organization process; perspective management shows that the precise governance of social assistance level is 0.089. According to the result, the condition number is 3.042. The eigenvalues are 1.371, 1.218, 0.750, and 0.451, respectively; the sample covariance matrix of the overall result is 0.564.

2.9. Sample Correlations (Group Number 1). Table 5 result describes that sample correlation in between variables included dependent and independent variables. The planning growth of the organization process shows 0.013 correlation which means 1% significant relation with planning, designing, and leading. The result presents that perspective management shows a negative relation with planning, designing, and the growth of the organization process at rates of −0.132 and −0.154. The precise governance of social assistance presents 0.129 correlation with planning, designing, and leading. The 0.200 levels of growth organization process result shows that perspective management positively correlates with the governance of social assistance. According to the result, the condition number is 2.042; its eigenvalues are 1.260, 1.138, 0.985, and 0.617, respectively.

2.10. Sample Means (Group Number 1). Table **6** result presents that sample mean values of each variable included independent and dependent variables; the planning, design, and leading show 2.848 value of the average mean. The result shows 2.505 rate points of the growing organization process [26]. The result presents that the perspective management value is 2.051 and it shows 2.030 mean value of an independent variable.

3. Result (Default Model)

The result describes that the minimum was achieved; its chi-square level is =35.916 showing 35% levels of squared; the overall degrees of freedom = 8 and overall probability level = .000 show 100% significant level.

3.1. Regression Weights: (Group Number 1 - Default Model). Table **7** result presents the regression weight analysis of each variable with the help of estimated values 1.00, 0.000, 1.000, 0.330, and 0.670, respectively. The overall values present that ICEPT and SLOPE rate with each other included dependent and independent variables.

3.2. Means: (Group Number 1 - Default Model). Table **8** result presents that the mean values of each growth curve included ICEPT value and SLOPE value with the help of estimate rates, standard error, and the C.R. value; also, Table 8 describes that probability. So the result presents that the estimated value is 1.923 and 0.872; the standard error values are 0.076 and 0.129, respectively. So, according to the result, its C.R. values are 25.377 and 6.744; also, the probability values show a 100% significant level with each SLOPE.

3.3. Variances: (Group Number 1 - Default Model). Table 9 result describes that each variable's variance included estimated factors such as e1, e2, e3, and e4. The result presents that the estimate values are −0.094, −0.046, and 0.940; its standard error values of variables are 0.104, 0.289, and 0.095, respectively. The probability presents 0.369 of ICEPT level and 0.873 of SLOPE level. Other probability values

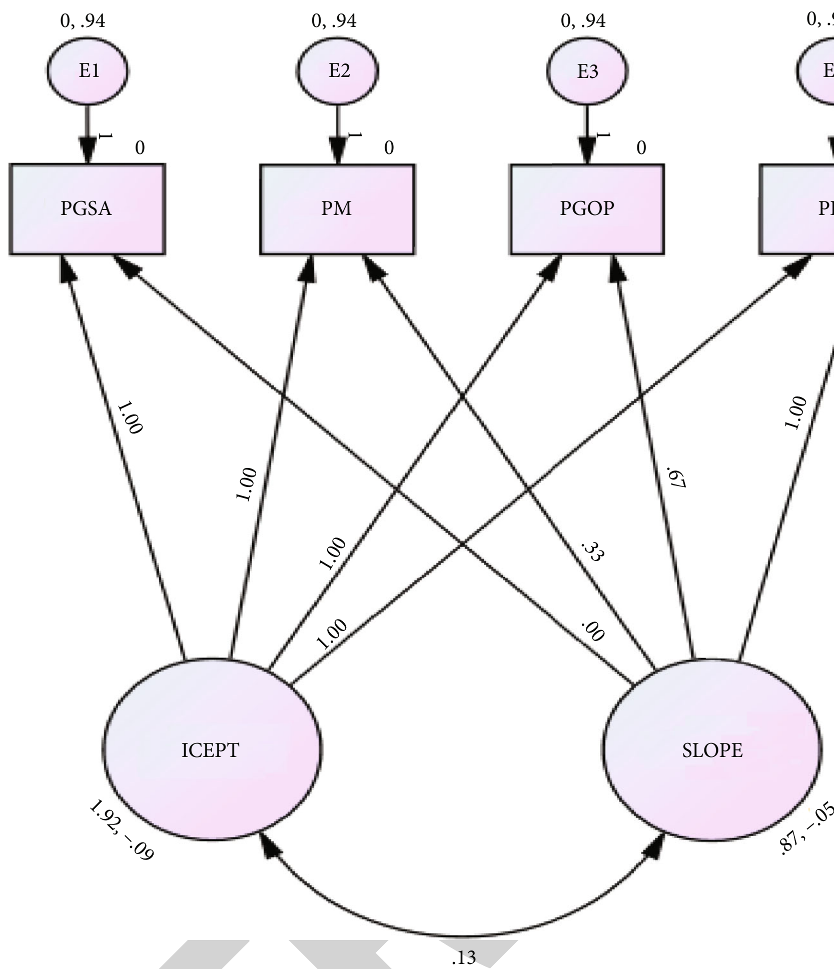

Figure 2: Growth curve model.

Table 3: The assessment of normality test analysis.

Variable	Min	Max	Skew	C.R.	Kurtosis	C.R.
Planning, designing, and leading	1.000	5.000	.135	.549	−.961	−1.952
Planning growth of organization process	1.000	5.000	.460	1.870	−.422	−.856
Perspective management	1.000	3.000	−.084	−.341	−1.252	−2.543
Precise governance of social assistance	1.000	5.000	.517	2.101	.067	.136
Multivariate					−2.180	−1.565

Table 4: The sample covariance.

	PDL	PGOP	PM	PGSA
Planning, designing, and leading	1.300			
Planning growth of organization process	.016	1.179		
Perspective management	−.114	−.127	.573	
Precise governance of social assistance	.126	.187	.089	.736

Condition number = 3.042; eigenvalues, 1.371, 1.218, 0.750, and 0.451; determinant of sample covariance matrix = .564.

Table 5: Sample correlations in between variables included dependent and independent variables.

	PDL	PGOP	PM	PGSA
Planning, designing, and leading	1.000			
Planning growth of organization process	.013	1.000		
Perspective management	−.132	−.154	1.000	
Precise governance of social assistance	.129	.200	.138	1.000

Condition number = 2.042, eigenvalues, 1.260, 1.138, .985, and .617.

Table 6: Sample mean values.

PDL	PGOP	PM	PGSA
2.848	2.505	2.051	2.030

Table 7: the regression weight analysis.

			Estimate
PGSA	<—	ICEPT	1.000
PGSA	<—	SLOPE	.000
PM	<—	ICEPT	1.000
PM	<—	SLOPE	.330
PGOP	<—	ICEPT	1.000
PGOP	<—	SLOPE	.670
PDL	<—	ICEPT	1.000
PDL	<—	SLOPE	1.000

Table 8: The mean values of each growth curve included ICEPT value and SLOPE value.

	Estimate	S.E.	C.R.	*P*	Label
ICEPT	1.923	.076	25.377	***	I-mean
SLOPE	.872	.129	6.744	***	S-mean

Table 9: Variable's variance.

	Estimate	S.E.	C.R.	*P*	Label
ICEPT	−.094	.104	−.898	.369	I-variance
SLOPE	−.046	.289	−.160	.873	S-variance
E1	.940	.095	9.899	***	Var
E2	.940	.095	9.899	***	Var
E3	.940	.095	9.899	***	Var
E4	.940	.095	9.899	***	Var

present a 100% significant level of variance between each variable.

3.4. Minimization History (Default Model). Table 10 result describes the minimization history of each iteration with the help of negative eigenvalues, condition numbers, and the smallest eigenvalues; the diameter also presents the *f*-statistical values. The result also presents that the ratio analysis's negative eigenvalues are 2, 1, 0, 0, and 0; its condition numbers are 1544.343, 61.392, 106.823, 118.055, 110.932, and 110.899, respectively. The result presents that diameter value is 9999.000, 0.786, 0.154, 1.289, and 0.130. According to the result, its ratio analysis values are 999.000, 0.858, 0.000, 1.057, 1.078, 1.016, and 1.000, respectively.

3.5. Model Fit Summary. Table 11–14 results describe that model fit summary of overall research included precise governance social assessment and perspective of management. The result presents the default models of each factor: the RMSEA value is 0.189, LO90 is 0.129, H190 is 0.254, and its overall probability value is 0.000 showing 100% significant level of the comprehensive research study. Therefore, the result shows that the model is fit for analysis; the PRATIO value is 1.333, and the PNFI value is −2.220. The result also presents that the NFI Delta1 model is −1.665 and the RFI rho1 default model is −0.999.

4. Discussions and Conclusion

Corporate governance affects the turn of events and activity of capital business sectors, just as on asset portion. As indicated by a review directed by the bookkeeping firm PwC, many organizations in the china are neglecting to accomplish a connection between pay and execution. For instance, they found that 7 of 270 public corporations put their compensation report to an investor vote. In addition, just 5% of organizations unveiled, even in broad terms, how execution measures identify with long-haul organization destinations [27–29]. While relative correlations build the adequacy of administrative impetuses and compensation productivity, the exact proof of relative exhibition impacts is relatively negative.

This research study describes that assessment effect of precise governance related to the social assistance in the perspective of management. This research study based on the primary data analysis for measuring the research used smart PLS and AMOS software and run informative analysis related to the social assistance. The overall result presents that there are positive and significant effects of precise governance social assistance based on perspective management. One justification for this could be that investment opportunities with an exhibition target should be considered an expense against benefits under current bookkeeping rules. At the same time, choices with a decent exercise cost do not lessen current profit. Accordingly, one arrangement suggestion is to bookkeeping rules for investment opportunities with variable and fixed exercise costs. For this situation, sheets would presently do not be deterred from binding

Table 10: The minimization history of each iteration.

Iteration		Negative eigenvalues	Condition no.	Smallest eigenvalue	Diameter	F	Entries	Ratio
0	e	2		−.301	9999.000	188.286	0	9999.000
1	e *	1		−.022	.786	79.234	18	.858
2	e	0	1544.343		.154	56.520	6	.885
3	e	0	61.392		1.289	42.559	4	.000
4	e	0	106.823		.130	36.549	1	1.057
5	e	0	118.055		.064	35.927	1	1.078
6	e	0	110.932		.015	35.916	1	1.016
7	e	0	110.899		.000	35.916	1	1.000

Table 11: CMIN.

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	6	35.916	8	.000	4.490

Table 12: Baseline comparisons.

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	−1.665	−.999	−4.097	−1.800	.000

Table 13: Parsimony-adjusted measures.

Model	PRATIO	PNFI	PCFI
Default model	1.333	−2.220	.000

Table 14: RMSEA.

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.189	.129	.254	.000

investment opportunities to execution. Given the significance of stock and investment opportunities in untouchable frameworks as a component of general administrative pay, special consideration should be paid to the plan of principal compensation bundles [30]. The Cadbury Committee suggested in China that there should be a compensation board of trustees that decides the degree of top pay. This panel is made up essentially of nonleader chiefs. While this is an admirable statement, found awry changes in leader pay levels, implying that chiefs who generally came up short in the past period get pay increments, while leaders who were overpaid are not exposed to descending changes. This is predictable with the protest of different investor bunches that compensation panels bid up leader pay rather than reinforcing the compensation execution relationship. These research studies raise genuine worries not just about the viability of chief compensation contracts but also about the inspirations driving them.

For example, when organization issues are severe and the board checking is insufficient, chief compensation, if not planned, can be one more vehicle for management lease confiscation. Employee remuneration plans may also serve to intensify short-termism. The spread of offer choices, for instance, may add to a transitory overvaluation of values and contort the economy by expanding administrators' impetuses to build transient investor esteem. Finally, there are no kidding worries about the administration's present act of giving obligation and utilizing the returns to repurchase value, in this manner expanding the company's portion cost. While what a firm is financed should not to mean its worth in principle, amazingly significant degrees of corporate obligation make a firm more defenseless against insolvency in case of a social assistance.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Entrepreneurial Willingness, Practice, and Management Path of College Graduates in a Green Development Environment

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Before entrepreneurial behavior occurs, individual personality traits have a very important impact on the formation of entrepreneurial willingness. The purpose of this research is to explore the entrepreneurial intention, practice, and management path of college graduates in a green development environment. In this study, three dimensions of green entrepreneurial traits (risk propensity, ecological values, and social responsibility) and three dimensions of green entrepreneurial motivation (fame and fortune motive, spiritual motive and responsibility motive, and green entrepreneurial intention) are determined, and a questionnaire is compiled. Then, the questionnaire survey data of college graduates is collected, and a structural equation model is constructed. The influence of risk tendency, ecological values, and social responsibility on green entrepreneurship motivation is studied in turn, and the influence of fame and fortune motive, spiritual motive, and responsibility motive on green entrepreneurship willingness is explored. Finally, the mediating role of the three dimensions of green entrepreneurial motivation in the influence of green entrepreneurial traits on green entrepreneurial willingness is tested. The study finds that the average score of families with entrepreneurial experience was 4.0526. The average score of families without entrepreneurial experience was 3.6463, and the significance index was at the level of 0.001. The same results as previous scholars have appeared, that is, students with entrepreneurial family background have stronger (green) entrepreneurial willingness. Green entrepreneurship creates green value through green products or services, drives green consumption, leads green values, and contributes to the sustainable development of society and ecology.

1. Introduction

In the current era of difficult employment for college students, although the state strongly supports innovation and entrepreneurship, the entrepreneurship rate of college students is still low. As an emerging entrepreneurial method, green entrepreneurship can not only solve the problem of college students' employment difficulties and stimulate economic growth, but also lead green consumption and spread green values, contributing to the sustainable development of the ecological environment. Understanding the structure and characteristics of college students' green entrepreneurial traits and green entrepreneurial motivation and deeply analyzing the impact and mechanism of the two on green entrepreneurial willingness of college students can help the education department identify potential green entrepreneurs. It is also possible to formulate clearer training goals and programs, encourage, and support more college students to invest in green entrepreneurship, so as to help more people put their green entrepreneurship will into practice. With the increasingly serious ecological and environmental problems, from environmental protection, sustainable development, ecological civilization, beautiful China to the concept of green development, it is the logical necessity of the continuous deepening of the ecological value proposition. The related research on college students as the object of education has also been deepened.

In the research on green entrepreneurship, there are very few researches on green entrepreneurship willingness by scholars, and few articles deal with the influence of personal characteristics on green entrepreneurship willingness. Radu-Lefebvre et al. argued that entrepreneurial legitimacy is described as a trigger for entrepreneurial career choice and motivation, which means that an individual's propensity to pursue an entrepreneurial career increases with the social legitimacy of the career [1]. Dutra's research data on entrepreneurial willingness was not very rich. He reviewed previous articles and optimized entrepreneurial willingness based on the green development environment. As one of the five development concepts related to the overall economic and social development, the concept of green development has a strategic, programmatic, and leading role [2]. Voda et al. believed that unemployment among young people has become a particularly serious problem [3]. Decreton et al. believed that the headquarters of multinational companies can help the development and transfer of innovative ideas of subsidiaries [4]. Ebrahimi and Mirbargkar assessed the role of green entrepreneurship [5]. Mrkajic et al. studied the selection bias between green and nongreen entrepreneurs [6]. Demirel et al. believed that the number of green start-ups is steadily increasing [7]. Yang et al. believed that green entrepreneurship is a special type of entrepreneurship that can achieve sustainable development and is advocated by many countries and regions [8]. Song and Lee believed that positive relationships are important for the skills and personal development required for entrepreneurship [9]. Green development is shared by everyone, and everyone is responsible. College students are the hope of the nation and the future of the motherland. The value orientation of green development will greatly affect the value orientation of the whole society in the future, and it is the key object of education on the concept of green development. The green development environment will be further introduced later.

This study takes college graduates as the object; explores the relationship between green entrepreneurial characteristics, green entrepreneurial motivation, and green entrepreneurial willingness of college graduates; and builds a theoretical model based on this. Combined with the existing research, the corresponding research hypotheses are put forward according to the theoretical model designed in this research. After confirming the scope and object of investigation, referring to the existing mature scales, and combining with the theoretical assumptions put forward, the initial questionnaire is drawn up. In the process of model validation, AMOS24 software is used to construct the structural equation model between variables. Firstly, the fit degree of the structural equation conceptual model is evaluated by using the model fit index. The survey of green entrepreneurial willingness finds that the standardized factor loadings of the five items of green entrepreneurial willingness are all greater than 0.5. Therefore, it is suitable for the next test of CR and AVE. The CR value obtained by calculation is 0.903, which is greater than 0.7. The AVE is 0.653, which is greater than 0.5. The results of ecological values study showed that the CR value was 0.840, which was greater than 0.7, and the AVE value was 0.568, which was greater than 0.5.

2. Method of Entrepreneurial Intention, Practice, and Management Path

2.1. Entrepreneurial Willingness. Willingness is an individual's subjective attitude toward a particular behavior. It helps predict actual behavior and reflects commitment to future actions. At the end of the twentieth century, under the dual role of market and ecological orientation, green entrepreneurship came into being. With the development of green entrepreneurship practice, the research on green entrepreneurship is also deepening, but scholars have no unified conclusion on the definition of green entrepreneurship so far. According to the theoretical analysis of entrepreneurial willingness and green entrepreneurship in this study, this research defines the green entrepreneurial willingness of college graduates as a subjective attitude of individual college graduates about whether to carry out green entrepreneurship in the future. This subjective attitude can predict whether they will conduct green entrepreneurship in the future. The influencing factors of entrepreneurial intention are shown in Figure 1. The measurement of entrepreneurial willingness can well identify potential entrepreneurs. Many scholars have done a lot of research on entrepreneurial willingness, but the research on green entrepreneurial willingness is relatively scarce. In addition, in the existing research, most of the influencing factors of entrepreneurial intention are from the personality traits of entrepreneurs, the external entrepreneurial environment and the entrepreneurial policies of the government or schools. Meanwhile, some studies have shown that entrepreneurial motivation is affected by the personal characteristics of entrepreneurs. However, existing research has not systematically considered the mediating role of entrepreneurial motivation in the relationship between entrepreneurial personality traits and entrepreneurial intention. Therefore, this paper explores potential green entrepreneurs by studying the relationship between green entrepreneurial characteristics, green entrepreneurial motivation, and green entrepreneurial willingness of college graduates. From the perspective of behavioral psychology, the prediction mechanism of individual psychology on behavior is discussed, specific green entrepreneurial situations are given, and psychological characteristics can more accurately predict which psychological characteristics can increase the possibility of their green entrepreneurial practice.

The independent variable X has an influence on the dependent variable Y, and M acts as an intermediary variable. X can influence Y through M. The relationship between variables can be described by the following regression equation as [10]

$$Y = cX + e_1, \tag{1}$$

$$M = abX + e_3, \tag{2}$$

$$Y_2 = cX + \mathrm{bm} + e_3. \tag{3}$$

Among them, c represents the direct effect of X on Y after controlling for M [11].

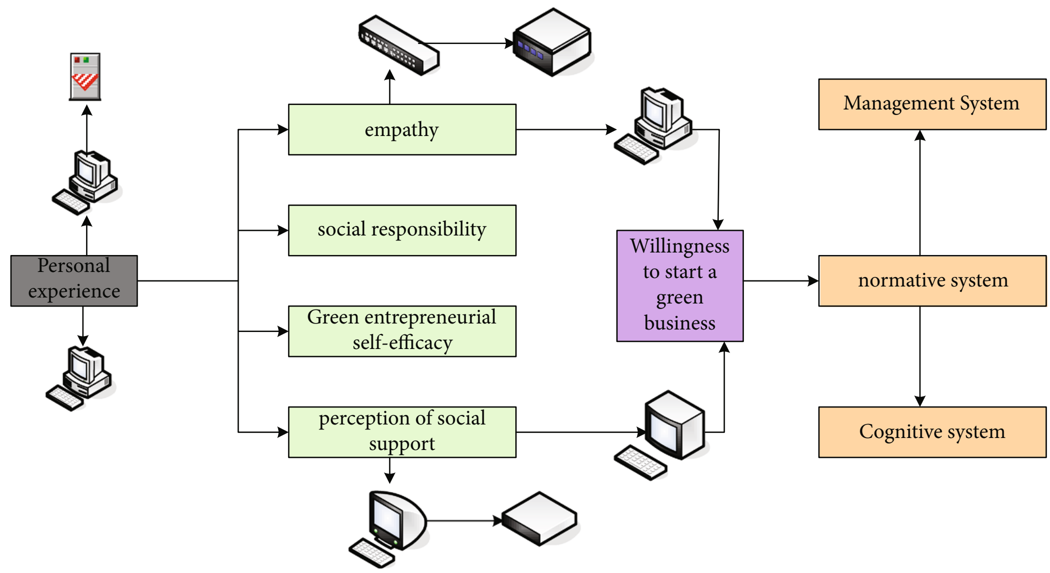


Figure 1: Influencing factors of entrepreneurial intention.

The product of the elements of each row of the matrix is calculated as [12]

$$m_i = \prod a_{ij}. \tag{4}$$

The n-th root of m_i is calculated as

$$W_i = \sqrt[n]{m_i}. \tag{5}$$

It is normalized through [13]

$$w_g = (W1, W2, \cdots Wn)^T. \tag{6}$$

The largest eigenvalue λ max is computed as

$$\lambda \max = \frac{1}{N} \sum \frac{A}{W}. \tag{7}$$

The index CI of the inconsistency of matrix A is calculated as [14]:

$$\mathrm{CI} = \frac{[\partial(A) - n]}{(n-1)}. \tag{8}$$

Green entrepreneurs focus on sustainable strategies, that is, emerging technologies, markets, suppliers, customers, and other stakeholders, which mean breakthrough innovation. Sustainability here includes two possible aspects. One aspect refers that green entrepreneurship is a structural system, and all elements and links in the system, including entrepreneurial motivation, process, and team spirit, should have a neutral or positive impact on the environment. The other is that some aspects of the entire green entrepreneurship process are in line with green requirements, while other aspects may not necessarily meet. The index CR of the consistency of matrix A is calculated as [15]

$$\mathrm{CR} = \frac{\theta \mathrm{CI}}{\mathrm{RI}}. \tag{9}$$

2.2. Green Development Environment. Willingness is the precondition of individual behavior, and entrepreneurial willingness under green development environment is the key link in entrepreneurial research under green development environment. Personality traits of individuals have an important impact on their entrepreneurial intentions. Entrepreneurship in a green development environment has higher requirements on the entrepreneur's personality traits such as risk inclination, ecological values, and social responsibility. The entrepreneurial theory believes that entrepreneurial motivation is an effective indicator to predict the entrepreneurial willingness and behavior of individuals. The main techniques of the study are shown in Figure 2. Different dimensions of motivation have different degrees of influence on the formation of entrepreneurial intention. Entrepreneurs in a green development environment may have the will to start a business in a green development environment out of motivations such as gaining fame and fortune, realizing spiritual pursuits, and taking on environmental protection and social responsibilities. Previous studies have found that personality traits such as risk-taking tendencies have an impact on entrepreneurial motivation. Entrepreneurial activities in a green development environment have higher risks, and individuals with strong ecological values and social responsibility are more likely to engage in entrepreneurial activities in a green development environment. Therefore, entrepreneurial motivation in a green development environment is likely to be affected by individual risk tendencies, ecological values, and social responsibility.

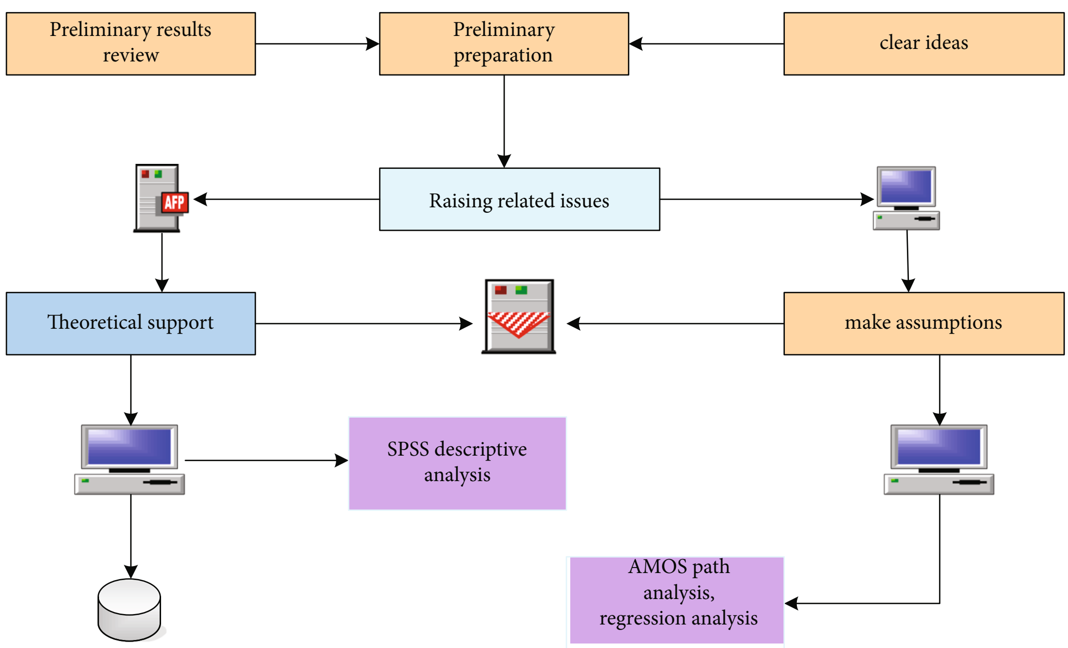


Figure 2: Main techniques of the study.

The arc elasticity coefficient R in economics is introduced as [16]

$$R = \frac{(N/M)}{[N/(M1 + M2)]}. \tag{10}$$

Green entrepreneurship stability is Z_M, as shown in

$$\delta = \frac{\pi}{2(g + h + i + e + t)}. \tag{11}$$

The diffusion efficiency of entrepreneurial behavior in the whole group of college graduates will be affected.

The essence of entrepreneurship is innovation and change, and innovative green business practices can bring competitiveness while improving environmental performance. Ecoentrepreneurship builds a bridge between business success and protection of the ecological environment through environmental innovation. The difference between their ecological entrepreneurship and other entrepreneurship is that they are oriented to protect the ecological environment, and most of this way of protecting the ecological environment is achieved through innovation. Influence coefficients δ_J and δ_I for diffusion between entrepreneurial behaviors can be obtained through

$$\delta_{J=}\delta_I(G, H, I, E, T), \tag{12}$$

$$\delta_{I=}\delta_{CE}(G, H, I, E, T). \tag{13}$$

Expression in mathematical mode: it is supposed that the input set of subject M is Z_M [17]:

$$Z_M = \{Z_1, Z_2, \cdots, Z_N\}. \tag{14}$$

The output set is Y_M [18]:

$$Y_M = \{Y_1, Y_2, \cdots, Y_N\}. \tag{15}$$

Since the input determines the output, there is

$$Y = F(XV). \tag{16}$$

Compared with ordinary entrepreneurship, green entrepreneurship has higher requirements for product or service innovation, and the market entry threshold is higher. Meanwhile, the awareness of green consumption among Chinese residents is not strong enough, so green entrepreneurship is more difficult to succeed than ordinary entrepreneurship. Although people with high-risk propensity are willing to experience high-risk entrepreneurial activities, relatively speaking, their ecological environment protection concept and social responsibility have a greater role in promoting the formation of their green entrepreneurial willingness. Gray evaluation weight Re of the e-th gray category of evaluation index V is shown as

$$\mathrm{Re} = \frac{\mathrm{Xi}}{\mathrm{Xj}}. \tag{17}$$

Then, the gray evaluation weight vector of each gray category is obtained as [19]

$$r_{11} = [m]\begin{pmatrix} r_1 & \cdots & r_{151} \\ \vdots & \ddots & \vdots \\ s_{11} & \cdots & s_{11} \end{pmatrix}. \tag{18}$$

Comprehensive evaluation of the awareness of college graduates' self-employment support system is

$$G = \mathrm{HQ} = [H_1 \cdots H_N]. \tag{19}$$

If the adoption of implementation behavior a (entrepreneurial behavior) leads to different profit and loss values w, the probability of being finally realized is P. If the implementation behavior b (nonentrepreneurial behavior: employment or unemployment, etc.) is adopted, resulting in different profit and loss values w, the probability of realization is q. Decision-makers choose entrepreneurial behavior a over nonentrepreneurial behavior b mainly based on the following basis as

$$\sum g(p)v(\Delta w - c) > \sum g(q)v(\Delta w - c). \tag{20}$$

In Formula (20), Δw represents the deviation of profit and loss caused by the implementation of the behavior.

2.3. Green Entrepreneurship Questionnaire Design. The research objects were college graduates, and a total of 507 questionnaires were distributed. Among them, 307 questionnaires were collected, and 200 paper questionnaires were distributed on the spot. Excluding the questionnaires with missing answers and inaccurate filling (the normal filling time of the questionnaire was 2.5-3.5 minutes, excluding the questionnaire star and the answer sheet with the paper questionnaire filling time less than 2 minutes), a total of 461 valid questionnaires were recovered, and the effective rate of the questionnaire was 90.9%.

2.3.1. Preresearch. The survey data of this study were obtained by two methods: network distribution and field research. In order to ensure the credibility and authenticity of the questionnaire, this study will conduct on-site interviews in classrooms, libraries, study rooms, and other places and distribute the questionnaires. For network, first, the questionnaires were formed on the Questionnaire Star platform, and then the questionnaires were distributed through QQ and WeChat platforms. For field, questionnaires were distributed to major colleges and universities in the city. The conclusion of this study was drawn through the data entry, arrangement, and necessary analysis of the questionnaire. The design process of the questionnaire for this study is as follows:

Firstly, the measurement of each variable referred to mature scales that have been used many times in existing studies. Usually, the scales that have been tested by many studies have good reliability and validity, which can not only effectively shorten the time for researchers to conduct questionnaire tests, but also ensure the reliability of research results.

Secondly, since the scales referred to are mostly mature scales, literal translation and back-translation of the scales were carried out to ensure the accuracy of the content of the translated version. In order to adapt to the habit of the Chinese context, appropriate adjustments have been made to the words and expressions of the items. Before the formal investigation, this study conducted a small-scale pretest with students around the school as subjects. The pretest subjects were mainly postgraduate students around them, and the questionnaires were distributed online and on-site. 50 questionnaires were distributed, and a total of 48 were returned. Excluding the 5 invalid questionnaires with missing answers, regular answers, and not serious filling (the basis for judgment is that the filling time was less than 2 minutes), the number of valid questionnaires was 43, and the effective rate of the questionnaires was 89.6%. Reliability analysis and exploratory factor analysis were carried out on the preinvestigation data, and the Cronbach's coefficient of each variable's reliability index was greater than 0.7. The validity index KMO (Kaiser-Meyer-Olkin) value and Bartley's sphericity test results met the requirements, and the principal component analysis results showed that the variable dimension was consistent with the research design. In addition, according to the analysis results of the questionnaire data and the feedback of the survey respondents, teachers and doctoral students in the professional field were invited to discuss and evaluate. Considering that too many items in the questionnaire would affect the answering experience of the respondents, the questions about the subject's school and the current major in the basic information were deleted. The items that might cause ambiguity were adjusted accordingly to form the final version of the measurement questionnaire.

2.3.2. Composition of the Questionnaire. The scales in the questionnaire of this study were standardized according to the Richter 5-level scale. There were 42 items in this survey questionnaire, 34 items in the core part, and 8 items in the basic information part. There were 7 research variables in the questionnaire, including risk tendency, ecological values, social responsibility, green entrepreneurship motivation (including three dimensions of fame and fortune motive, spiritual motive, responsibility motive), and green entrepreneurship willingness, with a total of 34 items.

The first part was the measurement scale of green entrepreneurial traits, with a total of 18 items. There were 5 items in risk propensity. Ecoenvironmental values referred to the 2007 WVS (World Values Survey) questionnaire on the Chinese public's ecoenvironmental values. There were 7 items in total to measure the ecological values of college graduates with four dimensions: the view of dedication to environmental protection, the view of economic-environment relationship, the view of environmental problem cognition, and the environmental satisfaction. The sense of social responsibility measured the sense of social responsibility from the four dimensions of social morality, sense of urgency, self-discipline, and dedication.

The second part was the green entrepreneurship motivation scale. Green entrepreneurial motivation referred to the research on entrepreneurial motivation of college graduates. The motivation of green entrepreneurship is divided into three dimensions: fame and fortune, spirit, and responsibility. Considering that this paper studies the green entrepreneurship willingness of college graduates, the question of contributing to the construction of the ecological environment was added to the responsibility motivation, with a total of 11 questions.

The third part is the green entrepreneurship willingness scale. Green entrepreneurial willingness drew on the entrepreneurial willingness measurement scale and made appropriate modifications according to green entrepreneurial willingness, with a total of 5 items. In addition, referring to previous studies by scholars, this paper selected the gender, age, educational background, whether they have received entrepreneurship education, whether they have entrepreneurial experience, whether they have work experience, whether their family members have business experience, and whether they are an only child as eight items of background information to investigate the basic information base of the tested object.

3. Results of Entrepreneurial Intention, Practice, and Management Path

Before the confirmatory factor analysis of the ecological value scale, the KMO and Bartlett sphericity test values were tested by SPSS25 software. The test results are shown in Table 1. It can be seen that the KMO test value of the ecological value scale was 0.922, which was greater than 0.70. The results indicated that the ecological value scale is suitable for the next factor analysis.

Confirmatory factor analysis was performed on the ecological value scale by AMOS24 software. The value of X^2/dF was 0.544, which was less than 3. The values of NFI, CFI, and GFI were all greater than 0.9 and very close to 1. The value of RSMEA was less than 0.05. The above five indicators all met the requirements, indicating that the fitting degree of the ecological value model meets the requirements. The confirmatory factor fitting indicators of ecological values are shown in Table 2. Amos 24.0 is a full-featured structural equation modeling (SEM) software.

It can be seen from Table 3 that the standardized factor loadings of the seven items of ecological values are all greater than 0.5, indicating that the next step of CR and AVE tests is suitable. The calculated CR value was 0.840 (>0.7), and the AVE value was 0.568 (>0.5). The above indicators showed that the combined reliability and convergent validity of the ecological values scale are ideal. The convergent validity test of the ecological values questionnaire is shown in Table 3. CR is a reliability standard, which means that the indicators in the evaluation index system are interrelated and consistent, and there is no conflict or irrelevance. The evaluation index system is highly consistent with the performance dimension and distribution of the evaluation object.

Since each software has its own advantages and disadvantages, in order to ensure the quality of the research, multiple software verifications are carried out. Before the confirmatory factor analysis of the green entrepreneurship motivation scale, the KMO and Bartlett sphericity test values were tested by SPSS25 software. The results are shown in Table 4. KMO test value of the green entrepreneurial motivation scale was 0.880, which was greater than 0.70. Approximate chi-square value was 2088.214, and the significance probability was 0.000 ($P < 0.001$), all of which met the requirements.

Table 1: KMO and Bartlett's test.

KMO sampling appropriate quantity	Related parameters	0.922
Bartlett's sphericity test	Approximate chi-square	1583.552
	df	20
	Sig	0.000

Table 2: Confirmatory factor fitting indicators for ecological values.

Model	Index
X^2/dF	0.544
NFI	0.997
CFI	1.134
GFI	0.997
RMSEA	0.00

It can be seen from Table 5 that the value of X^2/dF was 0.2011, which was less than 3. The value of NFI was 0.733. The value of CFI was 0.820. The value of GFI was greater than 0.9 and very close to 1, and the value of RSMEA was less than 0.05. It can be judged that the fitting degree of the green entrepreneurial motivation model is acceptable. The index factors of green entrepreneurial motivation are shown in Table 5.

The standardized factor loadings of the 11 items of green entrepreneurial motivation were all greater than 0.5, indicating that the next step is suitable for the test of CR and AVE (CR is shown in Figure 3(a)). The calculated CR values of fame and fortune motive, spiritual motive, and responsibility motive were 0.869, 0.806, and 0.736, respectively, which were all greater than 0.7, and the AVE value of each variable was greater than 0.5. The above indicators showed that the combined reliability and convergent validity of fame and fortune motives, spiritual motives, and responsibility motives are very ideal (AVE is shown in Figure 3(b)).

The convergent validity test results of the green entrepreneurship intention questionnaire are shown in Figure 4. The standardized factor loadings of the five items of green entrepreneurial intention were all greater than 0.5, indicating that it is suitable for the next test of CR and AVE. The calculated CR value was 0.903 (>0.7). AVE was 0.653 (>0.5) (the results of those who were very interested in green entrepreneurship, with serious consideration about green entrepreneurship, and would like to try their best to start their own green business are shown in Figure 4(a)). The above indicators showed that the combined reliability and convergent validity of green entrepreneurship intentions were very ideal. In addition, the AVE value was also used to test the discriminant validity of the scale. The square root of the mean and the correlation coefficient between the variables are compared. The discriminant validity of the scale is good if the square root of the mean of the latent variable is greater than its correlation coefficient with other latent

Table 3: Convergent validity test of the ecological values questionnaire.

Variable	Item	Normalized factor loadings	Combined reliability(CR)	Average extracted variance (AVE)
Social responsibility	1. Only be a follower of social morality, but also a leader of social morality	0.745	0.840	0.568
	2. Be prepared for danger in times of peace and enhance the awareness of danger	0.767		
	3. Affect the city appearance and public environment in public places	0.681		
	4. I will actively participate in group activities	0.771		
	5. Donate after a major disaster	0.723		

Table 4: Green entrepreneurship motivation scale KMO and Bartlett spherical test values tested.

KMO sampling appropriate quantity	Related parameters	0.880
Bartlett's sphericity test	Approximate chi-square	2088.214
	df	54
	Sig	0.000

Table 5: Indicator factors of green entrepreneurial motivation.

Model	Index
X^2/dF	0.2011
NFI	0.733
CFI	0.820
GFI	0.950
RMSEA	0.49

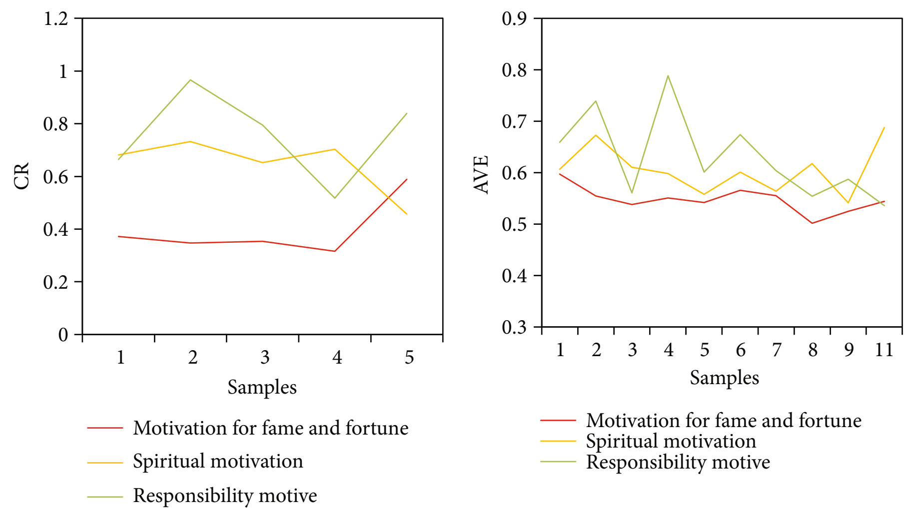
variables in the model (the results of those who were preparing for green entrepreneurship in the future and firmly believed that green enterprises would be established in the future are shown in Figure 4(b)). The comparison showed that the square root of the AVE value of each latent variable was larger than the Pearson correlation coefficient of this latent variable and other latent variables, so it can be proved that each variable scale has good discriminant validity.

From the statistical analysis results shown in Figure 3, it can be seen that among the respondents, males accounted for 46.9% and females accounted for 53.1%. The gender ratio of the sample was basically the same (the gender ratio is shown in Figure 5(a)). In terms of age, the proportion of the sample size was 87.9% for people aged 19-25 and 7.8% for people aged 26-30. This age distribution was in line with the age distribution of college students in all grades. The above two data showed that this survey met the requirements of random sample sampling (the proportion of age is shown in Figure 5(b)). It can also be seen from the table that in terms of educational background, the majority of the surveyed groups were college graduates. In addition, the number of people who have received entrepreneurship education only accounted for 32.2% of the total number of respondents, which showed that the current investment in entrepreneurship education in colleges is not large enough, and students' interest in entrepreneurship education also needs to be improved. The number of people with entrepreneurial experience only accounted for 11.9% of the total number of surveys, indicating that the current entrepreneurial atmosphere of college graduates is not strong enough, and the corresponding publicity and encouragement policies are not familiar to the majority of students. Meanwhile, the entrepreneurial awareness of college graduates also needs to be improved.

According to the research content of the survey report on ecological cognition, it is concluded that the ecological awareness of current college graduates is not strengthened enough. Although college graduates have a certain ecological knowledge base, their knowledge is relatively shallow, and their understanding of professional knowledge about ecological environment and relevant national policies and regulations needs to be further improved. There are differences in the mastery of different types of environmental knowledge among college graduates. Specifically, first, in terms of ecological scientific knowledge, the mastery of air quality knowledge was 66.3%, and the mastery of water environment quality was 38.7%. This shows that college students' mastery of ecological science knowledge is not comprehensive enough, and there are major problems (air quality and water environment quality are shown in Figure 6(a)). In terms of daily scientific knowledge and value awareness of environmental protection and resource conservation, there is also a phenomenon that ecological awareness is not strengthened enough (daily behavioral skills knowledge and common scientific knowledge are shown in Figure 6(b)). The mastery of daily behavior skills accounted for 85.5%, and the supervision and reporting accounted for 14.5%.

The survey on purchasing green products is shown in Figure 7. Nearly 90% of the respondents believed that it is important to purchase green food that meets the standards and green products with low pollution when shopping. But only 29.3% and 38.5% of the respondents made frequent purchases. Among them, the 18-30-year-old group was the smallest among all age groups.

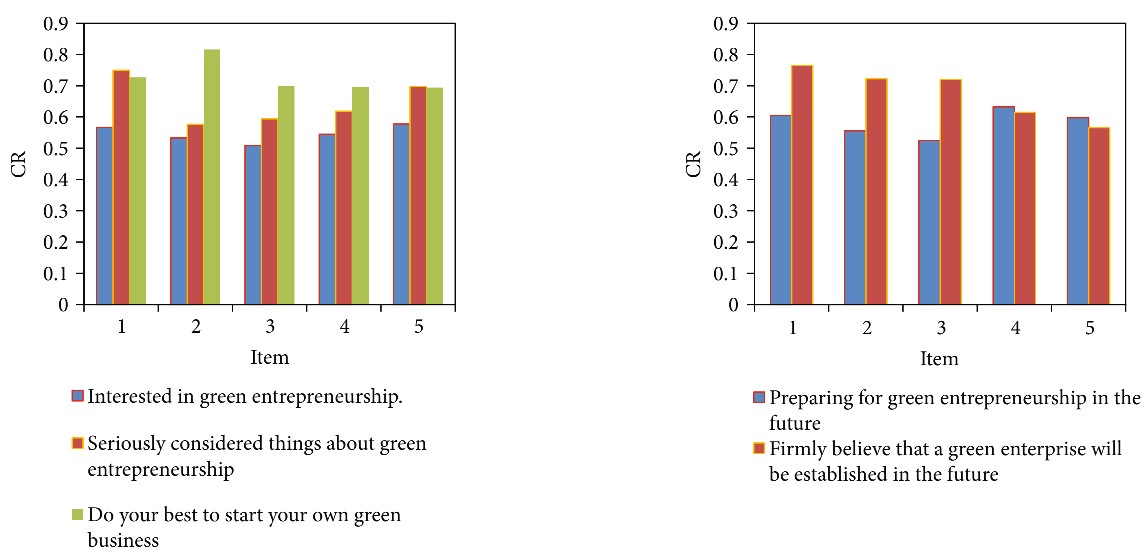
The survey on working hours is shown in Figure 8. 29.91% of the respondents worked for less than one year, 19.63% for 1-2 years, 27.10% for 2-3 years, 17.29% for 3-4



(a) CR

(b) AVE

Figure 3: Examination of green entrepreneurial motivation.



(a) Results of those who were very interested in green entrepreneurship, with serious consideration about green entrepreneurship, and would like to try their best to start their own green business

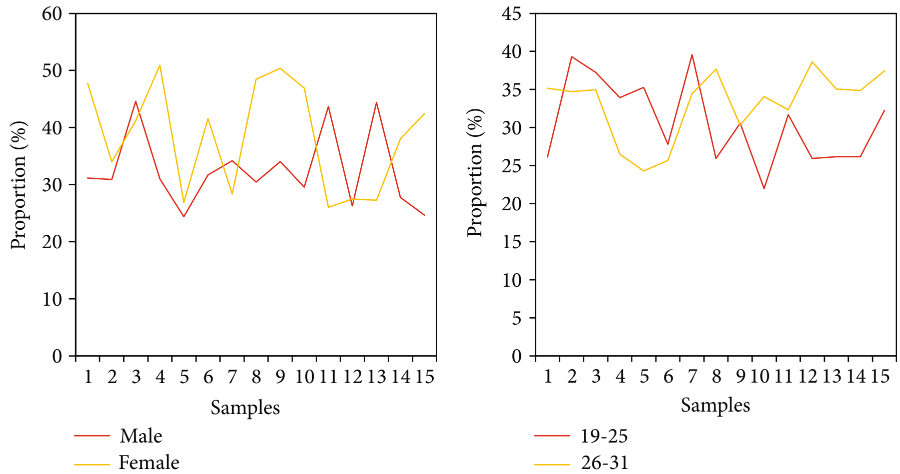
(b) Results of those who were preparing for green entrepreneurship in the future and firmly believed that green enterprises would be established in the future

Figure 4: Convergent validity test results of the green entrepreneurship willingness questionnaire.

years, and 6.07% for more than 4 years. The distribution of college student entrepreneur time is relatively even. With the passage of time, college student entrepreneurs may withdraw from entrepreneurship due to lack of funds, excessive pressure, project failure, social situation, and other reasons. There are relatively few people who can reach more than 3-4 years, and the others are mainly college students who have not yet encountered many pressures or have not worked for a long time.

The survey on the field of the enterprise is shown in Figure 9. The primary industry accounted for 7.94%. The secondary industry accounted for 18.23%. The tertiary industry accounted for 73.83%. College students have advanced thinking and can quickly accept new things. They themselves have some scientific and cultural knowledge, mainly involved in the field of scientific and technological services. Some of them also start businesses in agriculture and industry for their own reasons. However, there are many more college students and entrepreneurs in the service field.

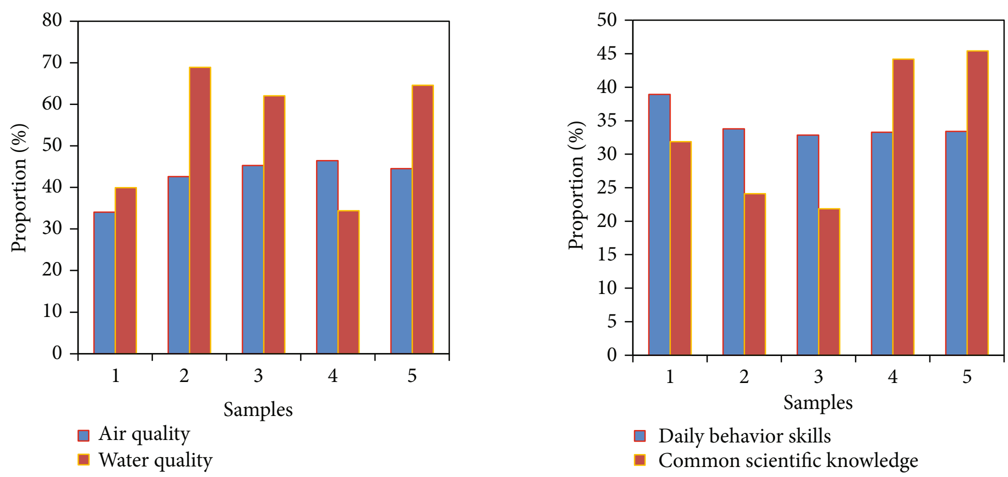
There is no significant difference in the performance of students' gender, age, education, and major in green entrepreneurship willingness, indicating that different gender, age, educational level, and professional background will not have a significant impact on college students' green entrepreneurship willingness. This is different from the previous research results. The reason for this result may be because of the unique attributes of green entrepreneurial



(a) Gender ratio

(b) Age ratio

Figure 5: Statistics of basic information of survey respondents.



(a) Air quality and water environment quality

(b) Daily behavioral skills knowledge and common scientific knowledge

Figure 6: Survey content on ecological cognition.

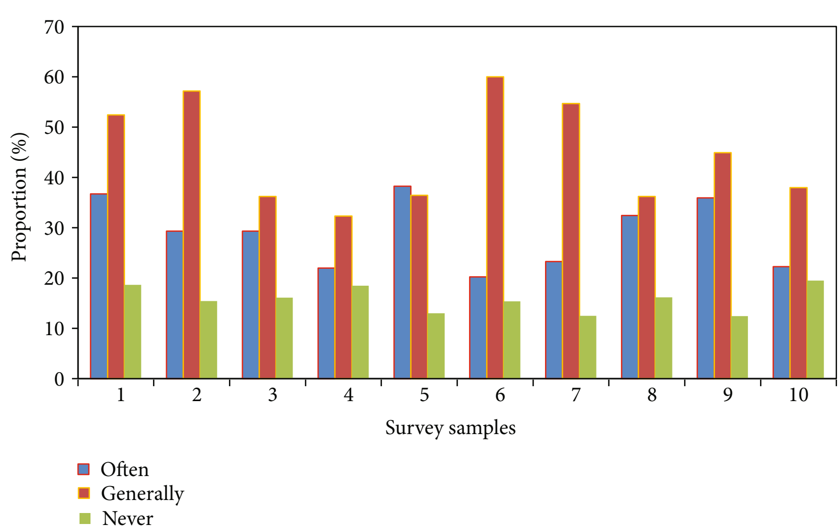


Figure 7: Survey on purchasing green products.

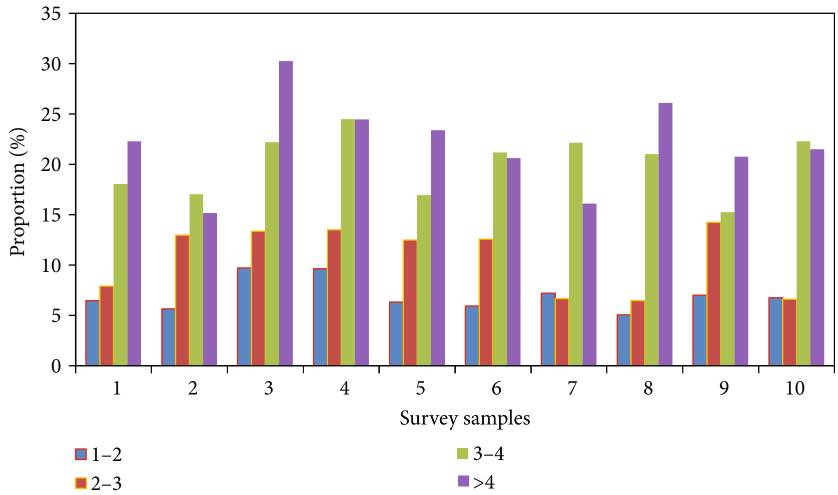


Figure 8: Survey on working hours.

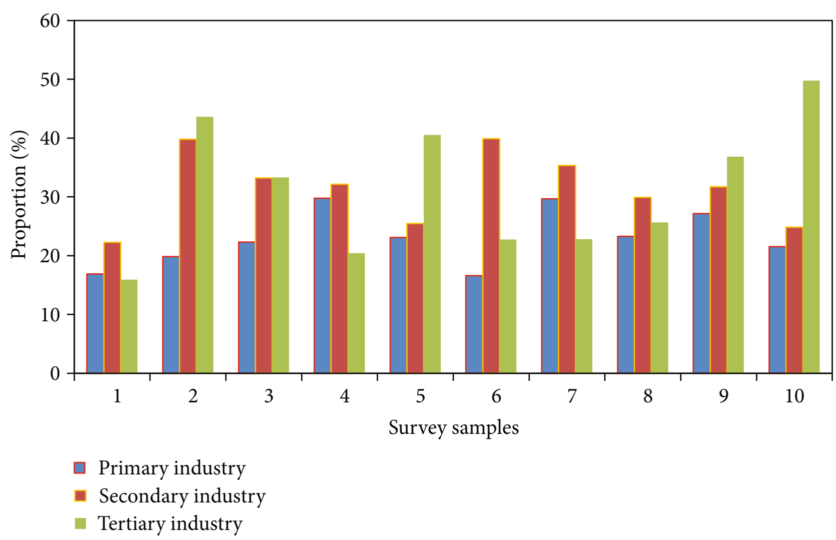


Figure 9: Aspects of the company's field survey.

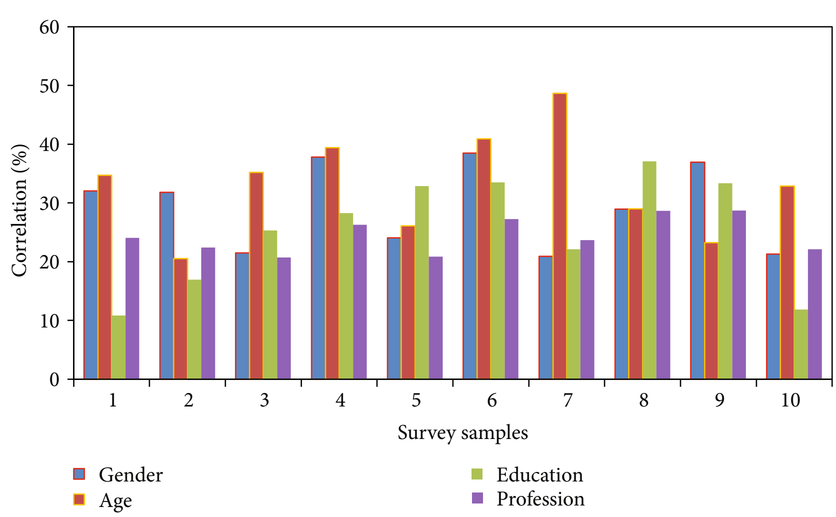


Figure 10: Difference analysis results.

willingness, which is different from the traditional entrepreneurial willingness. But it is worth noting that when exploring the influence of family's entrepreneurial background on college students' green entrepreneurial willingness, the average score of families with entrepreneurial experience was 4.0526, and the average score of families without entrepreneurial experience was 3.6463. Significance was presented at the 0.001 level greater than 0.05. The same results as previous scholars have appeared, that is, students with entrepreneurial family background have stronger (green) entrepreneurial willingness. This may be because the students will be influenced by the family entrepreneurial atmosphere and then subtly take entrepreneurship as the main way of making a living in the future and actively think about the problems of entrepreneurship to prepare for the future. The difference analysis results are shown in Figure 10.

4. Conclusion

Green entrepreneurship is a way to balance ecological and commercial benefits. College graduates' green entrepreneurship is a new branch of college graduates' entrepreneurship. It has some basic characteristics and conditions that entrepreneurship should have and also has the distinctive feature of green. The connotation of sustainable development is the inexhaustible driving force for green entrepreneurship of college graduates. This study incorporates risk tendency, ecological values, and social responsibility into the evaluation of entrepreneurial intention. People with strong ecological values usually hope to practice their values through practical actions, and they can obtain a greater sense of satisfaction and achievement in the process of ecological protection. Therefore, people with strong ecological values are more likely to have the idea of green entrepreneurship out of spiritual motivations such as realizing personal value and gaining a sense of achievement. The research object selected in this study is college graduates, which has certain limitations. Although under the guidance of policy incentives and education, the main target groups of green entrepreneurship activities are college students, but there are still some green entrepreneurs who are not in school. In the future work, colleges should first focus on the education of values and sense of responsibility, guide college students to establish ecofriendly values, and cultivate their sense of social responsibility. Secondly, colleges and universities should be guided by ecological values and social responsibility to identify potential green entrepreneurs. Through publicity and guidance, a communication platform between college graduates and green entrepreneurs is built to stimulate students' green entrepreneurial motivation. In the future work, we can explore the influencing factors and guarantees of green entrepreneurship, which will make the impact of green entrepreneurship more extensive.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

A Study of Fiscal Expenditure Structure and Green Economic Growth Effects: A Sample from Asian Economies

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The structure of fiscal expenditure in China has been suffering from over-reliance on a single type, while synchronisation and coordination with economic growth are lacking. This paper studies and analyses fiscal expenditure and green from a theoretical perspective. There is a close link between the structure of fiscal expenditure and green economic growth, and a reasonable and appropriate selection and allocation is conducive to promoting the overall development level of China, while financial resources input is a key consideration in optimising the structure of fiscal expenditure. This paper proposes hypotheses and establishes a regression model after an in-depth study of fiscal expenditure in a provincial economy in Asia in the light of domestic and international literature. Through empirical analysis, a green GDP reflecting economic growth and environmental pollution is synthesised using the principle of output per unit of pollution, and the impact of fiscal expenditure structure on green economic growth in China is empirically tested.

1. Introduction

The structure of fiscal expenditure has been a hot issue for scholars both at home and abroad and has been analysed and discussed in great depth. However, the government as a public good has the characteristics of non-competitiveness and exclusivity: firstly, it has the same indivisibility as other commodities; secondly, it is a form of public service supply or service supply; finally, there are two main sources of finance for fiscal expenditure: one is the central and local budget allocation, and the other is provided through tax revenue [1]. However, in the process of reform and opening up, many new problems have emerged. For example, the lack of investment in the "three rural areas," the backwardness of rural infrastructure construction and a series of other problems have plagued the process of economic development, and the problem of financial resources has become increasingly prominent. At the same time, as the level of social productivity increases [2], China's consumption of natural resources continues to intensify and other factors lead to serious environmental pollution and waste of resources, which seriously restrict our green economy and sustainable development. The consequences of the unreasonable structure of fiscal expenditure, such as the waste of resources and low utilisation rate, are already unimaginable. Therefore, how to adjust and optimise the relationship between fiscal expenditure structure and green GDP has become one of the hot spots of current research [3].

Fiscal expenditure has always been the top priority of China's economic development, playing an important role in promoting social equity and resource allocation, as well as being of great significance to the achievement of scientific and sustainable development in China. However, in recent years [4], the government has been increasing its efforts in environmental protection to strengthen environmental protection and ecological construction. The 12th Five-Year Plan for Energy Conservation and Emission Reduction was officially implemented on 1 May 2016, and the introduction of green fiscal policies was adopted [5].

The structure of fiscal expenditure refers to the allocation of funds by the national government within a certain period of time, which reflects the allocation of various resources and the proportional relationship between various economic factors in the process of social reproduction. With the rapid development of China's economy, fiscal expenditure is becoming more and more important in the national economy, but at the same time, there are also many problems [6]. As environmental pollution, resource waste and ecological damage are becoming increasingly serious, and how to achieve sustainable solutions to these problems has become a new issue facing the government. This paper argues that there is a link between green economic growth and the structure of fiscal expenditure as follows: the two have different degrees of impact on income and employment. The former measures the overall development of a region or industry in terms of total GDP, while the latter reflects a country's position and role in the national economy through the direct and indirect effects of national fiscal revenues as a percentage of gross national product (GNP) [7]. This paper analyses the relationship between green fiscal policy and industrial structure to understand the current trends in industrial structure and to discover what factors have influenced the current state of China's economic development and the future direction of economic development, and on this basis to propose corresponding optimisation measures to better promote the coordination of China's overall social, environmental, resource, and ecological benefits [8–10].

2. Analysis of the Factors Influencing the Promotion of Green Economic Growth

2.1. Analysis of the Mechanism for Promoting Green Economic Growth. In the past economic growth process, people generally focus more on the cycle between the economic system and the social system, but less consider the virtuous cycle between the economy, society, and the ecosystem. This phenomenon is evident in both theory and practice, for example, the Douglas production function, the endogenous economic growth model, the Solow economic growth model, and other classical growth models do not consider the contribution of ecosystems to economic growth. In practice, under the market mechanism, it is difficult for the economic system to spontaneously form a reasonable compensation mechanism for the ecosystem. Under the crude economic growth model, the dependence of economic growth on the inputs of ecological factors is higher, and the degree of damage to ecosystems is more serious. The negative feedback force between the economic and social systems and ecosystems is more obvious, and this imbalance leads to development that is not sustainable. As shown in Figure 1, it is generally accepted that the social system contributes to the growth of the economic system by providing labour and investment, and the economic system raises people's material living standards by providing goods and services.

The above diagram shows that economic growth is the result of joint inputs from social and ecological systems. The ecosystem provides ecological factors and services, and the social system provides labour and capital, which together contribute to economic growth. In turn, economic growth provides goods and services to the social system without

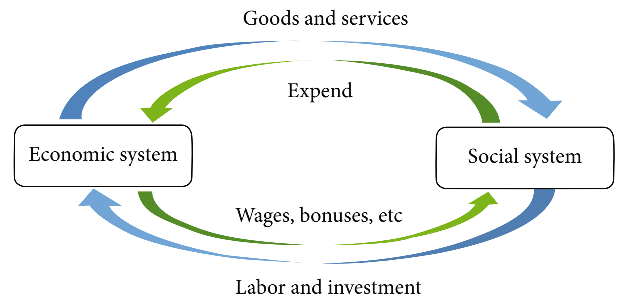

Figure 1: Diagram of the cycle of operation of the economic and social systems.

providing positive feedback to the ecosystem, making it difficult for the ecosystem to be reasonably compensated. At the same time, there are also negative feedbacks between the social system and the ecosystem [11]. The pollutants and wastes produced by society in the process of consuming goods and services will cause further degradation of the ecosystem and impede social development. This deterioration of the ecosystem will also result in a reduction in the "quality" and "quantity" of ecological factors and services available from the ecosystem, which will impede economic growth and lead to a reduction in the goods and services available from the economic system, thus creating a vicious circle [12].

There are both negative and positive feedback mechanisms between the three systems. Only by forming a positive feedback mechanism between the three systems can a balanced development be achieved and the three systems can co-exist and jointly promote green economic growth. First, the positive feedback relationship between the economy and the ecosystem. Ecological factors and services are input into the economic system and are the basis for economic growth. At the same time, economic growth creates a material base, a level of science and technology that can repair and rebuild ecosystems and can enhance the ability of ecosystems to cycle through to provide ecological factors and services. Secondly, there is a positive feedback relationship between social systems and ecosystems. The social system has human development as its main goal, and the improvement of the comprehensive quality of human beings is conducive to people raising their awareness of environmental protection, improving their level of science and technology, and contributing to the protection and repair of the ecological environment [13]. On the other hand, the ecological environment is also the basis for people's survival and life, so the good or bad ecological environment is the basis for social development. Thirdly, there is a positive feedback mechanism between the economic and social systems. On the one hand, the economic system is the basis of human development and is the foundation of social development. The development of the economic system is the basis for social development. Economic growth is both the basis for human material life and makes it possible to improve education and scientific and technological innovation, thus promoting social progress. On the other hand, social development can also contribute to economic development.

Social conditions such as social harmony, fair distribution, effective forms of cooperation, and highly qualified human resources are more conducive to driving economic growth [14]. As shown in Figure 2, the three systems can either constrain or reinforce each other and develop together.

Thus, there is a mutual feedback mechanism between the three systems. The ecosystem is the basis for development, while there are also positive and negative feedback effects of economic system development on the social and ecological systems. Green economic growth is not the absence of economic development, but the formation of positive economic, social, and ecological feedback mechanisms.

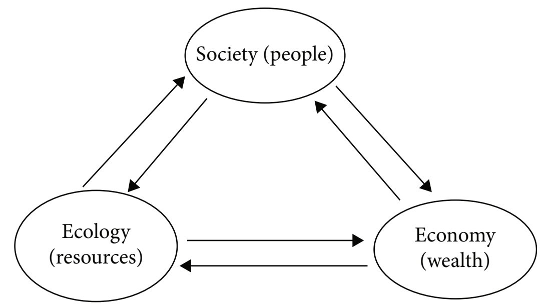

Figure 2: Diagram of positive feedback mechanisms for ecological, economic, and social systems.

2.2. Using the Cobb-Douglas Production Function to Construct a Green Economic Growth Model. The classical Cobb-Douglas production function considers only the amount of capital and labour inputs, and the Cobb-Douglas production function is as follows.

$$Y = AL^{\alpha}K^{\beta}. \quad (1)$$

Y represents the quantity of output, A represents the total factor productivity, L represents the quantity of labour, K represents the quantity of capital, and α and β represent the elasticity of labour and capital to output, respectively, $0 < \alpha$ and $\beta < 1$.

Green economic growth is people-centred development, a balanced development of ecosystems, social systems, and economic systems. The Douglas production function, which includes ecological occupation, means that the level of labour, capital, and ecological factor inputs determines the level of output of the economy at a certain total factor productivity. Ecological factors, as one of the driving forces of economic growth, should be included in the Douglas production function. The Douglas production function with ecological occupation is as follows: assume that the annual ecological factor input is $E1$ and γ indicates the elasticity of ecological occupation with respect to output, $0 < \gamma < 1$.

$$Y = E_1^{\gamma}AL^{\alpha}K^{\beta}. \quad (2)$$

The progressive aspect of $E1$, together with L and K, as an input factor for economic growth is that the ecological factor input is not an output of labour and capital, but a primitive input factor parallel to labour and capital, which represents when the ecological factor is not fully regenerative, not constantly regenerative by the increase in the amount of labour and capital. The economy is not constantly increasing in production only by increasing the amount of labour and capital.

2.3. Accounting for the Costs of Economic Growth and Growth Models that Incorporate Green Economic Growth Mechanisms. It is generally accepted that economic growth and social consumption lead to an increase in ecological occupation and thus in the cost of development. On the one hand, an increase in the ecological inputs required in the process of economic growth leads to an increase in ecological occupation. On the other hand, the increase in pollutants and waste generated by economic production and social consumption leads to an increase in ecological occupation. The increase in ecological occupation not only increases ecological costs but also social costs. Ecological occupation and the ecological environment are negatively related. When ecological occupation exceeds ecological carrying capacity, the ecological environment will be damaged, i.e., an increase in ecological occupation will lead to a decrease in the total ecological environment, a decrease in the ecological elements and ecological services available in the ecological environment, and an increase in ecological costs. The destruction of the ecological environment will lead to a series of social problems, such as an increase in the incidence of cancer and lung disease, which will lead to a further increase in social costs. Assuming that the total ecological environment is TE, the relationship between ecological occupation and ecological environment is as follows.

$$TE_1 = TE_0 - ef(E) + \Delta E(i). \quad (3)$$

$TE0$ represents the total ecological environment in the previous period, $TE1$ represents the total ecological environment in the current period, and $ef(E)$ represents the degree of influence of the level of ecological occupation on the total ecological environment. ef functions are influenced by factors such as production patterns, consumption patterns, the degree of ecological dissipation of pollutants and waste, the ability of science and technology to degrade pollutants, and the carrying capacity of ecosystems. e represents the level of ecological occupation and is equal to the ecological factor input ($E1$) and the sum of the inputs of pollutants and waste dissipation ($E2$). $\Delta E(i)$ represents the impact of ecological restoration inputs on the total ecological environment, which is influenced by the level of science and technology to combat pollution and the expenditure on protecting and restoring ecosystems (i). Therefore, when the amount of ecological restoration is 0, and the ecological occupation is greater than the ecological carrying capacity, i.e., greater than what the ecosystem can consume through its own cycle, $ef(E)$ is greater than 0, the total ecological environment is reduced, and $TE1$ is less than $TE0$.

Studies have shown that a reduction in the total ecological environment will result in a reduction in the ecological services available, further increasing the cost to society. When the total ecological environment is reduced, the ecological services available to people are also reduced. For example, fossil energy burning leads to high levels of haze, further leading to people not being able to breathe fresh air and creating or increasing the cost of access to health care. In some places, land cannot be cultivated due to mining and water sources are contaminated and undrinkable, increasing social costs such as access to health care and migration. The reduction in the total ecological stock thus brings increased costs to society in two ways. Firstly, the deterioration of the ecological environment increases the social costs of medical care, ecological services, and migration for people. The higher the economic level of a country or a region, the greater the impact of a smaller ecological stock on the level of social well-being. Secondly, people's input costs to restore the ecological environment, including economic costs and human costs.

$$C = cf(TE_1) + i + C_0. \tag{4}$$

C represents the total cost, assuming that the ecosystem is an ecological asset that can be converted into a corresponding output for comparison. The cf function represents the effect of the total ecosystem on the total cost. If the total ecological environment is low, or if the ecological carrying capacity is low, or if the ecological input and consumption capacity is lower, this will lead to limited economic growth, resulting in higher economic costs. On the other hand, a lower total ecological environment means that the ecological elements and ecological services that the ecological environment can provide will also be lower, resulting in higher social costs. Therefore, a reduction in the total ecological environment will lead to an increase in economic and social costs. i represents the expenditure in a country's economy that is invested in ecological protection and restoration.

Bringing equation (3) and equation (4) into equation (2) yields a Douglas production function that includes social and ecological costs as follows.

$$R = AL^{\alpha}K^{\beta}E_1^{\gamma} - cf[TE_0 - ef(E)+\Delta E(i)] - i - C_0. \tag{5}$$

The analysis from the formula has the following implications:

Firstly, analysed in terms of the impact of the economic system in the development process, i.e., from A1, promoting green production has the following implications, firstly increasing the level of science and technology innovation, i.e., increasing the total factor productivity of production and obtaining maximum economic output with limited ecological factor inputs; secondly, green economic growth can increase the contribution of labour (L) and capital (K) to the economic system and reduce the dependence on the ecosystem. Second, green economic growth can increase the contribution of labour (L) and capital (K) to the economic system and reduce dependence on the ecosystem. Thirdly, it reduces ecological factor inputs ($E1$), especially those that are not recycled.

Secondly, the social cost of ecosystem damage during development is analysed in terms of the $cf\,[TE0 - ef(E) + \Delta E(i)]$ function, i.e., the better the ecosystem, the lower the social cost, with an inverse relationship between the two. The total ecological environment is influenced by the original ecological stock, ecological occupancy flow, and ecological restoration. The higher the value of ecological restoration construction, the less ecological occupation, the higher the total ecological environment (TE1), and the higher the ecological carrying capacity. Secondly, the level and scope of ecological restoration construction by ecological conservation inputs (i) can be improved through scientific and technological development, and the maximum amount of ecological restoration can be obtained with limited ecological conservation inputs. Thirdly, from the analysis of the ecosystem, promoting the development of the ecosystem requires an increase in expenditure on ecological inputs (i).

Finally, from the analysis of the economic system, the social system and the synergistic development of the ecosystem, when the economic level is high and the total amount of ecological environment is low, the higher the cost of the total amount of ecological environment to the social system in the cf function; when the building capacity of ecological restoration is high, the more the increase of the economic system's input to the total amount of ecosystem. In terms of the contribution of ecosystems to economic systems, increasing ecological carrying capacity can increase the contribution of ecologically occupied economic systems. Therefore, the promotion of green economic growth should increase the efficiency of the output of ecological occupation, the capacity of ecological restoration, and the increase of ecological carrying capacity.

3. A Test of the Impact of Fiscal Expenditure Structure on Green Economic Growth

Compared to Western federalism, the Chinese style of fiscal expenditure structure reform focuses more on incentivising local governments to focus on economic growth. Although the fiscal expenditure structure has brought about the phenomenon of "beggar-thy-neighbour" and rent-seeking corruption, it has generally contributed to the growth of the regional economy and is an important factor in driving China's high economic growth. In addition to financial incentives, the promotion mechanism for officials has motivated local governments to promote economic growth. China has a top-down vertical management system and a strict system of mobility control, so the Western "voting with one's feet" does not work substantially in China. In China's multilayered commissioning relationship, economic performance assessment is the main indicator for evaluating the performance of officials in office, and some studies have shown a positive correlation between the promotion opportunities of officials and regional economic performance. In summary, there are two types of competition between local governments: one is for regional economic growth and fiscal revenue, and the other is for political promotion. Either type of competition must be obtained through economic growth performance; therefore, the fiscal expenditure structure and competition between governments drive economic growth. The Chinese-style fiscal expenditure structure drives economic growth while also having an impact on the environment. The green economic growth studied in this paper is a kind of economic growth that only considers the environmental pollution status. Therefore, when the fiscal expenditure structure policy affects the economic growth and also has an impact on the environmental pollution status, it will inevitably bring some impact on the green economic growth, and the specific impact depends on the direction and size of the impact of the fiscal expenditure structure on the environmental quality when driving the economic growth. If the structure of fiscal expenditure exacerbates environmental pollution while driving economic growth, and the economic growth brought about is not enough to compensate for the cost of environmental pollution, then the structure of fiscal expenditure will have a suppressive effect on green economic growth; if the structure of fiscal expenditure exacerbates environmental pollution while driving economic growth, but the increase in economic growth can compensate for the cost of environmental pollution, then the structure of fiscal expenditure has a suppressive effect on green If the fiscal expenditure structure contributes to the improvement of environmental pollution while driving economic growth, then the implementation of the fiscal expenditure structure contributes to green economic growth, and this green growth effect is greater than the economic growth effect. Based on the above analysis, this paper constructs a comprehensive index to reflect the environmental pollution situation, and empirically analyses the impact of the fiscal expenditure structure on environmental pollution, and tests whether the fiscal expenditure structure has an ameliorating effect on environmental pollution or a counter-effect of aggravating it. The paper then uses the comprehensive index of environmental pollution and GDP to synthesise green GDP, which reflects the cost of environmental pollution, and uses green GDP to measure green economic growth.

3.1. Measurement of Green Economic Growth. Green economic growth is a sustainable form of economic growth, which can reconcile economic development with resources and environment and, to a certain extent, achieve the organic unity of economic development, environmental protection, and ecological environment improvement.

This paper uses the term "green GDP" (i.e., EDP) to refer to the economic growth rate. In this paper, we use green GDP (i.e., EDP) to measure China's green economic growth. Based on the summary of previous studies, we draw on the measurement method of [15] and use the comprehensive index of environmental pollution constructed in Chapter 3 to construct the green output index of EDP by adopting the principle of output per unit of pollution, whose mathematical expression is EDP = GDP/comprehensive index of environmental pollution. The lower the EDP index and the larger the GDP, the higher the quality of economic growth and the higher the level of green economic development. This paper uses the real EDP per capita growth rate calculated by the growth rate definition formula to measure green economic growth, which does not reflect the full range of green economic development, but it is considered a useful attempt to portray the level of green economic development using EDP per capita until a better comprehensive indicator is available. Green economic growth is expressed as the growth rate of EDP, with the following formula.

$$\mathrm{EDP} = \frac{\mathrm{EDP}_{it} - \mathrm{EDP}_{i,t-1}}{\mathrm{EDP}_{i,t-1}}. \tag{6}$$

3.2. Variable Setting and Descriptive Statistical Analysis. This paper studies the impact of fiscal expenditure structure on green economic growth and therefore sets green economic growth (edp) as the explanatory variable. In order to compare the similarities and differences between the impact of fiscal expenditure structure on green economic growth (edp) reflecting environmental costs and economic growth (gdp) without considering environmental costs, economic growth (gdp) is chosen as the explanatory variable in this paper. The data used in this study were obtained from the Wind database and the WIEGO statistical database. The sample data was selected from 30 provinces in China over a 14-year period, and the total cumulative sample size was 408, excluding vacant values. The results of the descriptive statistical analysis of the selected data are shown in Table 1.

3.3. Analysis of Regression Results Based on a Random Effects Model. In order to study the impact of fiscal expenditure structure on green economic growth, this paper conducts an econometric analysis of panel data and the basic regression model is set as

$$\begin{aligned}\mathrm{edp}_{ii} = \alpha_1 + \beta_1 \mathrm{Dec}_{ii} + \beta_2 \mathrm{FDI}_{ii} \times \mathrm{Exp}_{ii} + \beta_3 k_{ii} \\ + \beta_4 En_{ii} + \beta_5 Is_{ii} + \beta_6 \mathrm{Jrben}_{ii} + \varepsilon_{ii}.\end{aligned} \tag{7}$$

The F-test and Hausman test were used to select between the mixed model, the fixed-effects model, and the random effects model to find the most suitable regression model for the regression analysis.

3.3.1. F-Test. The F-test is used to determine whether the assumption of parameter constraint is valid by comparing the squared residuals of the regression of the fixed-effects model with constraints to the squared residuals of the regression of the fixed-effects model without constraints. The results of the F-test are shown in Table 2.

The test results showed that with $P \leq 0.001$, regardless of expenditure as the explanatory variable, and thus rejecting the null hypothesis at a 1% significance level, the fixed-effect model outperformed the mixed regression model.

3.3.2. Hausman Test. In order to compare which of the random effects model and the fixed-effects model is more applicable to this panel data, the Hausman test was further conducted and the results of the test are shown in Table 3.

The Hausman test results show that the random effects model hypothesis cannot be rejected at the 1% significance level, so the random effects model is used to regress the panel data. In this paper, a random effects model regression was conducted on the panel data using stata12.0 to

Table 1: Variable definition and descriptive statistical analysis.

Variable name	Variable definition	Mean value	Standard deviation	Crest value	Least value	Number of observations
edp	Green economy growth rate	0.108	0.095	0.415	-0.511	408
gdp	Economic growth rate	0.117	0.050	0.325	-0.047	408
Expdec	Fiscal expenditure	0.988	0.615	3.621	0.359	408
FDI	Foreign direct investment	0.026	0.022	0.146	0.001	408
k	Growth rate per capita fixed capital	0.155	0.053	0.391	-0.047	408
En	Resource endowment	4.846	3.731	25.485	0.695	408

Table 2: F-test.

	F null hypothesis	F statistics	P price
Fiscal expenditure for interpretation change The regression equation for quantities	$H0 : \mu i = 0$	10.14	0.0001

Table 3: Hausman test.

	Chi-sq statistics	F statistics	P price
Fiscal expenditure for interpretation change The regression equation for quantities	10.20	0.1774	The random effects model cannot be rejected

Table 4: Regression results of the impact of fiscal expenditure structure on green economic growth.

Explanatory variable	edp	edp
Expdec	0.024^{*} (1.94)	
Delivery item (FDI $*$ Expdec)	-0.032 (-0.68)	
Per capita fixed capital growth rate per capita (k)	0.229^{**} (2.43)	0.292^{***} (3.28)
Resource endowment (En)	-0.011^{***} (-6.32)	-0.010^{***} (-5.80)

Note: *** is a test passed at 1% significance level, ** is a test passed at 5% significance level, and * is a test passed at 10% significance level.

investigate the impact of fiscal expenditure structure on green economic growth. The regression results are shown in Table 4.

The regression results show that there is a significant positive relationship between fiscal expenditure and green economic growth. For the study on the influence of control variables on green economic growth, the influence of per capita fixed capital growth rate on green economic growth is significantly positive, indicating that among the factors promoting green economic growth, fixed capital investment plays a great role; the influence of industrial structure is significantly positive; a reasonable explanation for this phenomenon is that the green economic growth in this paper is the growth rate of output per unit of pollution, although the secondary industry is the most polluting industry. Although the secondary sector is the most polluting industry, it is also the main driver of economic growth, and the contribution of the secondary sector to economic growth can compensate for the cost of environmental pollution, so the effect of industrial structure is positive overall. The above findings do not obscure the fact that the secondary sector also contributes to environmental pollution, so the government needs to guide such industries to use advanced production technologies to reduce pollutant output and to strengthen the regulation of pollutant compliance to facilitate the transformation of the secondary sector's production methods. The significant negative effect of resource endowment is due to the fact that, for the time being, labour-intensive industries are more advantageous than capital-intensive industries, and capital-intensive provinces tend to be accompanied by lower technical efficiency.

3.4. Comparative Analysis of Differences in the Economic Effects of Fiscal Expenditure with and without Environmental Constraints. In order to compare the similarities and differences in the effects of fiscal expenditure structure on green economic growth (edp), which reflects environmental costs, and economic growth (gdp), which does not take into account environmental costs, the regression results are shown in Table 5.

In order to compare the similarities and differences in the effects of fiscal expenditure structure on green economic growth (edp) reflecting environmental costs and economic growth (gdp) without considering environmental costs, regressions were also conducted on fiscal expenditure structure and economic growth.

Table 5: Comparison of regression results.

Explanatory variable	edp	edp	gdp	gdp
Fiscal expenditure	0.024^{*} (1.94)		0.009^{*} (1.78)	
Delivery item (FDI $*$ Expdec)	-0.032 (-0.68)		0.037^{*} (1.87)	
Per capita fixed capital growth rate per capita (k)	0.229^{**} (2.43)	0.292^{***} (3.28)	0.392^{***} (9.07)	0.412^{***} (9.62)
Resource endowment (En)	-0.011^{***} (-6.32)	-0.010^{***} (-5.80)	-0.008^{***} (-10.07)	-0.007^{***} (-9.46)

Note: *** is a test passed at 1% significance level, ** is a test passed at 5% significance level, and * is a test passed at 10% significance.

3.4.1. Direct Impact of Fiscal Expenditure Structure. From the regression results, it can be seen that the structure of fiscal expenditure has a significant positive relationship with green economic growth and economic growth. From the magnitude of the regression coefficients, the coefficient of the impact of fiscal expenditure structure on green economic growth is larger than that on economic growth, which echoes the findings of the study on the impact of environmental pollution: the direct impact of fiscal expenditure structure on environmental pollution is negatively related, i.e., the improvement of fiscal expenditure structure helps to improve environmental pollution. While boosting economic growth, it also improves environmental pollution, so the impact of fiscal expenditure structure on green economic growth is greater than the impact on economic growth.

3.4.2. Indirect Effects of Fiscal Expenditure Structure. The coefficient of the cross-section of fiscal expenditure structure and FDI variables on economic growth is significantly positive, while the coefficient of the cross-section of revenue decentralisation and FDI variables on economic growth is negative but insignificant. The explanation for this phenomenon draws on the findings of [16], where there is a threshold effect based on the degree of fiscal expenditure structure in the case of technology spillovers from FDI. When the level of fiscal expenditure is too low, local governments are competing for FDI by attracting foreign capital through tax incentives on the one hand, and on the other hand, based on the pressure of fiscal expenditure, part of the basic inputs are not guaranteed, hindering domestic enterprises. When the level of fiscal expenditure is relatively high, local governments are able to improve the local investment environment and increase their incentive to fully absorb the spillover effects of FDI and improve local productivity. The level of fiscal expenditure in China is much higher than the level of fiscal revenue, thus leading to the phenomenon that the coefficient of the cross-section of fiscal expenditure structure and FDI variables on economic growth is significantly positive, while the coefficient of the cross-section of revenue decentralisation and FDI variables on economic growth is negative but not significant.

The cross-section of fiscal expenditure structure and FDI variables has a negative but insignificant coefficient on green economic growth, while the cross-section of revenue decentralisation and FDI variables has a significantly negative coefficient on green economic growth. The explanation for this phenomenon is that, combined with the findings of this paper on the relationship between fiscal expenditure structure and environmental pollution, the fiscal expenditure structure intensifies competition among governments, and government competition for FDI brings about distorted government behaviour, which brings about environmental pollution; under the fiscal expenditure structure measured by the fiscal expenditure structure, the fiscal expenditure structure encourages local enterprises to absorb FDI technology spillovers, which increases productivity However, this increase in productivity is not sufficient to compensate for the cost of environmental pollution, and therefore, with the introduction of FDI, the contribution of the fiscal expenditure structure to green economic growth is weakened; under the fiscal expenditure structure measured by income decentralisation, the fiscal expenditure structure hinders the absorption of FDI technology spillovers by local enterprises, which does not increase productivity and brings about pollution at the same time, which makes the impact of the cross multiplier on green growth significantly negative " the fiscal expenditure structure... fiscal expenditure to green growth." with:the structure of fiscal spending discourages local firms from absorbing foreign investment and technology, affects productivity, and is detrimental to environmental protection, while making the cross multipliers significantly negative for green growth, i.e., the low level of fiscal spending structure weakens the contribution of fiscal spending to green growth.

In general, a good expenditure structure can facilitate the absorption of FDI technology spillovers by local enterprises and increase economic growth. As long as the "competition among governments" is addressed, the environmental threshold is not lowered and environmental regulation and management are strengthened, the quality of economic growth can be improved and green economic growth can be driven.

4. Policy Recommendations

In the empirical analysis of fiscal expenditure structure and green economic growth, we can find that although China has become the world's largest consumer market, there are still many improvements to be made and more options to choose from that affect its efficiency in resource allocation and environmental quality. Therefore, we propose policy recommendations at three levels: inter-governmental, intra-enterprise, and external.

4.1. Implement Structural Fiscal Expenditure Policies. First, clarify the division of fiscal and administrative powers between the central and local governments and improve the economic efficiency of government transfers. Financial power refers to the power of governments at all levels to obtain fiscal revenues and allocate fiscal expenditures, as well as the right to own and manage local wealth. Affairs power, on the other hand, refers to the function of governments at all levels to carry out their basic duties, to manage regional administration and economy, and to provide public goods and public services. The two are both distinct from each other and complementary to each other. Financial power is the material basis for the realisation of the government's powers, which in turn provides the criteria and basis for the exercise of financial power. Under the current system of fiscal decentralisation in China, the division of responsibilities between central and local financial and ministerial powers is unclear, local governments rely excessively on central transfer payments for their sources of income, and there is a huge gap between local financial revenues and expenditures. In the long run, this is not conducive to the healthy development of our economy and society. Therefore, we should start by promoting the reform of the structure of fiscal affairs and financial powers to improve the efficiency of fiscal expenditure.

Secondly, we should increase investment in science and technology innovation, support the development of strategic emerging industries and service industries, and provide sustained impetus for the healthy development of our economy. Striving to improve the capacity of independent innovation, relying on innovation and entrepreneurship to expand the scale of employment and raise people's income, and promoting the transformation and upgrading of China's industrial and economic structures are important tasks for China's economic development at present. While the main actors in improving the capacity for independent innovation and developing new industries are the market, enterprises, and the people, government intervention and adjustment is also one of the essential conditions for their healthy development. Among the many ways of government regulation and control, fiscal expenditure policy is of particular significance. On the one hand, the government, with its strong economic power, can provide the necessary upfront capital for the development of the relevant industries and improve market confidence. On the other hand, government spending has a strong guiding and demonstration effect. Increasing government investment in science and technology innovation can lead to a greater convergence of idle social capital in new industries and increase the enthusiasm of the whole society for innovation and entrepreneurship. Therefore, we should shift the fiscal expenditure towards the field of science and technology innovation, play the guiding role of fiscal expenditure, increase the investment in research and development in key areas and core technologies, focus on cultivating a number of products and enterprises that can independently master the core technologies, have high added value of products and have international competitiveness, and play its demonstration effect. At the same time, more special funds should be set up for R&D in science and technology innovation, more investment should be made in the construction of relevant science and technology industrial parks, and more financial subsidies should be provided for the production and operation of strategic emerging enterprises. Of course, we should also be aware that the excessive use of government financial subsidies also has the disadvantage of distorting market prices. For this reason, we can appropriately introduce a competition mechanism into our fiscal subsidy policy, make timely and dynamic adjustments to the scope and intensity of fiscal subsidies according to the actual situation of industrial development, optimise the structure of fiscal expenditure subsidies, improve the economic efficiency of fiscal expenditure, and provide a favourable policy environment for the development of relevant industries.

Thirdly, we should strengthen investment in people's livelihood, ease social conflicts, and create a favourable social environment for the smooth operation of the economy. Premier Li Keqiang has pointed out that continuous improvement of people's livelihood is one of the objectives of our government's administration. He believes that the government should strive to become a government of people's livelihood, focusing on safeguarding basic livelihoods and gradually filling up the shortcomings of people's livelihoods such as compulsory education, healthcare, and retirement.

4.2. Reducing the Scale of Government Maintenance Expenditure. First, the reform of administrative institutions should be further deepened, government agencies should be streamlined, and government administrative expenditure should be vigorously reduced. First, we should strengthen the innovation of government organisations and deepen the reform of administrative institutions. We should implement the 2018 State Council's institutional reform programme, which, on the one hand, should reflect the reform idea of one department being responsible for one thing, integrate departments and institutions with similar functions, continuously optimise the setting of administrative institutions, and reduce institutional overlap. On the other hand, government functions should be redefined and new departments formed in accordance with the real needs of national and social development in the new era. We should scientifically dismantle and integrate government administrative agencies and strive to build a modern government organisation system with unified powers and responsibilities, a clear division of labour, efficient operation, public rationality, and adaptability to the needs of the new era. Secondly, we should change the original rough and tumble system. Secondly, we should change the original rough and loose way of controlling government administrative expenses, set clear objectives and standards for controlling administrative expenses, increase the control of each unit's budget, further clarify and implement the responsibility system for expenses, and realise strict management and effective monitoring of government administrative expenses. At the same time, it should also further enhance the cost consciousness and saving awareness of all administrative and institutional units, in line with the principle of living within one's means and practising economy, to continuously reduce administrative costs and build an economical government.

Second, further simplify and decentralise government and continue to reduce government approvals. Simplify and decentralise government and reduce government intervention in market activities.

In addition to enhancing market dynamics, it will also significantly reduce the scale of government administrative expenditure in related areas.

This will be beneficial to the role of the market mechanism and promote the smooth operation of the economy. Therefore, we should further.

We should further accelerate the pace of decentralisation and simplification of government administration, except in strategic areas such as energy and minerals, which are of national importance and livelihood. Simplify the administrative approval procedures for normal production and operation and enhance the vitality and autonomy of the market. At the same time, the government should. At the same time, we should thoroughly implement the directives of the 18th Party Congress and establish and improve the negative list and power list system for government investment projects, and the powers and responsibilities of the government should be further clarified, and the powers and scope of the government's administrative approvals should be clearly disclosed to society as a whole and subject to the supervision and questioning of society as a whole.

Thirdly, we should speed up the innovation of government administration, reduce government administrative costs, and improve the efficiency and level of government macro-control. Innovation in government administration can effectively reduce administrative costs and streamline administrative expenses, while at the same time effectively improving the efficiency of governance and realising scientific and effective governance of society by the government. Therefore, we should vigorously innovate government administration and promote the process of modernising the government's ability to govern.

4.3. Maintain the Stability of Social Service Expenditure Policies. A stable and continuous fiscal expenditure policy can provide a good policy environment for the development of economic agents, which is conducive to the formation of rational market expectations by market agents and the reduction of market speculation brought about by unstable policies, which is beneficial to the stability and healthy development of the macro economy. Therefore, we should attach importance to maintaining the stability of fiscal expenditure, especially social service expenditure policies, to enhance the efficiency of government macro-control. People's livelihood-oriented fiscal expenditure policies should be stable, and innovation-oriented fiscal expenditure policies should be continuous. Only by ensuring the continuity of these policies in time and space can we guide the market investment and production subjects to establish rational policy expectations, increase the enthusiasm of market subjects for "dual innovation," and encourage relevant enterprises and investors to make long-term strategic decisions, so as to reduce the negative impact of market speculation on the stable and healthy development of the economy. We can start from the policy formulation to enhance the continuity of the relevant expenditure policy.

4.4. Enhancing the Flexibility of Productive Spending Policies. Maintaining the flexibility of fiscal expenditure policy can lead to better adaptation to the dynamic changes in the complex economic situation and improve the relevance and effectiveness of government macro-control. Empirical analysis shows that productive spending has a dual impact on macroeconomic fluctuations, which can vary depending on the specific economic situation. Therefore, when applying fiscal expenditure policies, we should pay special attention to enhancing the flexibility of production-oriented fiscal expenditure policies.

5. Conclusions

Through the previous analysis, we can see that there is a strong positive correlation between the structure of fiscal expenditure and the effect of green economic growth, although on the whole, the two have a positive correlation, but for China at present, it still has a large gap compared with other developed countries. Fiscal expenditure has played an important role in the process of green economic growth in China, but there are still some shortcomings. It is clear that green finance has great potential to promote social equity and justice in the face of imperfect competition between governments and low market development, which makes it necessary for the government to make further efforts to reform and innovate in order to enhance the level of sustainability and efficiency, while also focusing on improving the efficiency of resource allocation. In order to better promote and improve the government's policy formulation and implementation of its functions, environmental protection, and resource conservation, it is inevitable that further efforts will be made to promote the optimisation and upgrading of the fiscal expenditure structure.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

The Impact of Environmental Technology and Environmental Policy Strictness on China's Green Growth and Analysis of Development Methods

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Environmental technology and the stringency of environmental policies have a certain effect on green growth in the country, and the sustainable development of the environment under the influence of green growth requires the effective application of the environmental technology based on such institutional policies related to the environment. In this paper, the mutual effect of green growth on the ecological environment is fully analyzed to identify an intrinsic link between them. Based on the intrinsic link, policies related to environment protection and environmental technology are conducive to facilitating green growth while at the same time playing a continuous role in the improvement of the environment. Driven by the factors of scientific and technological innovation, it can boost the harmonious development of the economy and the environment. The empirical evidence has demonstrated that the appropriate environmental policy and environmental technology model can be identified with full understanding of the environmental policy and environmental technology. At the same time, the industry drive and technological innovation can also be taken as a strong support for the environmental policy and the environmental technology in accordance with the market demand through research from the perspective of the government, the market, and the general public. The stringency of environmental policies has substantially increased the requirements of environmental technology, and the innovation of environmental technology, the structure of economic organizations, and the level of development have a great effect on the green growth in the country.

1. Introduction

In the continuous progress of industrialization and urbanization, economic development has had a certain influence on the natural environment, and the issue of "pollution first and treatment later" is observed in the development process of developed countries. In comparison, the economic development level in the country is not high. However, the environmental problems have also gradually affected the routine activities of people and their quality of life. The pursuit of economic growth can lead to a serious decline in the efficiency of economic development and severe problems of environmental pollution. The capacity to ensure economic growth and environmental improvement has become a consensus of research scholars in many countries to achieve sustainable development and scientific development [1, 2]. With the improvement of environmental technology as a goal of economic growth, it is necessary to ensure the continuous improvement of environmental sustainability so that the economic development can have lasting momentum and a solid foundation for the steady development of society. However, as environmental protection in general lags behind economic construction, green growth activities are carried out in the context of the economic conditions and the living environment, which can be controlled in the form of monetary policies in the general direction, and at the same time, it can also be controlled in the form of setting restrictions in exploiting the living environment, promoting the implementation of green growth, and facilitating the efficient use of resources [3, 4]. The so-called green growth is a new form of green growth activity where computer Internet factors and digital technologies are combined with the traditional economy to achieve investment financing, payment and security business. However, in contrast to the traditional economy, the business of green growth is more convenient, universal, and highly efficient, which has the features of green growth itself, thus making it easy to achieve the purpose of joint development in the economy and environment. As a basic requirement and effective approach to modernize the national management system, the report of the 18th Party Congress pointed out that the environmental policy and environmental technology should be applied. Under the influence of environmental policy and environmental technology, the thinking of environmental policy will become the mainstream ideology of society in the future, and the environmental policy model will gradually become the basic approach adopted in national institution management, government management, and social management [5, 6]. At different historical moments in history, there are different priorities for the formulation of policies related to the environment. As a result, the content of legal thinking and the policy approach related to the environment can also present different features. In the present, the main focus of environment-related policy thinking is about adhering to the premise of legality in combination with the rule ideology, focusing on making judgment in under the premise of legality with the awareness of environment-related policy and paying attention to the procedural justice. Based on the so-called "environment-related policy thinking", the power holder audits the environment-related policy concepts, carries out analysis, summarizes findings, makes judgment, and conducts reasoning in multiple dimensions such as detailed analysis, change, and coordination of problems that arise in the process of laws and regulations, legal principles, legal spirit, and legal thinking [7–9]. With the full awareness of the process of cognitive activity of decision-making thinking, it is necessary to use the environment-related policy thinking as the basis of the relevant environment awareness to achieve the harmonious development of the related theory for improve the environmental policies. It has played a guiding role in the improvement and practice of the regulatory system. The related environmental regulations, policies, and environmental technology are developed mainly based on the behavior patterns that emerge from the thinking of environment-related policies, and the communication channels of environment-related policies and environmental technology are the thorough manifestation of their contents and forms. At present, the environmental technology requires the enterprises engaging in the environmental technology to have the capacity to provide one-stop services, offers strong support in lives, and ensures that the greatest economic benefit can be obtained through the environmental technology, which is the overall goal in the work of environmental technology enterprises. For the regions with frequent records of green growth business in the previous period, it has indicated that the local level of communication technology and communication business capacity are relatively good. As the green growth is developed based on the Internet technology, the analysis on the green growth development evolution based on the environmental technology has an important effect. A sound green growth development evolution analysis system can accelerate the flow of environmental technologies, reduce costs, ensure the proper operation of services, while at the same time ensuring the implementation of effective management and use of resources [10, 11]. For the purpose of effectively improving the accuracy of the analysis of the evolution of the green growth development of the environmental technology process, an evaluation algorithm is used to analyze the evolution of the objectives for the green growth development in real time. At the same time, it will also bring more long-term benefits to each region of the country. He Bin developed a set of restriction threshold model, this model for each region of China to reflect on the role of green growth per capita and the effect of the state-owned economy on the improvement of the ecological environment. With regard to the proposed sustainable growth of economic development, the key is to make breakthroughs in the economic structure through the energy perspective of the analysis, which, in fact, is the current general environment and the existing situation. It has been verified that the green growth situation in the country is inseparable from the two main causes of pollutant generation and environment in each region of the country, especially for the domestic situation.

With the formulation of environmental technology and environmental policy in the country, scientific and reasonable evaluation is carried out on the practical effect of environmental policies and subsidies on making effective improvement, which can provide a certain reference and play a guiding role in the implementation of the relevant environmental policies. The application of environmental technology and environmental policy system can play a certain positive role in driving the rapid economic growth, the effective improvement of environmental quality, and the optimization of the environmental system.

2. Mechanism of the Dual Effects of Environmental Technology and Stringency of Environmental Policy

The environmental technology and the stringency of environmental policies can often be deemed as potential constraints that have a direct effect on the transaction expenses, costs, profits, and management effectiveness in the growth of a green economy [12, 13]. While changing the green growth in the country, with regard to safeguarding the rights and obligations of the economy as a whole, it can urge people to save energy and contribute to the stable economic growth and improvement of social welfare standards effectively. In general situations, the use of environmental technologies and the stringency of environmental policies has many advantages in driving the economic growth and facilitate the environmental improvement processes. In addition, the environmental technology and the stringency of environmental policies can change the internal management efficiency and macroeconomic configuration via a number of pathways, as shown in Figure 1.

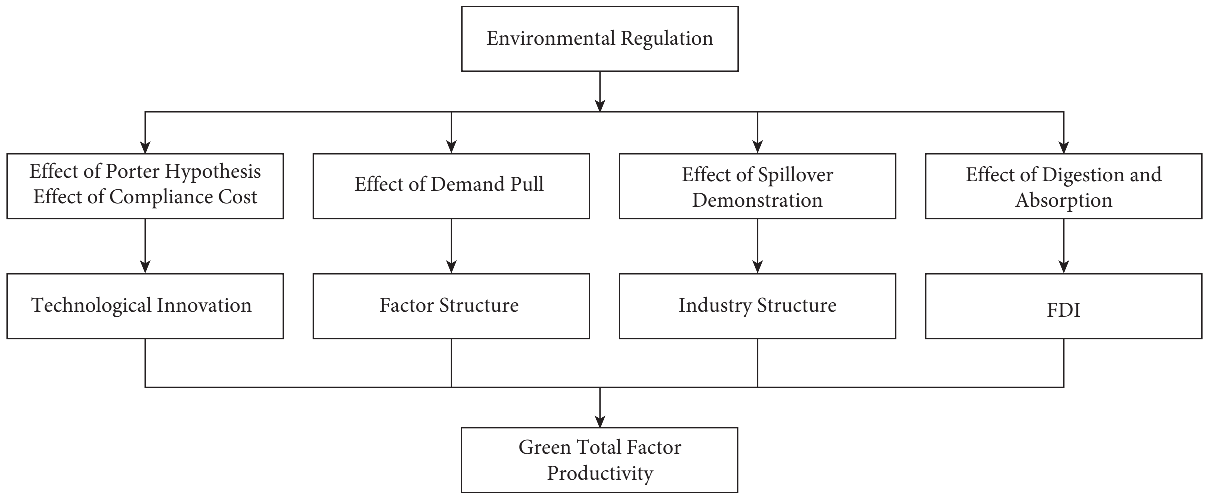

Figure 1: Pathway by which environmental technology and stringency of environmental policy affect the economic growth.

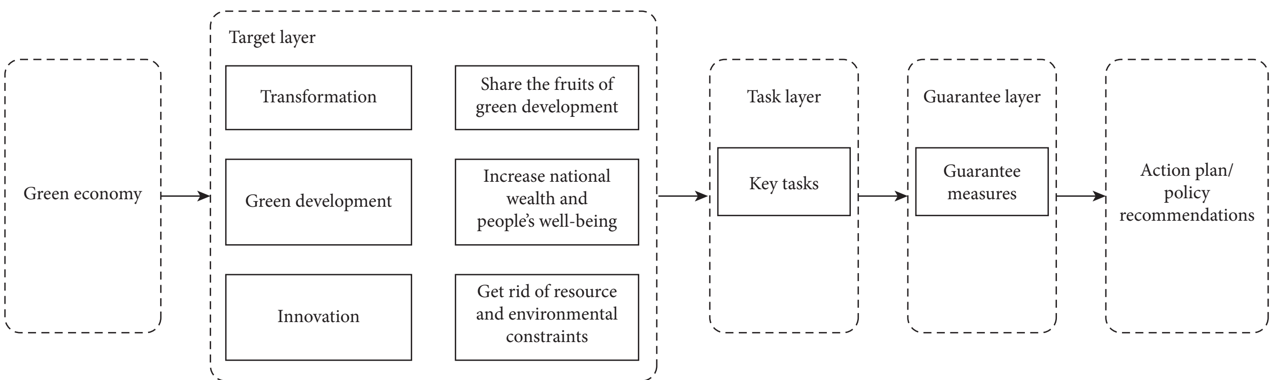

Figure 2: General framework of the green growth model in China.

For developing countries, green economy is not a new term. In the research process of green growth both at home and abroad, no uniform template has been formed yet; and the construction of a green growth model is not a quick fix, which needs to be continuously adjusted and improved in the process of practice. In the early stage of rapid economic development, it may have high economic costs and expenses, along with high social costs. Hence, green growth is a long process of gradual advancement. Combined with the analysis above, a green transformation strategy is established in this paper, as shown in Figure 2. Its framework is designed around the main objectives of development, the strategies to be adopted, the criteria for the tasks, and the guarantee measures. Through the application of the "double transformation, entrepreneurship, and innovation" approach, the fruits of economic growth can be shared to finally achieve the purpose of national wealth and welfare for all the people [13, 14].

The goal of green economic growth is to implement economic "transformation" and "innovation". With economic "transformation" as a strategic plan, it focuses on two key influences: the paradigm shift in the economic development and the policy changes in government agencies. First, the ultimate goal and positioning of the government and enterprises in the growth of green economy are determined. The "innovation" is taken as the criterion of development strategy, and then, it is necessary to focus on two aspects, that is, the economic growth mechanism innovation and the science and technology innovation. The continuous progress in science and technology will provide a solid foundation for green growth, while the innovation and change in the mechanism and system will provide effective guarantee for the growth of green economy. The relevant index data are collected from the process of ecological environmental protection, and the feedback is given accordingly. The data obtained are used to analyze the operating status of the ecological environment, diagnose the causes of faults, and also monitor the causes of faults. Green growth has facilitated the upgrading of industrial structure by optimizing the allocation of credit funds, boosting the technological innovation of enterprises, and enhancing the demand of residents for consumption. In turn, it can further affect the interaction effect of economic system and the environmental system. With the innovation of science and technology as a driving force of green growth, it can create a virtuous cycle between green growth and environmental technology. With the innovation of science and technology as the key to green growth, through in-depth theoretical research and analysis, it can be known that the investment in science and technology can facilitate green growth and create a scale effect, which will promote productivity and sustainable development of the economy. With the driving force of green growth, technological innovation can be applied and transformed to achieve economic growth at a higher speed [15]. In the formulation of low-carbon emission reduction policies, it is necessary to address the issues in the basic resources, environmental pollution status, and industrial structure features in different regions, different areas, and the corresponding cities in detail, taking into consideration the basic situation of each country's own economic development and social situation effectively, the availability of energy and policies related to green growth in various countries to actively explore the allocation of pollutant emissions and renewable energy that are most suitable for the respective region and guide the whole society to save energy, improve energy efficiency, and alleviate the pollution to the environment. In the analysis process of the traditional economic and ecological environment, ecological protection and risk alert in real time is also a process of effective data collection and analysis of the ecological protection status.

3. Measurement and Evaluation of Green Growth in China

The accurate measure of economic growth is taken as an important research index for the empirical evidence of growth [16]. In this paper, with the EBM model as the basis, the directional distance function (DDF) is defined. In accordance with the definition, it can be derived that if there are m types of inputs ($i = 1, \ldots, m$) and 3 types of outputs ($i = 1, \ldots, s$) in n decision units ($j = 1, \ldots, n$); then, the EBM model established can be expressed as follows:

$$\begin{aligned} \gamma^* &= \min\theta - \varepsilon_x \sum_{i=1}^{m} \frac{w_i s_i}{x_{i0}}, \\ s.t.\ \theta x_0 - X\lambda - s &= 0, \\ \lambda Y \geq y_0, \quad \lambda &\geq 0, \quad s \geq 0. \end{aligned} \tag{1}$$

Among them, γ^* in the expression stands for the optimal efficiency value of the function, which should be comply with the condition of $0 \leq \gamma^* \leq 1$; w_i stands for the weight of the input economic factor i, which should comply with the condition of $\sum_{i=1}^{m} w_i = 1 (w_i \geq 0, \forall i)$; θ stands for the efficiency value of the radial direction; s_i stands for the corresponding function slack variable of the i-th input economic factor; ε_x stands for the combined radial θ and the nonradial slack variables as function parameters; λ stands for the level of significance in the objective decision unit adopted. $X = \{x_{ij}\} \in R^{m\times n}$ stands for the input vector of the economy, and $Y = \{y_{ij}\} \in R^{s\times n}$ stands for the output vector of the function, which should comply with the condition of $X > 0$ and $Y > 0$.

The GML index can be expressed by the available production set across the world, which can effectively address the issues of nontransmissibility and linearity that are observed in the ML index [17, 18]. In this paper, the EBM model and the GML index are used to provide a forecast of the green growth. For the global producible set in the t period and the $t + 1$ period, the GML index can be expressed as the following equation:

$$\mathrm{GML}^{t,t+1}\left(x^t, y^t, b^t, x^{t+1}, y^{t+1}, b^{t+1}\right) = \frac{1 + D^G\left(x^t, y^t, b^t\right)}{1 + D^G\left(x^{t+1}, y^{t+1}, b^{t+1}\right)}. \tag{2}$$

In equation (2), b^t and b^{t+1} represent the undesired output and the directional distance function $D^G(x^t, y^t, b^t) = \max\{\beta\colon (y + \beta y, b - \beta b) \in P^G(X)\}$ of the decision unit t period and $t + 1$ period, respectively.

It is assumed that S_t and S_{t+n} stand for the green growth in the t frame and the $t + n$ frame and the mathematical model can be established in accordance with the workflow as follows:

$$\begin{aligned} S_t &= B_t(x, y) + V(x, y) + N_t(x, y), \\ S_{t+n} &= B_{t+n}(x, y) + V(x + \Delta x, y + \Delta y) + N_{t+n}(x, y). \end{aligned} \tag{3}$$

In equation (3), $B_t(x, y)$ and $B_{t+n}(x, y)$ stand for the factors of green growth in the t frame and the $t + n$ frame; $V(x, y)$ and $V(x + \Delta x, y + \Delta y)$ stand for the environmental technology in the t frame and the $t + 1$ frame; $N_t(x, y)$ and $N_{t+n}(x, y)$ stand for the external disturbances of green growth in the t frame and the $t + n$ frame.

The difference value ($\Delta S_{(t+n)/t}$) for the t frame and the $t + n$ frame can be obtained by using the real-time update algorithm for economic data, as shown in the following equation:

$$\begin{aligned} \Delta S_{\frac{(t+n)}{t}} &= S_{t+n} - S_t = \left[B_{t+n}(x, y) - B_t(x, y)\right] \\ &\quad + \left[V(x + \Delta x, y + \Delta y) - V(x, y)\right] + \left[N_{t+n}(x, y) - N_t(x, y)\right]. \end{aligned} \tag{4}$$

In equation (4), $[B_{t+n}(x, y) - B_t(x, y)] + [V(x + \Delta x, y + \Delta y) - V(x, y)]$ stands for the factor of green growth and $[N_{t+n}(x, y) - N_t(x, y)]$ stands for the factor of external interference.

$K(x, y)$ stands for the binary differential green growth based on the real-time update algorithm for economic data, as shown in the following equation.

$$K(x, y) = \begin{cases} 1, \Delta S \geq T, \\ 0, \Delta S < T. \end{cases} \tag{5}$$

In equation (5), T stands for the threshold value.

If the green economy in the country is regarded as 1 in 2002, then the growth level of domestic green economy in 2003 is the product of the level of growth in 2002 and the GML index for the corresponding growth in 2003. In this way, the value for the provincial domestic green growth during the period from 2003 to 2014 can be calculated accordingly. The specific arithmetic results of the domestic green growth in the two regions on average, that is, domestic and the east, central, and west regions, are shown in Figure 3:

In accordance with the green growth curve in Figure 3, the mean value of green growth in the country gradually increased from 2003 to 0.951. However, in 2014, the value

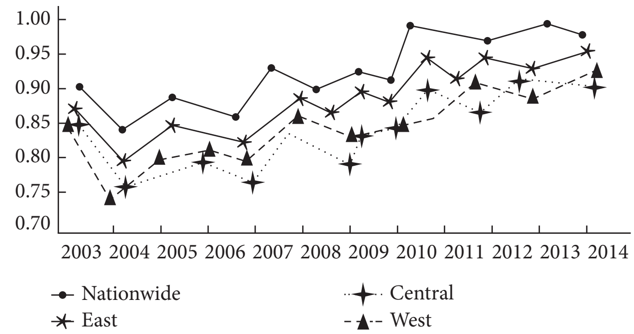

Figure 3: Green growth across the country and in the three major regions (east, west, and central).

was merely 0.951. This suggests that the measured index has a great potential for improvement. According to the change in the curve, the economy has presented an upward trend in the periods from 2005 to 2008 and from 2010 to 2014, which is mainly manifested in the period of the "11th Five-Year Plan" and the "12th Five-Year Plan". With limiting the emission of pollutants as a binding index, the national government has clarified the responsibility for environmental protection, which has improved the overall environmental effect in the region to a great extent. However, the green growth of various regions in China started to decline after the occurrence of the economic crisis in 2008. The mean values for the green growth in the country are 0.9115, 0.8603, and 0.8756 in the east, central, and west regions, successively. The mean values in the eastern provinces, regardless of Hainan, Liaoning, or Hebei Province, are all higher than the average level in the country. Hence, it can be determined that there is a relatively high level of coordination maintained between the economic growth and the environmental performance in the east region.

4. Analysis of the Results

Based on the dual impact mechanism of environmental technology and the stringency of environmental policies on green growth in China analyzed in the above section, the potential nonlinear relationship of the environmental technology and the stringency of environmental policies with green growth in China is taken into comprehensive consideration [19, 20]. In this paper, a quadratic term for the environmental technology and the stringency of environmental policies is introduced to establish an econometric model in the following to explore the direct effect of environmental technology and the stringency of environmental policies on green growth in China.

$$\ln \mathrm{GTFP}_{it} = \beta_1 \sum_{j=1}^{3} \ln \mathrm{ER}_{jit} + \beta_2 \sum_{j=1}^{3} \ln \left(\mathrm{ER}_{jit}\right)^2 + \beta_3 \ln \mathrm{TI}_{it} + \beta_4 \ln \mathrm{FS}_{it} + \beta_5 \ln \mathrm{IS}_{it} + \beta_6 \ln \mathrm{FDI}_{it} + \mu_i + \varepsilon_{it}. \tag{6}$$

In equation (6), i and t stand for provincial and annual GTFP for green growth in China, respectively; its specific value is obtained based on EBM-DDF; the command and control type (cer), the market incentive type ER_j (mer) free contractual environmental technology and the stringency of environmental policies (ver). It can be observed from Figure 1 that the direct factors influencing green growth in China include technological innovation (TI), factor structure (FS), industrial structure (IS), and foreign direct investment (FDI). The definition and descriptive statistics of each variable are shown in Table 1.

In addition, for the purpose of further exploring the indirect effect of the stringency of environmental technologies and environmental policies on the green growth in China, the following econometric model is established by adding the interaction terms for the stringency of three environmental technologies and environmental policies with the technological innovation, factor structure, industrial structure, and FDI [21, 22].

$$\ln \mathrm{GTFP}_{it} = \beta_1 \sum_{j=1}^{3} \ln \mathrm{ER}_{jit} * \ln \mathrm{TI}_{it} + \beta_2 \sum_{j=1}^{3} \ln \mathrm{ER}_{jit} * \ln \mathrm{FS}_{it} + \beta_3 \sum_{j=1}^{3} \ln \mathrm{ER}_{jit} * \ln \mathrm{IS}_{it} + \beta_4 \sum_{j=1}^{3} \ln \mathrm{ER}_{jit} * \ln \mathrm{FDI}_{it} + \mu_i + \varepsilon_{it}. \tag{7}$$

In equation (7), $\ln \mathrm{ER}_j * \ln \mathrm{TI}$ stands for the interaction term of the three environmental technologies and the stringency of environmental policies with the technological innovation; $\ln \mathrm{ER}_j * \ln \mathrm{FS}$ stands for the interaction term of the three environmental technologies and the stringency of environmental policies with the factor structure; $\ln \mathrm{ER}_j * \ln \mathrm{IS}$ stands for the interaction term of the two environmental technologies and the stringency of environmental policies with the industrial structure; $\ln \mathrm{ER}_j * \ln \mathrm{FDI}$ stands for the interaction term of the two environmental technologies and the stringency of environmental policies with FDI. Table 2 shows the direct effects of the two environmental technologies and the stringency of environmental policies on green growth in China. The economic analysis model established for each region is analyzed in depth to evaluate the development factors of the relevant economy and the influencing factors in the development of each regional economy and the environmental technology. The results indicate that the accuracy in the sustainability of green growth can be improved rapidly, which can also enhance the efficient utilization of economic resources. In an environment of green growth, the rapid restructuring of the economy in each region can play a complementary role for environmental protection. In the process of analyzing the green growth development and evolution based on the traditional environmental technology [3, 4], it generally focuses on the green growth development evolution analysis based on the environmental technology. As the two-dimensional map can only describe a relatively high level of environmental plane information, but it cannot provide the relatively complete information on economic data [5, 6], the result can be inaccurate. Through the establishment of a model to evaluate the influencing factors on the development and environmental technologies in each regional economy, the accuracy in the sustainability of green

Table 1: Descriptive statistical analysis of various variables.

Symbols of variables	Minimum value	Maximum value	Mean value	Standard deviation	Definition of variables and source
GTFP	0.521	1.138	0.890	0.086	Calculation based on EBM-DDF
cer	0	28	3.622	4.559	Number of environmental regulations in each region[a]
lnmer	6.764	12.531	10.470	1.026	Total amount of sewage emission expenses in each region[a]
lnver	2.565	9.387	7.251	1.118	Number of environmental petitions and visits made by general public in each region[a]
TI	0.130	36.804	3.978	6.336	Number of patent applications granted per 10,000 people[b,c]
FS	0.010	0.228	0.057	0.029	Number of skilled labor force per unit of energy[d,e]
IS	0.494	3.658	0.901	0.448	Proportion of the output value in the tertiary industry divided by the output value in the secondary industry[f]
FDI	0.015	10.512	2.687	2.126	Proportion of foreign direct investment in GDP[c,f]

Data sources are annotated as the following: a: China Environment Yearbook; b: China Science and Technology Statistical Yearbook; c: China Statistical Yearbook; d: China Labor Statistical Yearbook; e: China Energy Statistical Yearbook; f: Statistical Yearbooks of various provinces.

Table 2: Direct effects of three environmental technologies and the stringency of environmental policies on green growth in China.

Variable	(I)cer	(II)mer	(III)ver	(IV)cer	(V)mer	(VI)ver
ER	0.001 (0.13)	0.031*** (3.10)	−0.010* (−1.75)	0.001 (0.08)	0.175** (2.19)	−0.137** (−3.37)
ER2				−0.0002 (−0.04)	−0.007* (−1.82)	0.009*** (3.17)
Lnti	0.041*** (3.66)	0.032*** (3.17)	0.041*** (4.07)	0.041*** (3.59)	0.033*** (3.19)	0.044*** (4.47)
Lnfs	0.077** (2.37)	0.075*** (2.72)	0.071** (2.49)	0.077** (2.36)	0.072*** (2.63)	0.062** (2.22)
Lnis	0.052 (1.54)	0.063 (1.52)	0.074 (1.47)	0.052 (1.53)	0.058 (1.56)	0.087 (1.26)
Lnfdi	0.251** (2.29)	0.021** (2.21)	0.023** (2.44)	0.025** (2.27)	0.026** (2.61)	0.024** (2.52)
_cons	−0.315*** (−2.89)	−0.635*** (−4.25)	−0.225** (−2.32)	−0.318*** (−2.88)	−1.315*** (−3.27)	0.208 (1.25)
Hausman test p value	0.001	0.001	0.001	0.001	0.001	0.001
R-sq	0.813	0.717	0.772	0.813	0.725	0.768
F statistic quantity	32.13	42.64	40.15	26.67	36.34	36.06
Selection of the model	Fixed effects	Fixed effects	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Sample size	360	360	360	360	360	360

The data in the parentheses are t statistic quantities, *, *, and *** indicate that it is significant at the levels of 10%, 5%, and 1%, respectively.

growth thus obtained can be rapidly improved. In addition, it can also facilitate the effective implementation of green growth in each domestic region. By comparing the specific practices of other green growth development and analyzing their commonalities and features in depth, the suitable pathway for green growth in China development is explored to provide solutions and a theoretical basis for the green growth development in the country.

The industrial structure (IS) has not presented the expected positive effect on green growth in China. The possible reason is that in the special stage of China's economy at present, it has determined the dependence of economic growth on heavy industry. Hence, it is a slow process to improve green growth in China simply by adjusting the industrial structure. The foreign direct investment (FDI) has significantly improved the green growth in China with the technology spillover and demonstration effects [23, 24].

Table 3 shows the indirect effects of three environmental technologies and the stringency of environmental policies on green growth in China. The effect of the environmental technology is analyzed in detail to explore the problems and defects of the green growth development process so that targeted training programs and effective improvement plans can be developed in a later stage. Green growth development has gradually become an essential research direction for urban environmental technology. Through the in-depth analysis of the typical green growth development models

Table 3: Indirect effects of three environmental technologies and the stringency of environmental policies on green growth in China.

Variable	(I)cer	(Il)mer	(I)ver
LnER ∗ Lnti	0.019 (1.24)	0.002*** (2.49)	0.006*** (4.87)
LnER ∗ Lnfs	0.015* (1.80)	0.010*** (4.50)	0.003*** (1.98)
LnER ∗ Lnfdi	0.017** (2.59)	0.002** (2.09)	0.004*** (3.59)
_cons	−0.119*** (−11.9)	−0.392*** (−5.27)	−0.105** (−2.57)
Hausman test p value	0.001	0.001	0.001
R-sq	0.693	0.751	0.767
F statistic quantity	14.35	64.24	61.10
Selection of the model	Fixed effects	Fixed effects	Fixed effects
Sample size	360	360	360

The data in the parentheses are t statistic quantities, *, *, and *** indicate that it is significant at the levels of 10%, 5%, and 1%, respectively.

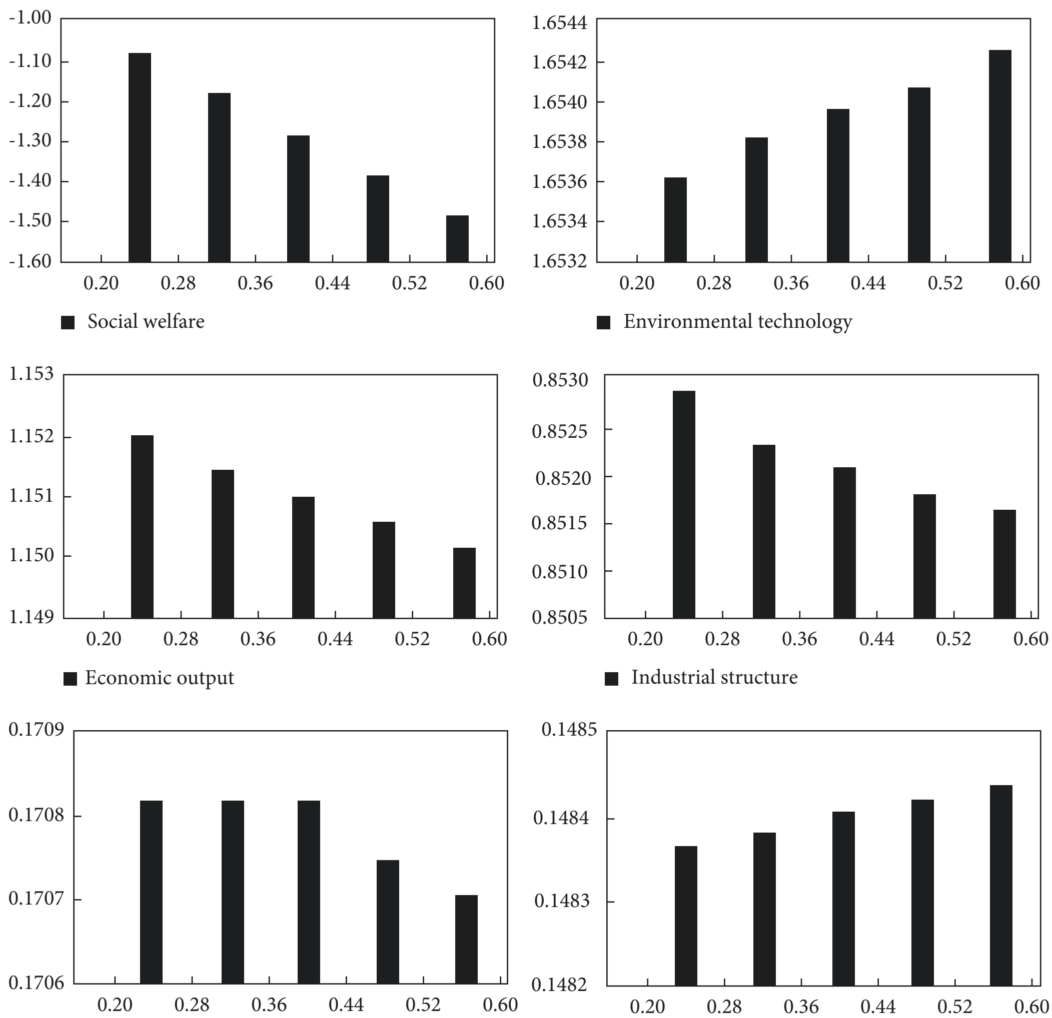

Figure 4: Policy effects of increasing the intensity of environmental taxes.

Table 4: Comparative analysis of the effects of various policies for environmental regulation.

Objective	*Ranking of the effects of various policies for environmental regulation (effects arranged in a descending order)*			
	Best	Relatively good	General	Relatively weak
Economic growth	Subsidy to producers	Subsidy for research and development	Environmental tax	Subsidy to consumers
Economic structure	Subsidy to producers	Subsidy to consumers	Subsidy for research and development	Environmental tax
Social welfare	Subsidy to producers	Subsidy to consumers	Subsidy for research and development	Environmental tax
Environmental quality	Subsidy for research and development	Subsidy to consumers	Environmental tax	Subsidy to producers
Environmental technology	Subsidy for research and development	Subsidy to producers	Subsidy to consumers	Environmental tax

both at home and abroad, the commonalities and features of their development processes are explored to summarize the regularity and innovation in the process of facilitating green growth development effectively. In this paper, the evaluation algorithm is used to obtain high-precision green growth development objective analysis results effectively, which can meet the requirement for real-time analysis of green growth development.

From the perspective of the factor structure pathway, the positive coefficient of the interaction term suggests that the environmental technologies and the stringency of environmental policies will in turn force the upgrading of factor structure so as to promote a higher level of green growth in China. In general, the coefficient of the indirect effect of factor structure is larger than that of the other two pathways. This suggests that China is gradually lowering its dependence on traditional energy sources to improve the factor structure, which can be attributed to the progress made in the energy price reform at present, and a substitution relationship can be observed between labor and energy [25, 26].

In this paper, the effect of an increase in the intensity of environmental restrictions on the economy, welfare, and environment is demonstrated, as shown in Figure 1. In this way, real-time, rationalization, and precise monitoring of ecological environment improvement can be implemented to provide a sound theoretical basis for analyzing the decisions made by the relevant environmental protection testing departments, which is of great significance for improving massive environmental technologies that have been emerging constantly. The environmental technologies are analyzed in detail to explore the problems and defects of the ecological improvement process so as to develop training programs and improvement plans subsequently. In the analysis on the improvement of the traditional ecological environment, the ecological environment improvement and real-time risk alerts are also effective data collected in the analysis processes by using the ecological environment improvement devices. The index data elated to the ecological improvement are collected, and the relevant feedback is given. The data obtained are used for the analysis on the performance of improvement in the ecological environment. The operational status of ecological environment improvements is analyzed to diagnose the causes of failures, which can also be used to monitor the causes of the relevant failures [27]. As shown in Figure 1, the environmental tax cost paid by enterprises based on clean technology is higher than the research and development cost. The technological innovation of enterprises based on clean technology has brought about the progress of clean technology and the improvement in the quality of clean technology products. However, the proportion of industries based on clean technology to the whole industry (as shown in the industrial structure variable in Figure 4 below) still presents a downward trend, and the features of economic structure optimization are not evident.

In the aspect of pollution emissions and pollution intensity, as the economic growth rate is decreased and the industrial structure has changed, the energy consumption of enterprises, especially those enterprises with substantial pollution emissions, has been reduced, and the total pollution emissions are also decreased accordingly. However, since the effect of environmental taxes on economic growth is more significant than its effect on pollution emissions, the pollution emission intensity still presents a slight upward trend in the end.

Based on different objectives, comparative studies of the effectiveness of producer price subsidies, consumer price subsidies, technology development subsidies, environmental tax policies, and other environmental control policies can also be implemented. Subsequently, the policies that have a more significant effect on improving social welfare are determined. Through research, the priority of different environmental control policies based on five objectives, that is, social welfare, economic growth, economic structure, environmental quality, and environmental technology, is obtained in this paper (as shown in Table 4).

In the aspect of economic growth and economic structure, price subsidies to producers have a relatively good effect, which is assessed from the production side where the manufacturing industry is regarded as the main body of the real economy in its development. Green growth is created based on the development needs of the real economy, and better quality green growth services can be provided to the manufacturing industry through the network platform and the green technology, so as to improve the market structure in the green growth. In the aspect of environmental quality and environmental technology, the subsidies for technology development should have the highest priority. As research and development investment is the main driver of technological progress, especially the enhancement of the green technology, the technological efficiency and technology level can truly be improved only by increasing the investment in research and development and carrying out the rational allocation of research and development resources. The advancement in green technology is in turn the main pathway to achieve cleaner production, lower pollutant emissions, and thus eliminating the relevant environmental problem. Hence, the direct role of subsidies for research and development in the technological advancement and its transmission effect in improving the environmental quality is very significant. The fundamental objective of environmental management is to achieve improvement in environmental quality while improving social welfare, that is, to achieve ecological and social benefits and to gain double dividends.

5. Conclusion

As China's economy enters a new normal, the downward pressure on economic growth has increased, and some local governments and enterprises are not committed enough to carry out environmental management properly. In this context, it is of tremendous theoretical and practical significance to study the environmental technologies and the stringency of environmental policies and their relationship with green growth in China. The development analysis on green growth has been extensively applied in the research on green growth development. For the purpose of further increasing the accuracy of the development analysis on the effect of environmental technology for green growth, a method for development analysis of environmental technology boosting the implementation of green growth is put forward in this paper. Based on this method, economic data and information on the objectives of environmental technology processes are collected, and the diversity of environmental technology processes present is taken into full account. The evolution of upgraded environmental technologies is analyzed in real time, and the evaluation algorithm is combined to carry out development analysis on the green growth based on environmental technologies. The method proposed in this paper can be used to analyze the green growth development in environmental technology process accurately and quickly. The result indicates that the environmental technology and the stringency of environmental policies have an indirect effect on the green growth in China through two pathways, that is, the technological innovation and the factor structure and FDI. This has demonstrated that the proposed method is relatively superior to the other analysis methods and can be used as a powerful tool for the subsequent analysis of environmental technologies.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Assessment of the Impact of Higher Education on Environmental Quality in BRICS Economies Based on Sustainable Development Pathways

Journal of Environmental and Public Health

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Research Article

Assessment of the Impact of Higher Education on Environmental Quality in BRICS Economies Based on Sustainable Development Pathways

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From the perspective of ecological environmental protection, higher education can not only train a large number of professionals dedicated to environmental protection for the construction of environmental quality, but more importantly, it can promote the improvement of the quality of ecological civilization in the whole society, so as to achieve the effect of indirectly improving environmental quality. BRICS economies, as the most important economies in the world, have an impact on the development of the world in many aspects. However, under the guidance of the concept of sustainable development, whether the environmental quality of BRICS economies meets the standards has also become the focus of scholars. Starting from the sustainable development path, this paper summarizes the model of environmental education in BRICS national higher education. At the same time, through the establishment of the BRICS environmental quality assessment system, the environmental quality of the BRICS countries after the implementation of environmental education was assessed based on the content of the sustainable development system. This paper performs matrix operations on the weight values of the indicators at all levels and the membership vector to obtain a 4×4 matrix, that is, the evaluation result Q of each indicator is [0.050, 0.200, 0.113, 0,011], which proves that the evaluation results in this paper are basically reasonable. It can be seen that in terms of forest coverage and environmental protection areas, environmental education in higher education has the deepest impact on Russia. In terms of carbon emissions, South Africa benefits the most from environmental education in higher education, so each country should take corresponding actions according to different environmental assessment results.

1. Introduction

As the external space for the development of a region, its quality determines the development of other aspects of the region, especially the economy. If the environmental quality is maintained well, it can provide a basis for economic development, and at the same time attract foreign investment and introduce people to live a virtuous circle in the region. However, if the environmental quality is not good, it will not only cost a lot of financial expenditures for external improvement but also will be difficult to maintain in the subsequent development, resulting in a rebound, which is likely to form a vicious circle and damage other aspects of development. Since the concept of sustainable development and green development was put forward, environmental quality has been continuously evaluated and studied in various forms because it is closely related to economic development. School is an important place for environmental quality education, and various types of schools play a major role in the process of environmental quality education. Young people are the key groups of environmental quality, and colleges and higher education should be the main positions for the implementation of environmental quality education. The construction of a country with green mountains, clean water, blue sky, and fresh air requires not only high-level planners and scientific and technological talents who are passionate about environmental protection but also the majority of ordinary workers with high ecological civilization quality.

However, the cultivation and shaping of these talents needed by the society basically depends on education, especially the environmental quality education. As several major economies that make great economic contributions to the world, the BRICS countries' development path is more worthy of in-depth discussion, so it is of practical significance to study the impact of higher education on environmental quality.

Environmental quality is closely related to everyone's quality of life and has always been a hot topic of research by scholars. Abdouli examined the impact of environmental quality and capital stock on economic growth in 17 MENA countries. By the systematic generalized moments panel data method, his findings show that economic growth in MENA countries negatively responds to environmental quality [1]. His research provided ideas for us to avoid environmental degradation, but there is still a lack of countermeasures to improve environmental quality. Abid proposed through research that there is a monotonically increasing relationship between CO_2 emissions and GDP in the Middle East, Africa, and the European Union [2]. His research is instructive on the balance between environmental quality and economic development, but the experimental procedures are not rigorous enough. Raju et al. used geospatial technology to assess environmental quality by taking thermal power plants as an example [3]. Although his research has a guiding role in improving environmental quality, the scope of his research is too narrow. Liu et al. proposed that although rapid urbanization leads to the deterioration of urban environmental quality, it has limited impact on the spatial pattern and driving factors of urban environmental quality in mountainous cities in China [4]. Although their research has obtained valid results, it also has the problem that the research area is too narrow. Paramati et al. studied the impact of tourism on economic growth and environmental CO_2 emissions in Eastern and Western European Union countries by incorporating FDI and trade into the production and CO_2 emission functions [5]. Their research shows that tourism adversely affects the environmental quality of Eastern Europe, but there is no valid validation of the same adaptation in other regions.

As an important path for human survival and development, sustainable development path has been widely used in different object research centers since it was proposed. Wu and Zhang introduced environmental quality and nonrenewable resources as endogenous factors and constructed a sustainable growth model with dual constraints of resources and environment [6]. Although his research is extensive, the derivation process is too complicated. Taking India as an example, Srikanth proposed to develop innovative strategies to clean up the country's coal sector while strengthening the integration of renewable energy into the national grid from a sustainable path [7]. His research is exemplary for developing countries, but not in all regions. Syangbo introduced the integration of sustainable development paths and organic farming practices from an educational perspective [8]. His research is very helpful for the education of sustainable development path, but the research is still relatively simple and not deep enough. Pietrzak et al. analyzed the quality of the entrepreneurial environment at the regional level in Poland under the framework of sustainable development paths [9]. Their research takes Poland as an example, which has a unique perspective, but lacks specific guidance and suggestions, and is not practical.

From the perspective of sustainable development path, this paper evaluates the environmental quality of BRICS countries after the implementation of environmental education in higher education. The innovation of this paper mainly lies in the diversification and multiangle of the environmental assessment of the BRICS countries, and it is further subdivided from the three perspectives of forest coverage, climate conditions, and environmental protection areas. The situation and data of each country are visually presented and compared, which makes the analysis of the article more accurate and objective.

2. Methods for Assessing the Impact of Higher Education on the BRICS Environmental Quality

2.1. Sustainable Development Path. The concept of sustainable development comprehends social development as the quality of human life and the overall optimization of the natural and human environment. The sustainable development path is fundamentally different from the traditional development path. In contrast, sustainable development needs to first solve the universal problem of the nonsustainable problems of contemporary economic and social development, so that development can be transferred to a benign track, and the ecological and social costs of economic and social development can be reduced to a minimum [10]. It essentially reflects the concept of developing and implementing the concept of ecological civilization.

The basic concepts of sustainable development concept are its premise is development, its goal is to increase human well-being and improve the quality of human life, and it focuses on the harmony and unity of the economy, society, population, environment, and resources. The sustainable development path is to use the conditions and opportunities of contemporary people to create an environment that can continue to develop, leaving a harmonious and green space for future generations. Rather than impair or jeopardize the ability and condition of future generations to meet their needs, future generations should also enjoy reasonable and equal opportunities for development. In the pursuit of human rights of development, we must always maintain a harmonious and mutually beneficial relationship with nature, organically combine economic development and ecological sustainable development, and achieve it in a harmonious and natural way. The development and utilization of the environment, resources, and energy must be within the control and carrying capacity of the ecosystem, instead of the traditional way of increasing investment, increasing consumption and sacrificing the environment, which balances production's demand for resources with the environment's availability of resources.

Specifically, the connotation of sustainable development can be understood from another perspective into three aspects: fairness, sustainability, and commonality [11]. The connotation of fairness refers to the fairness of contemporary people, which means that sustainable development should meet the basic needs of all people and give the world fair distribution and fair development rights. At the same time, when distributing the resources of the present generation fairly, the resource utilization of future generations should also be considered, and the limited resources should be distributed fairly [12]. The connotation of sustainability means that sustainable development should not destroy the ability of environmental regeneration, and human economic and social activities should ensure that the environment can bear the living. For example, sustainable development should not destroy the natural ecosystems that support life on Earth: the atmosphere, water, soil, organisms, etc. The connotation of commonality means that all human beings should be united to maintain sustainable development. Because sustainable development is not the goal of individual regions nor the fate of individual groups, it requires the joint efforts of all countries and regions. Based on the above description, a framework diagram of the sustainable development path can be drawn, as shown in Figure 1.

2.2. Environmental Education Models in Higher Education in BRICS Countries. Under the guidance of the sustainable development path, as a formal national education, higher education can make use of its various advantages in environmental quality education, give full play to its positive role in cultivating talents needed by society, and improve the civilized quality of young people. With the guidance of the concept of sustainable development, the BRICS countries also attach equal importance to environmental protection in higher education. Colleges and universities in various countries have combined relevant teaching content, popularized ecological environment knowledge, and incorporated advanced and necessary content of various environmental quality educations into their teaching plans, so that young people can receive good environmental quality education. Therefore, it will be invested in the construction of sustainable development in the future [13]. Through literature review and data research, this section investigates the higher education policies of five BRICS countries and summarizes the environmental education methods of higher education in each BRICS country, mainly including the following:

Classroom Teaching. Classroom teaching is not only the most basic way of higher education but also the place where the largest amount of information is imparted. In the classroom, teachers can have the opportunity to instruct students how to help students carry out environmental quality transformation from the perspective of sustainable development. Teachers of various subjects use classroom penetration to organically integrate the specific goals of ecological civilization education into the process of subject classroom teaching, strengthen their awareness of ecological protection, and improve their ecological civilization quality and behavioral ability while learning relevant knowledge [14]. From the perspective of higher education, universities in BRICS countries not only provide ecological environment majors but also nonecological environment majors with corresponding education on ecological civilization and environmental protection. In BRICS countries, for students majoring in ecological environment and other related majors, environmental protection education continuously improves educational methods and means to further improve educational effects [15].

Second Classroom. The second class refers to the nonclassroom but also the form of classroom teaching effect, such as lectures and special reports. Relevant topics and reports can make full use of modern educational technology (such as multimedia, projector, and network) to mobilize the enthusiasm and pertinence of students to participate in the activities without destroying the academic and authoritativeness of the subject content and prepare for the activities in advance. In BRICS countries, the second classroom of higher education can be seen everywhere. Lectures to promote environmental protection are often held among students. Report activities advocating sustainable development are also emerging one after another, so as to improve students' awareness of environmental protection [16].

Campus Culture Construction. In BRICS countries, this kind of educational significance is no less than simply instilling the awareness of protecting the environment and saving resources in students. At the same time, this form can also have a positive impact on students' awareness of ecological civilization in a subtle way [17]. In addition, in BRICS countries, when schools carry out popularization of ecological environment knowledge, more students are introduced to understand, and the concept of sustainable development and environmental quality protection is further expanded [18]. The construction of campus culture helps to build not only the school culture but also the culture of national ecological protection.

Extracurricular Practical Activities. In higher education in BRICS countries, in addition to the above forms, practical activities are also one of the good ways of environmental quality education. In these countries, it is common for colleges and universities to jointly carry out public welfare activities oriented to the society, with the theme of saving resources and planting trees, and guide people to cooperate with nonprofit environmental protection organizations. Jointly carry out socially oriented ecological civilization education and practical activities with the theme of saving resources and rejecting pollution [19]. Carry out various missionary activities for the society. Taking college students' ecological and environmental protection associations as an important carrier to carry out various publicity and education activities also promotes the improvement of environmental quality invisibly [20]. It can not only deepen students' understanding of the concept of ecological environmental protection and exercise their social practice ability but also play an important role in promoting the direct transmission of the concept of ecological civilization in the whole society. Figure 2 shows the protection model of environmental quality in higher education in BRICS.

2.3. Construction of BRICS Environmental Quality Assessment System. This section will use the fuzzy evaluation model to build an evaluation system for the environmental

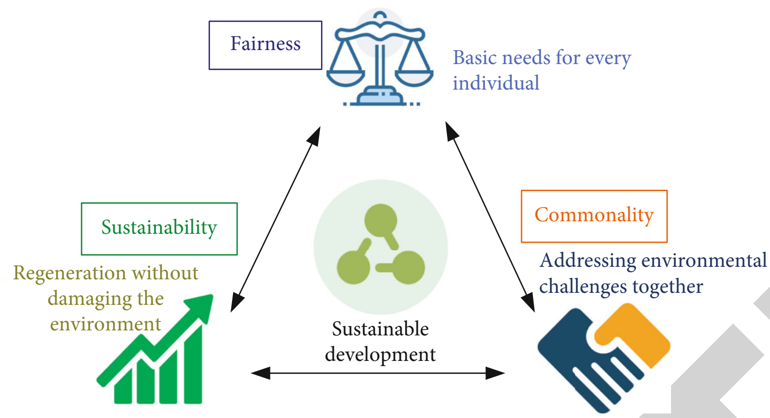


FIGURE 1: Framework of sustainable development pathways.

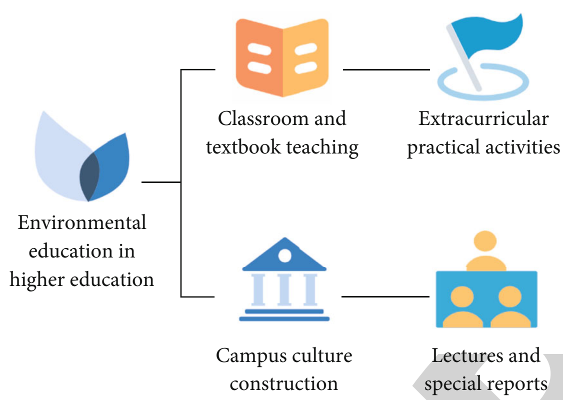


FIGURE 2: Environmental quality protection model for higher education in BRICS.

quality of BRIC countries. The fuzzy comprehensive evaluation is based on fuzzy mathematics, which was first proposed by experts in cybernetics in the United States. After that, it has experienced rapid development and is now used in many aspects, including industry, environment, and agriculture. Fuzzy comprehensive evaluation can effectively reduce the subjectivity of evaluation results, evaluate some objective fuzzy phenomena more accurately, determine the boundaries of evaluation objects from multiple aspects, and improve evaluation accuracy [21].

The Determination of the Evaluation Index Set U

$$U = \{u_1, u_2, u_3, \cdots, u_n\}, \tag{1}$$

where $u_i (i = 1, 2, \cdots, N)$ represents the evaluation index, and N is the number of evaluation indexes in the same layer.

Determination and Standardization of Evaluation Grades

$$V = \{V_1, V_2, V_3, \cdots, V_n\}, \tag{2}$$

where $V_j (j = 1, 2, \cdots, n)$ represents the comment level, and n is the number of levels. The rating scale can be a quantitative numerical value or a qualitative description.

Determination of Membership Vector

If the single-factor evaluation of the i-th evaluation factor u_i is V_j

$$R_i = \left(r_{i1} . r_{i2}, r_{i3} \cdots, r_{ij}\right), i = 1, 2, \cdots, N ; j = 1, 2, \cdots, n, \tag{3}$$

where r_{ij} represents the degree of membership of factor u_i in v_j, and $0 \le r_{ij} \le 1$. By analogy, the membership degree of n elements is a matrix of N rows and n columns. In this paper, the membership function is used to calculate the membership of each element.

$$y_i = \beta_o(u_i, v_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i) x_{ik} + \varepsilon_i \tag{4}$$

In the formula, y_i represents the dependent variable value of sampling point i; β_o is the intercept, (u_i, v_i) is the scalar value of i; $\beta_o(u_i, v_i)$ is the constant term of i. $\beta_k(u_i, v_i)$**is** the coefficient of the k-th independent variable of i, and x_{ik} is the k-th independent variable of sample i; ε_i is the random error term of i.

Multilevel Comprehensive Evaluation

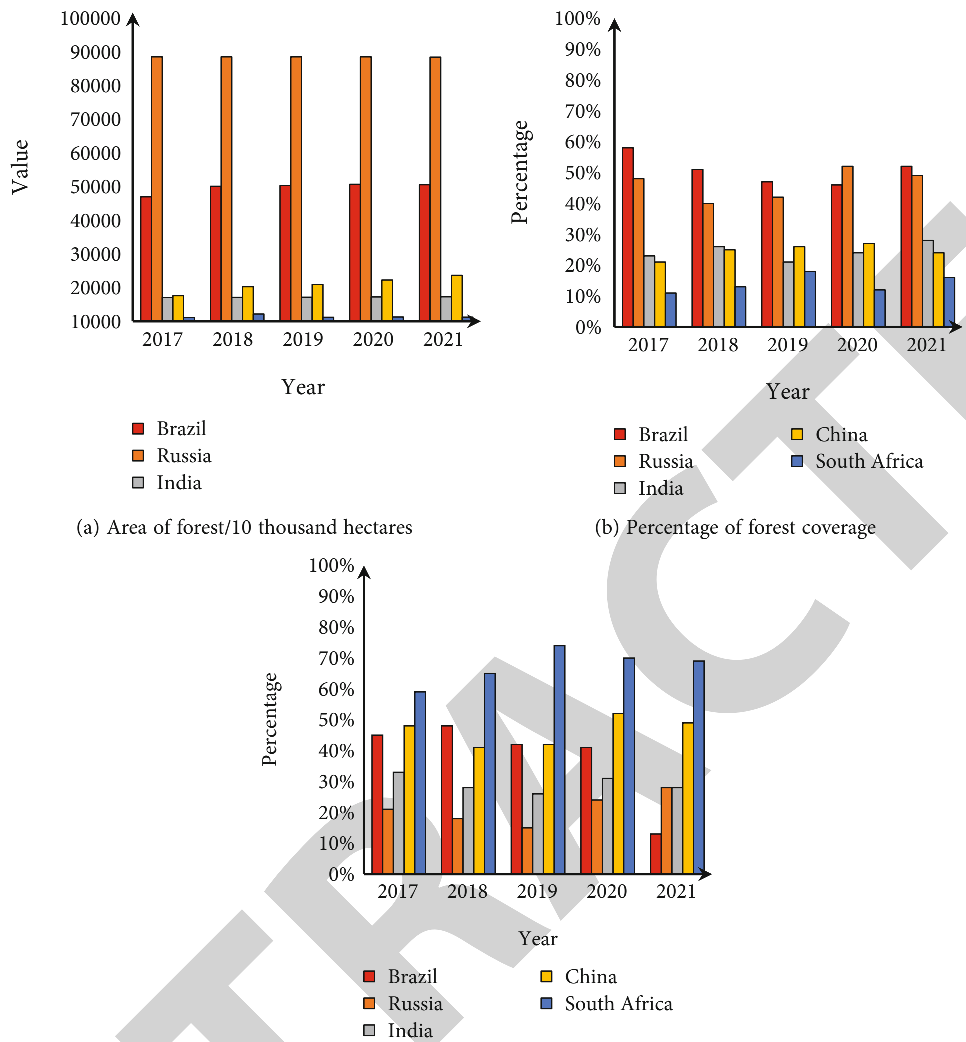
According to the evaluation principle of the maximum membership degree, the evaluation level of each index is determined, and the final evaluation result is obtained [22].

$$Q = R_i * B_i \tag{5}$$

Among them, Q is the ecological environment quality of the evaluation unit, R_i represents the membership degree matrix of the first-level evaluation index, and B_i represents the combined weight of the first-level evaluation index.

3. Environmental Quality Experimental Design and Data Sources

This section discusses the data sources of the experiment and the design of the relevant analysis process. The data for the analysis of the experimental results in this article are from the data of the BRICS National Bureau of Statistics and the national statistical yearbooks of various countries



(a) Area of forest/10 thousand hectares

(b) Percentage of forest coverage

(c) Plant diversities

Figure 3: BRICS national forest cover statistics results.

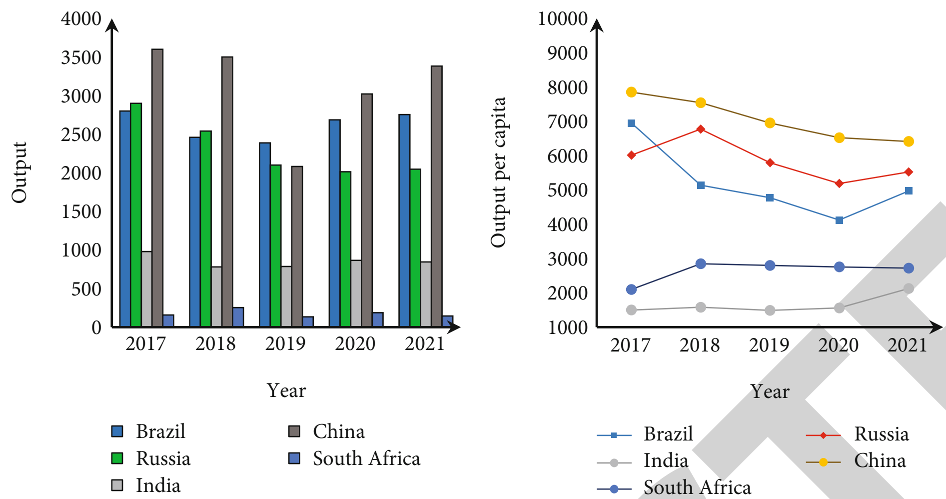
Table 1: Annual mean temperature change in BRICS countries.

	2017	2018	2019	2020	2021
Brazil	30.520	31.471	32.456	30.347	30.120
Russia	27.312	28.236	27.112	29.469	28.450
India	31.154	33.784	32.236	30.580	31.360
China	29.360	30.145	29.145	31.364	30.140
South Africa	28.874	27.324	30.013	28.457	29.214

[23]. The data sources can be obtained from the official websites of various countries and official announcements. BRICS has cooperated with many parties since its establishment in 2011. The data in this section on the impact of higher education on environmental quality are from 2017 to 2021. Since its establishment in 2011, the universities in the five BRICS countries have completed the planning of environmental protection education and the arrangement of environmental quality courses. After 2017, it was five years after the first batch of higher education on environmental quality ended. From the analysis of environmental quality in the past five years, it can be concluded that the effect of higher education on environmental quality and the trend of BRICS national environmental development, the research path of this paper is sustainable development. Therefore, in the results section, corresponding statistical analysis will be carried out on the data and performance of each country's environmental quality from the perspective of sustainable development.

4. Results Analysis

4.1. Deconstruction of Forest Cover Results. Forest cover has a significant impact on a country's environmental quality, and countries and regions with high forest cover mean that places can deal with carbon emissions more easily. At the same time, the forest area determines the size of the ecosystem. As a complex and huge ecosystem, the forest can provide shelter for animals and it can provide a growing environment for plant diversity, which further affects human activities [24]. The analysis of forest coverage in this section



(a) Total carbon emissions/10000 tons

(b) Carbon emissions per capita/kilogram

Figure 4: BRICS carbon emissions statistics.

is carried out from three perspectives, namely, forest area, proportion of forest coverage, and plant diversity. This section analyzes the data of the "Global Forest Resources Assessment" in recent years to obtain the forest vegetation coverage data of BRICS countries and statistics the results as shown in Figure 3.

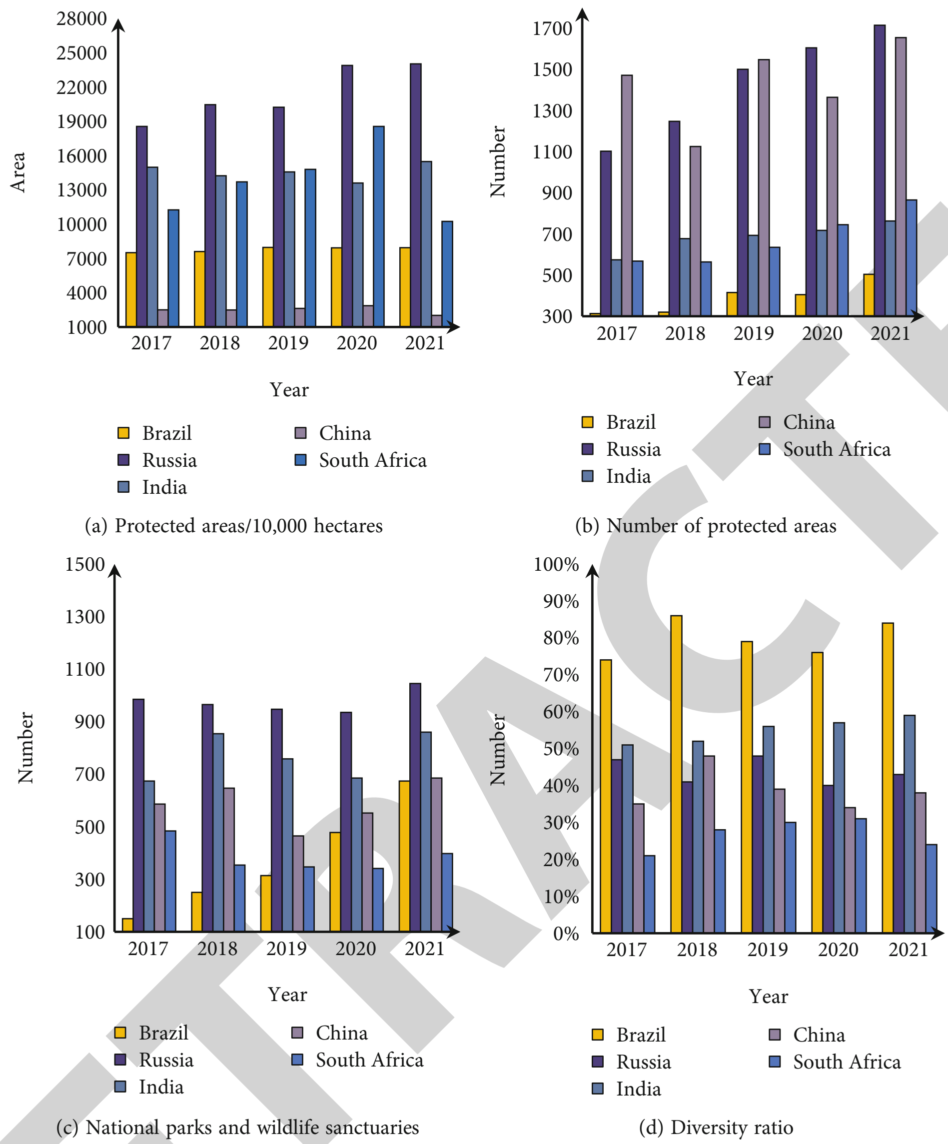
From Figures 3(a) and 3(b), it can be seen that from 2017 to 2021, the trend of forest coverage in the five BRICS countries has basically maintained a similar level. But Brazil has a downward trend, especially from 499.53 million hectares to 498.07 million hectares from 2019 to 2020. The 1 million hectares lost is not only related to the development of forest resources in Brazil to promote urbanization but also part of it is related to the fires in the Amazon forest. Among these five countries, Russia not only has the largest forest area, but also maintains the highest growth trend, with a total increase of 300,000 hectares from 2017 to 2021. The geographical environment of Russia, which is vast and sparsely populated, provides advantages for forest growth and area expansion [25]. As for the forest coverage rate of the rest of the countries, China has a relatively prominent performance. The forest area is large, but the land area is also large, so the forest coverage rate is not the highest.

As can be seen from Figure 3(c), in terms of forest vegetation diversity, according to the International Assessment Rules for Forest Plant Diversity, China has the highest average proportion of forest vegetation diversity in BRICS countries, and within 5 years, it has basically maintained a normalized high diversity rate. Among them, South Africa has the lowest diversity, which is not only related to the low forest coverage rate in South Africa (the average area is 1.7 million hectares) but also has a great relationship with the geographical location of the country.

4.2. Deconstruction of the Results of the Climate Environment. Climate factors, including temperature, precipitation, sunshine hours, and carbon emissions have an important impact on the regional environment. Different climate types correspond to different vegetation types, and the ecological conditions formed by different vegetation types are different [26]. Therefore, climate plays an important role in the ecological environment quality of BRICS countries. In this study, because each country has a very large area and spans a very wide range of latitudes and longitudes, it is difficult to summarize with one temperature level or climate type. Therefore, the climate factors are divided into two indicators: carbon emissions and temperature changes. Table 1 shows the variation of annual mean temperature in BRICS countries.

Combining with the temperature analysis in Table 1, it can be concluded that although the temperature changes of BRICS countries are not very different within their respective countries, the average temperature of some countries is slightly abnormal. There are many factors that affect temperature. Although the most important one is the climate factor, because each country has many dimensions and different climates, the change in average temperature can fairly show the results of temperature change. In order to further analyze the climate and environment of BRICS countries, through the arrangement of global carbon emission data, the article obtained the statistical results of total carbon emission and per capita carbon emission growth rate as shown in Figure 4.

From the carbon emission results in Figure 4, it can be seen that after planning environmental quality courses in higher education, the best carbon emission control in BRICS countries is South Africa, with an average per capita carbon emission of only 10 kg per year, far lower than other countries, while China and Russia have the highest carbon emissions. Among them, China's carbon emissions are higher than Russia's, and the per capita annual carbon emissions can reach about 10,000 kilograms. This is also related to China being the most populous country in the world. The large population base and high energy use rate lead to China's carbon emissions reaching the highest among the five countries. China's carbon emissions have a downward trend, which is also related to the "carbon neutrality" and "carbon peaking" policies implemented by China.



(a) Protected areas/10,000 hectares

(b) Number of protected areas

(c) National parks and wildlife sanctuaries

(d) Diversity ratio

Figure 5: Statistical results of BRICS environmental protection areas.

Table 2: Hierarchical total ranking and inspection.

	Natural environment	Climate environment	Soil environment	Hydrological environment	W
Natural environment	1.000	3.000	5.000	3.000	0.499
Climate environment	0.333	1.000	6.000	2.000	0.282
Protection environment	0.200	0.167	1.000	0.500	0.073
Hydrological environment	0.333	0.500	2.000	1.000	0.146
	Target layer consistency ratio CR: 0.056; weight to target layer: 1.000				

4.3. Deconstruction of Environmental Protection Zone Results. In addition to forest coverage, environmental protection areas are also one of the criteria for measuring environmental quality. In this section, the statistics on environmental protection areas mainly include the number of environmental protection areas and the proportion of biodiversity. The number of environmental protection areas also includes natural forest parks, wildlife reserves and national parks and other protection areas. The criteria for determining biodiversity and the proportion of data come from the "International Handbook of Common Biological Conservation". After statistics, the statistical results in Figure 5 can be obtained.

From the statistical results in Figure 5, it can be seen that among the BRICS countries, the construction and maintenance of environmental protection zones is the best in

Table 3: Composite weight values.

Evaluation target	First-level evaluation index	Value	Secondary evaluation index	Value
BRICS eco-environmental quality assessment	Forest cover rate	0.424	Forest area	0.200
			Coverage percentage	0.224
	Water resources	0.004	Freshwater resources	0.001
			Total water use	0.001
	Climate environment	0.354	Carbon dioxide emissions	0.232
			Temperature change rate	0.122
	Protected area	0.210	Number of protected areas	0.210
			Biodiversity as a percentage of protected area	0.008

Table 4: Membership matrix of the first-level evaluation layer.

Evaluation factors	Good	Generally	Poor	Very poor
Natural environment	0.039	0.340	0.169	≤ 0.001
Climate environment	0.155	0.017	0.012	≤ 0.001
Protected environment	≤ 0.001	0.057	0.085	0.030
Hydrological environment	≤ 0.001	≤ 0.001	0.031	0.064

Russia. The protected areas in Russia not only show an increasing trend year by year but also the highest number of protected areas reaches more than 100 in a year. In 2019, the number of protected areas reached 11,864, while Brazil and China were slightly behind in the number of protected areas. Among them, the number of protected areas in China shows a decreasing trend every year, from 2,750 to 480. Although Brazil has increased from a low of 320 to 400, the total number is still the lowest. Therefore, China and Brazil need more investment in the construction of environmental protection zones.

4.4. Comprehensive Assessment of Ecological Environment Quality. After analyzing the results of various environmental factors in the above content, this section takes the Fuzzy Comprehensive Appraisal (FCE) method introduced in Section 2 as the basic method for evaluation. Analytic Hierarchy Process (AHP) and Coefficient of Variation (CPA) were used to determine the comprehensive weight of each indicator, and then comprehensively evaluate the environmental quality of BRICS countries. The fuzzy evaluation method performs fuzzy operations on each index in the study area, which largely avoids the influence of human factors on the evaluation results, and the evaluation accuracy is high.

Analytic Hierarchy Process (AHP) to Determine the Weight. First, the weight of the evaluation index of the evaluation unit is calculated by the Analytic Hierarchy Process (AHP). Firstly, the matrix of each single factor index is constructed, and its consistency ratio is calculated. Because the consistency ratio is CR < 0.10, it means that the constructed matrix between each index can achieve satisfactory results, and the ranking and consistency ratio of the total level can be calculated continuously. Next, the total ranking and inspection of the hierarchy are calculated, as shown in Table 2.

It can be seen from Table 2 that in the calculation of the total hierarchical ranking, the CR value is 0.056 < 0.10, indicating that the matrix results constructed by the total hierarchical ranking can be used to determine the weight of each index and finally calculate the weight value of each single element to the target layer.

The Coefficient of Variation Method (CPA) Determines the Weights. According to the formula given in Section 2, the index weight based on CPA is calculated, and the objective weight value of each index of the evaluation unit is obtained. Using the linear combination method, by comprehensively calculating the weight values determined by APH and CPA, the comprehensive weight of each index of the evaluation unit is obtained, as shown in Table 3.

As shown in Table 3, according to the comprehensive weight value analysis, among the first-level evaluation indicators, the natural environment index has the largest weight, and the environmental protection area index has the smallest weight, which are 0.550 and 0.094, respectively. It reflects that the regional forest coverage rate has the greatest contribution to the regional ecological environment quality, while the impact degree of the environmental protection area is relatively low.

Fuzzy Comprehensive Evaluation. Before the calculation of the fuzzy comprehensive evaluation model, it is necessary to determine which level each index belongs to, that is, the calculation of the membership degree of the evaluation index. Firstly, based on the quantitative value (usually the mean) of each secondary index in the middle, the trapezoidal distribution algorithm is used to calculate the membership degree of each secondary index. That is, the membership degree value of each single factor. According to the matrix operation method, perform matrix operation on the weight values of the indicators at all levels and the membership vector to obtain a 4×4 matrix, that is, the evaluation results of each indicator in the secondary indicators, as shown in Table 4 and Formula (6).

$$Q = R_i * B_i = [0.050 \quad 0.200 \quad 0.113 \quad 0.011]. \tag{6}$$

Verification of Evaluation Results. Due to the lack of field verification work, this study mainly refers to the existing literature and expert opinions to verify the evaluation results. First, studies have shown that after environmental protection courses are planned into higher education, among BRIC countries, Russia has the best ecological environment quality. However, Russia is only doing well in forest coverage and environmental protection areas, but its carbon emissions are among the highest among the five countries. As a result of comprehensive environmental quality, Brazil has the lowest comprehensive quality and basically has no advantages except for the relatively large proportion of forest coverage. The other three countries, China, India, and South Africa, have their own advantages and disadvantages, but the overall results are all at the medium quality level [27]. Compared with the analysis in this paper, combined with the results obtained by the expert scoring method and calculation, it can be said that the environmental quality evaluation results of this BRIC economy are basically reasonable.

5. Conclusion

As the emerging economies of the world, the BRICS countries have brought great influence and changes that cannot be underestimated. In addition to the growth of the economy under the influence of the BRICS countries, the world environment is also affected by the development activities of the BRICS countries. This article starts from the path of sustainable development and summarizes the environmental education of higher education in BRICS countries. Then, an environmental quality assessment system is constructed based on the comprehensive fuzzy evaluation method. In the conclusion analysis, the environmental quality of the BRICS countries is analyzed from the three perspectives of forest coverage, climate environment and environmental protection area, and finally the fuzzy comprehensive evaluation is carried out. The analysis results of the article show that higher education has had different environmental impacts on different countries since the arrangement of environmental education. In terms of forest coverage, Russia is the most affected and therefore has the highest forest coverage. At the same time, Russia has also done the best in environmental protection zones, and among the five countries in terms of carbon emissions, South Africa has performed the best. Although the article evaluates the environmental quality from different perspectives, due to the limited space, there is still a lot of detailed analysis and specific process descriptions in the research methods and experimental demonstrations, which is also the shortcoming of the article. In the future, people could look forward to conducting research based on more scientific methods and making contributions to the research on education and environmental protection.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Article

Promoting Sustainable Green Growth through the Use of Political Institutions: The Role of the Law

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In the era of global development, due to the destruction of the environment by traditional production, traditional industries have been forced to open the road of green growth transformation. What kind of methods that can effectively promote sustainable green growth has become one of the current research topics that has attracted much attention. Addressing this issue is very important for the green growth sector. With the in-depth research on green growth, the research on the promotion of green growth by political institutions has gradually been carried out, and its policy advantages are of great significance to solve the problem of green growth transformation. The purpose of this paper is to examine the role of law in the promotion of sustainable green growth by political institutions. Through the analysis and research of sustainable green growth, law, and logistic regression model, it can improve the level of sustainable green growth of enterprises and solve the problem that the current level of sustainable green growth of enterprises is not high. This paper analyzes sustainable green growth, the role of law, and logistic regression models and uses relevant formulas to explain them. The experimental results show that the green growth index of group A production enterprises is higher than that of group B. Legal means have played a very important role in improving the level of sustainable green growth in the promotion of sustainable green growth by political institutions. It can meet the requirements of green growth under the current SDG concept, and its sustainability has been greatly improved.

1. Introduction

At present, the concept of sustainable development is deeply rooted in the hearts of the people. Many traditional enterprise production methods cannot meet the increasing requirements of green growth in terms of energy efficiency and environmental protection. Green growth requires the pursuit of economic growth and development while preventing environmental degradation, biodiversity loss, and unsustainable use of natural resources. Intervention by political institutions is a national coercive measure that can effectively solve the problems encountered in the process of promoting green growth in the SDG. Due to its policy advantages, it has been applied in various fields to successfully solve various direction guidance problems. Political institutions can take macromanagement, legislative, and administrative measures, the organization of public production and the provision of public property, financial, and other interventions. The method of law's intervention in political institutions is the most direct form of existence and has far-reaching implications for the study of how the law can play a role in promoting sustainable green growth using political institutions. The concept of green growth requires forcing changes in the traditional production methods of enterprises; so, its application is of great universal value at present. In recent years, scholars have used political institutions to solve the problem of sustainable green growth, but there are relatively few applications and researches on the role of law in this regard. Therefore, this paper is significant for the study of the role of law in promoting sustainable green growth in political institutions.

At present, with the continuous advancement of the transformation of the SDG concept, more and more scholars have conducted research on promoting sustainable green growth. Among them, in order to improve people's current sustainable living level, some scholars studied the process of G-IoT to create green and sustainable living places [1]. To study the relationship between business and the environment, Bendell explored how business owners make trade-offs related to environmentally friendly innovation [2]. In order to investigate the positive impact of green power on green product innovation performance, Chang believed that machine power and moral power have positive effects on green product innovation performance [3]. Retrofitting old cities to mitigate climate change has become a global trend. Covering a variety of strategies to improve the urban environment and make the city a more livable place, some scholars have proposed that improving the quality of life of urban residents requires sociopolitical participation, public education, and government leadership [4]. Using dynamic capability theory, Singh and El-Kassar proposed an empirically tested model for green concept research [5]. However, the methods used to promote sustainable green growth are not very efficient.

Intervention through political institutions has been shown to be direct and effective in promoting green growth. In addition, some scholars have studied the impact of government spending on the country's green economic performance under the "One Belt, One Road" initiative [6]. In order to evaluate the effect of political institutions in promoting green growth and analyze which factors drive green growth, some scholars developed a comprehensive model to study the relationship between ER, TI, and regional green growth performance (RGGP) [7]. In order to explore the influence of political relevant departments on agricultural green entrepreneurship, some scholars have studied the opportunities of agricultural entrepreneurship and the role of green entrepreneurship in achieving sustainable economic growth in Nigeria [8]. To clarify the link between political institutions and green growth, researchers have found that in addition to environmental benefits, the dissemination of technologies developed through green LIFE projects may also have important economic and social impacts [9]. These methods have promoted the progress of green growth to a certain extent, but their effect on improving the level of green growth is not direct enough.

In order to solve the mentioned low level of sustainable green growth, this paper uses a logistic regression model to analyze the role of law in promoting sustainable green growth. By simulating it, it can achieve the effect of promoting energy saving and emission reduction in the production of enterprises and improving the level of green growth. The novelty of this paper is that it uses logistic regression to analyze how political institutions, law, and logistic regression models play a role in promoting sustainable green growth through the use of political institutions: the role of law. The proposed model is described. Through experiments, it is found that the application of legal methods can effectively improve the level of green growth of enterprises.

2. Methods

2.1. Content and Organization of the Paper. With the gradual promotion of SDG thinking on a global scale, the defects and deficiencies in the production of enterprises with low sustainable green growth levels have become increasingly prominent [10, 11]. The problems of low sustainable green growth production are shown in Figure 1.

As shown in Figure 1, low sustainable green growth levels are often accompanied by uncontrolled exhaust emissions and waste water emissions, resulting in severe air pollution, water pollution, and great damage to the global environment and human living space. Therefore, it is very important to improve the level of sustainable green growth [12].

Intervention by political institutions can fully make up for the insufficiency of market supervision. From a macro and overall perspective, more appropriate action on the entire macro economy can achieve a comprehensive balance between environmental protection and economic development. The survey found that current research on the role of law in promoting sustainable green growth through the use of political institutions is incomplete. Therefore, this paper presents a study of the role of law in the use of political institutions to promote sustainable green growth [13, 14]. This paper applies a logistic regression model to the analysis of the role of law in the use of political institutions to promote sustainable green growth and proposes a new model for use in the analysis of the role of law in promoting green growth. Production enterprises controlled by legal methods through experiments and data analysis have a higher level of sustainable green growth than ordinary production enterprises. The organization of the full text is shown in Figure 2.

As shown in Figure 2, this paper is composed of five parts. The first part mainly introduces the research background of the role of law in promoting sustainable green growth through the use of political institutions to draw out the problems to be solved to illustrate the purpose and significance of this paper. Then, it makes a general analysis of the research status of the sustainable green growth field and the research field of political institutions promoting green growth and explains the content and innovation of this paper; the second part describes the organization structure and method of the whole paper, introduces the related method content of the logistic regression model, and describes the proposed logistic regression model; the third section details the data sources used for the study Promoting Sustainable Green Growth through the Use of Political Institutions: the Role of the Law; the fourth part is experimental analysis through the experimental analysis of the production consumption and energy consumption of different groups of enterprises, the production emissions of different groups of enterprises, and the level of sustainable green growth of different groups and draws conclusions after analyzing the result data; the fifth part is the conclusion.

2.2. Logistic Regression Model. In this paper, logistic regression is chosen for the analysis of relevant data in the study of the role of law in promoting green growth through the use of political institutions. Logistic regression is a special kind of linear model, which is a special form of the normalized linear model [15, 16]. Both logistic regression and linear regression are generalized linear models. Specifically, linear models derived from the exponential family of distributions. Linear regression is based on the premise that $Y|X$ follows a Gaussian distribution. Logistic regression is based on the

Figure 1: Problems with low sustainable green growth production.

Figure 2: Full-text content organization.

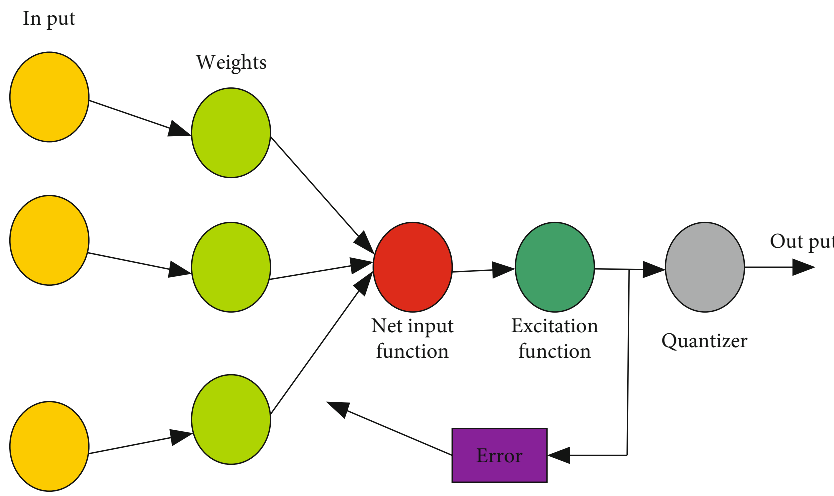


Figure 3: Data analysis based on logistic regression model.

premise that $Y|X$ follows the Bernue distribution. As shown in Figure 3, applying the logistic regression model to the relevant data analysis on the role of law in promoting green growth can yield better results [17].

Its advantages are that it is very simple to implement first, and secondly, it has a wide range of applications, less classification and calculation, fast speed, and easy understanding. In contrast to linear regression, logistic regression uses a logistic function to map the range of dependent variables from the actual range 0 to 1. Logistic regression is basically used for classification problems [18]. The former can only be used for regression problems, while the latter is used for classification problems (2-class, multiclass). Linear regression has no link function or does not work. The link function of logistic regression is a logarithmic probability function; linear regression uses the minimum square method as the parameter estimation method, and logistic regression uses the most-likelihood method as the parameter estimation method.

When a relevant dataset $\{M_{i,i}|l_i \in \{0,1\}, i = 1, \cdots, z\}$ is available on the role of law in promoting sustainable green growth through political institutions, there is formula (1):

$$M\vartheta = \sum_{i=1}^{z} l_i^Y \vartheta. \tag{1}$$

Among them, $l_i \in T^e, \vartheta \in T^e$.

To get the logistic regression model of the relevant data, a hypothesis function must firstly be constructed as shown in formula (2):

$$N_\vartheta(l) = G\left(l^Y \vartheta\right) = \frac{1}{1 + \exp\left(-l^Y \vartheta\right)'}. \tag{2}$$

$N_\vartheta(l)$ is the constructed hypothetical function that affects the green growth level; $G(x) = 1/1 + \exp(-x)$ is the logistic function.

Both function $J_\delta(a)$ and logic function $h(x)$ are assumed to have values between 0 and 1.

In the green growth related data set $\{M_{i,i}|l_i \in \{0,1\}, i = 1, \cdots, z\}$, the influence on the green growth level is set as the dependent variable, and the conditional probability when its value is 1 can be expressed by formula (3):

$$Y(b = 1|l, \vartheta) = N_\vartheta(a) = \frac{1}{1 + \exp\left(-l_i^Y \vartheta\right)} = y. \tag{3}$$

Conversely, the conditional probability when the dependent variable is 0 can be expressed by formula (4):

$$Y(b = 0|l, \vartheta) = 1 - N_\vartheta(l) = 1 - y. \tag{4}$$

According to the discussion, both sample data $M \in T^{z\times y}$ and class label $G \in T^z(b_i \in \{0,1\}$ conform to Bernoulli distribution.

By integrating these formulas, the logistic regression model affecting the level of green growth can be obtained as shown in formula (5):

$$R(b|l, \vartheta) = y^b (1 - y)^{(1-b)}. \tag{5}$$

$C(b|x, \vartheta)$ is the probability that the sample l belongs to the condition of class b; ϑ is the parameter vector of the variable.

The company's sustainable green growth level evaluation index is set as a nominal variable, and the company is investigated in the form of whether the intervention items implemented by the company affect the company's sustainable green growth level. Therefore, the logistic regression model is used to analyze the factors affecting the evaluation index of sustainable green growth level [19]. Assuming that the probability of occurrence of an impact on the sustainable green growth level of the enterprise is C, and the value range is 0 to 1, the probability that the event does not occur is $1 - C$. This probability can be calculated using a logistic regression function [16]. The expression is formula (6):

Table 1: Examples of basic characteristic information content of some manufacturers in the questionnaire survey.

Project	Enterprise 1	Enterprise 2	Enterprise 3
Business age	7	6	11
Property rights	Privately held	Collective holding	Foreign trade holding
Production type	Extractive	Assembly type	Decomposition type

Table 2: Examples of production information content of some manufacturers in the questionnaire survey.

Project	Enterprise 1	Enterprise 2	Enterprise 3
Annual output value	7.64 million	3.40 million	11.41 million
Annual energy consumption	34.15million tons	18.64 million tons	117.28 million tons
Annual carbon emissions	13.14 million tons	5.27 million tons	26.96 million tons
Annual carbon intensity	11.24	9.61	23.15

$$Ln\left(\frac{C_1}{1-C_1}\right) = \psi_0 + \psi_1 b_1 + \psi_2 b_2 + \cdots + \psi_i b_i (i = 1, 2, 3, \cdots, n). \tag{6}$$

C_1 is the probability of a positive impact, ψ is a constant term, ψ_i is the regression coefficient of the i-th factor affecting sustainable green growth, and b_i is the i-th independent variable.

According to the problems of today's low sustainable green growth level, presuppositions are made for the factors affecting an enterprise's sustainable green growth level. It is assumed that the energy consumption of the enterprise, waste emissions, output indicators, and production methods can be affected by legal control. Through the aspects of formulation of relevant tax policies in legal methods, formulation of relevant emission guidelines, energy use regulations, and so on, the deterministic factors for improving the level of green growth can be obtained through data investigation and analysis of these factors. At the same time, it determines the role of law in promoting sustainable green growth and adjusts the production-related items of enterprises through legal methods to better guide production enterprises to improve the level of sustainable green growth. After assigning the preset attributes into the initial model, a complete and sustainable green growth level factor influencing model can be obtained. The influence coefficient of each item is obtained, and the conclusion is drawn after analysis in Experimental Analysis.

3. Experimental Analysis

There are two main parts of the data used for the analysis of this experiment. On the one hand, it collects data on the experimental data on the use of political institutions to promote sustainable green growth: the role of law among middle and senior managers in 10 selected production enterprises in the form of a questionnaire survey. Among them, 300 questionnaires were issued, 286 questionnaires were recovered, 284 were valid questionnaires, and the recovery rate was 94.6%. The collected information data are mainly the basic information characteristics of the enterprise: the production situation of the enterprise. Examples of the specific content of the collected information are shown in Tables 1 and 2.

The object of this part of the dataset consists of three attributes, namely, the age of the manufacturer, the type of property rights of the manufacturer, and the type of production of the manufacturer.

The subitems included in this part are annual gross output value (unit: million yuan), annual standard energy consumption (unit: million tons), annual carbon emissions (unit: million tons), and annual carbon emission intensity (it is the carbon emission per million output value, and the unit is ton/million yuan).

At the same time, an expert group is established to evaluate the level of green growth by analyzing and discussing the collected corporate data. Examples of the evaluation criteria are shown in Table 3.

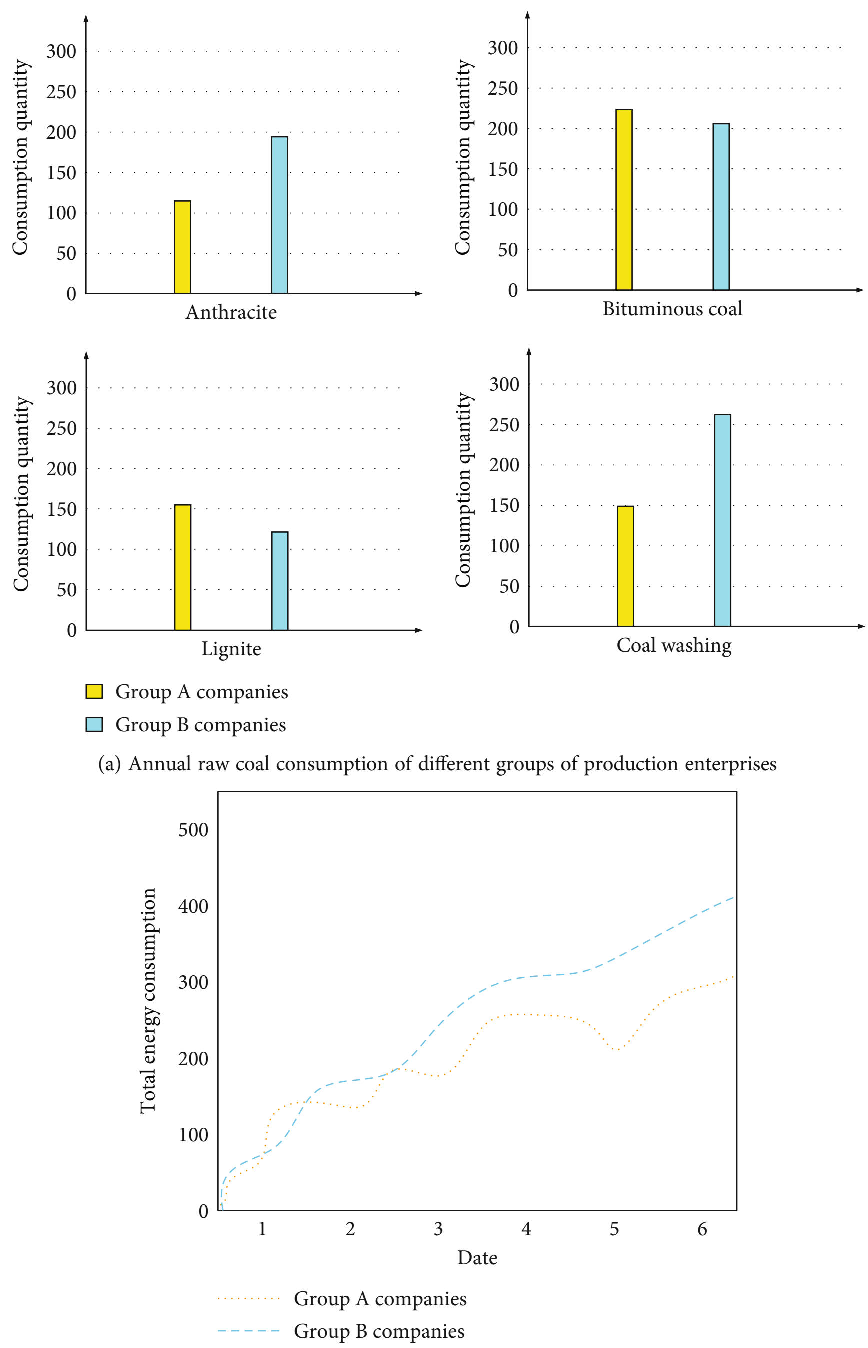
Among them, in view of the energy loss, energy utilization efficiency, the "three wastes" in the discharge process, the degree of environmental pollution, and the output efficiency of the production enterprises, the scoring rules are formulated and adopted after testing. The expert group scored the production enterprise's energy consumption, environmental protection, sustainability, and output, with a total of 10 points. The higher the score, the higher the green growth level of the item.

After a 6-month test in this experiment, several enterprises were divided into observation group A, which were production enterprises that were intervened and controlled through legal methods. The legal method adopted was to restrict the use of its resources, restrict its emissions, and make new plans for its production targets through the formulation of legal regulations; enterprises of group B were ordinary production enterprises without control. The following conclusions are drawn from the collected information related to the production situation of the enterprise, the environmental pollution situation, and the level of sustainable green growth.

3.1. Production Consumption and Energy Consumption of Different Groups of Enterprises. The collected information on production and energy consumption of the enterprise is compared among different groups, and the specific content of the result analysis is shown in Figure 4.

Table 3: Examples of the content of the evaluation of the green growth level of some enterprises by the expert group.

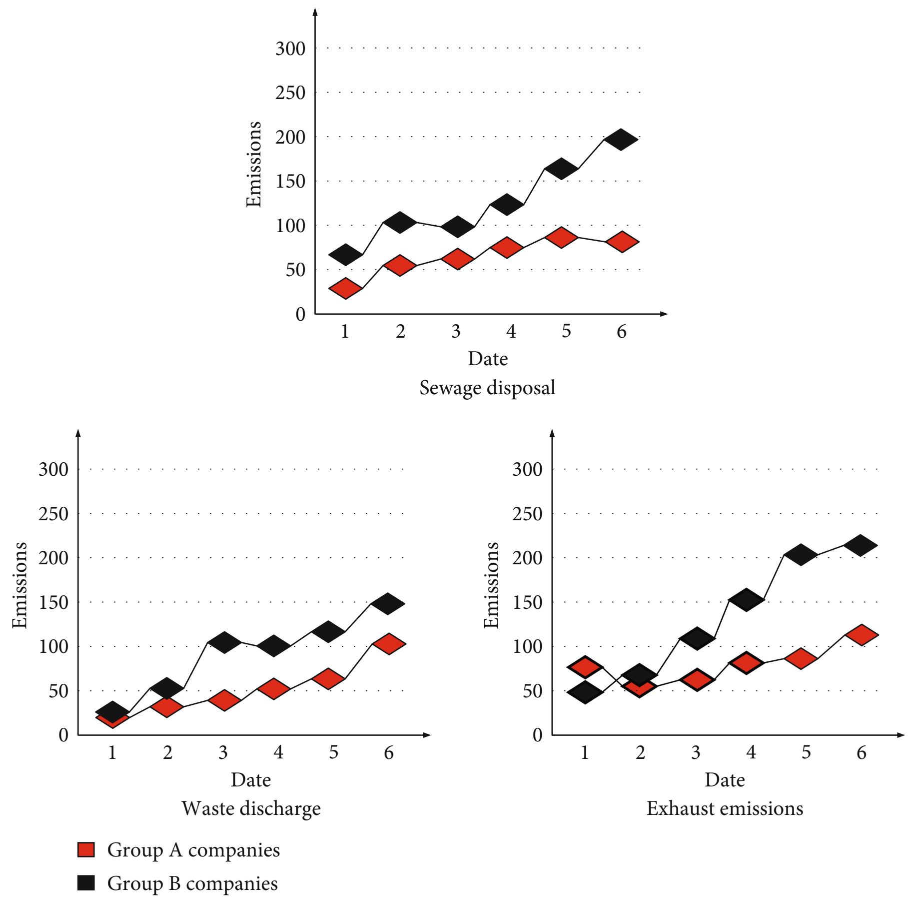
Index	Enterprise 1	Enterprise 2	Enterprise 3
Energy saving	3.64	7.54	4.51
Environmentally friendly	4.51	6.35	2.45
Sustainability	4.91	6.14	3.77
Productivity	7.64	5.46	8.63
Comprehensive index evaluation	5.14	7.38	4.76



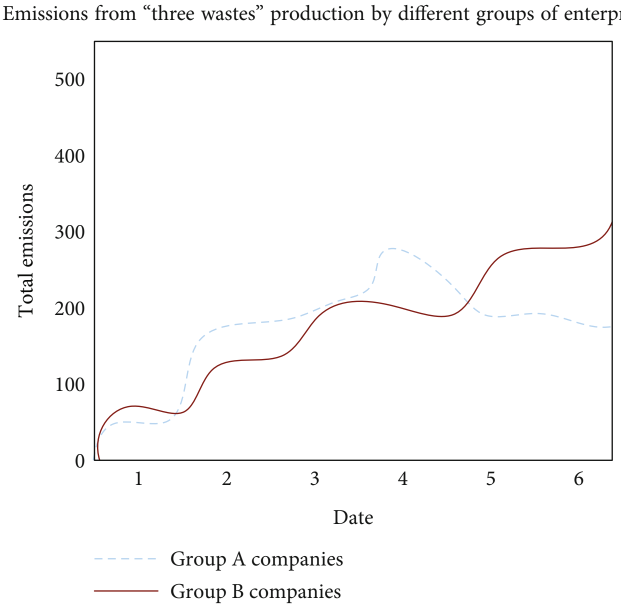
(a) Annual raw coal consumption of different groups of production enterprises

(b) Overall energy consumption growth of different groups of production enterprises

Figure 4: Production consumption and energy consumption analysis of different groups of enterprises.



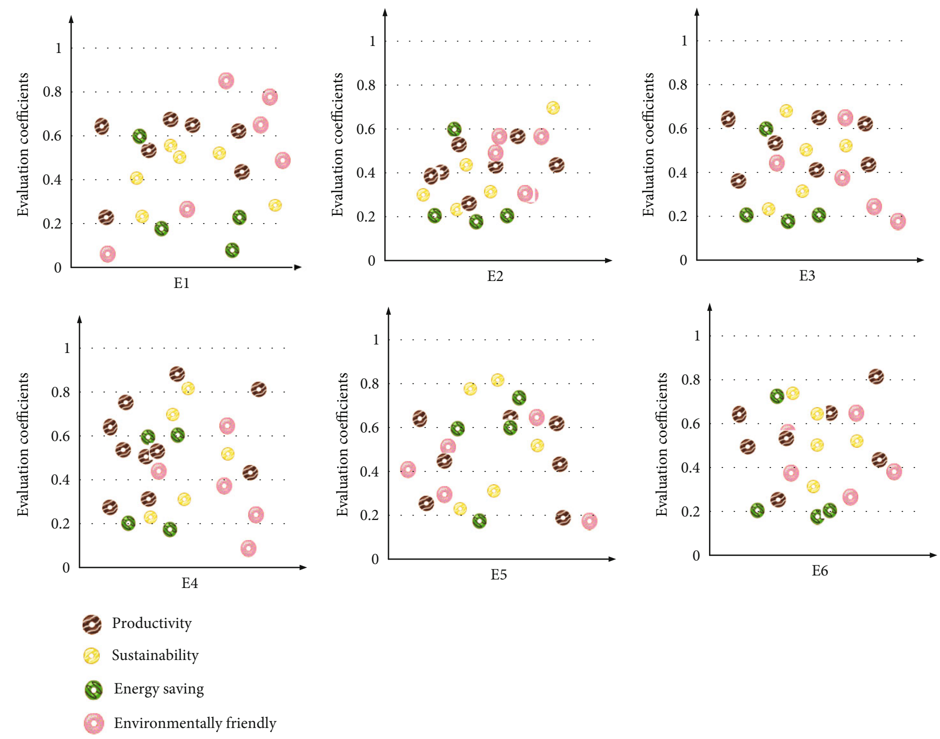
(a) Emissions from "three wastes" production by different groups of enterprises



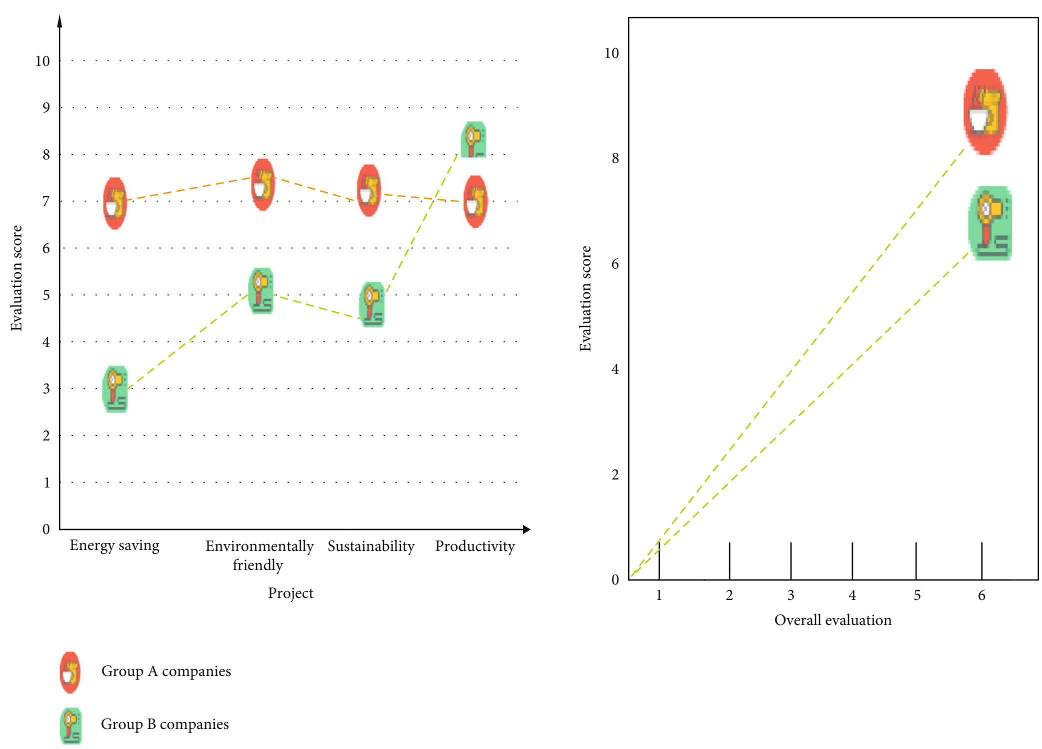
(b) Growth of overall waste emissions of different groups of production enterprises

Figure 5: Analysis of production emissions of different groups of enterprises.

As can be seen from Figure 4, overall, the energy consumption of group B enterprises is higher than that of group A enterprises. The annual consumption of coal washing by group B enterprises has reached 2.7614 million tons, which is twice as high as that of group A enterprises. The production consumption of this enterprise is very large. Judging from the overall consumption growth of different groups of production enterprises during the test



(a) Distribution of evaluation index coefficients of different production enterprises



(b) Sustainable green growth levels of different groups of enterprises

Figure 6: Evaluation of the sustainable green growth level of different groups of enterprises.

period, with the increase of time, the energy consumption rate of group A slowed down significantly, and the total consumption was lower than that of group B, with a difference of nearly 23.44%. This is due to the adjustment of the energy use of group A enterprises through legal control to make it optimize the energy use method and improve the energy utilization rate. Legal control can help enterprises save energy consumption in production.

3.2. Production Emissions of Different Groups of Enterprises. The collected data on the production and emission of different groups of enterprises are compared and analyzed, and the specific content of the results is shown in Figure 5.

Figure 5 The emissions of "three wastes" of group A enterprises are significantly lower than those of B renting enterprises. During the experiment, the total production emissions of group A enterprises initially increase faster than that of group B enterprises, reaching 2,765,800 tons, and then begin to decline again in the next two months, reaching only 1,371,500 tons. Group companies are less than half. This is because, under the constraints of laws and policies, the enterprises in group A firstly improve production efficiency through technological innovation, concentrate production emissions in the early stage to achieve production tasks, and gradually reduce production emissions in the later stage. Intervening in the production emissions of enterprises through legal methods can effectively reduce production emissions.

3.3. Different Sets of Sustainable Green Growth Levels. After analyzing and processing the data of each enterprise through the data analysis model, the expert group conducts an overall assessment of the sustainable green growth level of different groups of enterprises, and the specific results are shown in Figure 6.

Figure 6 On the whole, the sustainable green growth level of group A is significantly higher than that of group B. Among various evaluation indicators, although the score of group B enterprises in productivity is 8.31, it is higher than that of group A enterprises. However, the scores in the other three evaluation indicators are lower than those of group B enterprises. Therefore, in the comprehensive evaluation, the companies in group A achieved 8.69 points, and the companies in group B only scored 6.83 points. After controlling the green growth-related indicators produced by company A through legal methods, the sustainable green growth level of this group of companies has been improved.

4. Conclusion

Sustainable green growth under SDG is becoming more and more intense, and people's requirements for green growth are getting higher and higher. The development of sustainable green growth is inseparable from the contributions of political institutions and laws. Laws have been widely used in many fields because of their direct intervention advantages. Through comprehensive experimental analysis, group A companies that use legal methods to manage and control are better than group B companies that do not use political agency intervention in various indicators of sustainable green growth. They are not only more sustainable but also better. The production of legally controlled enterprises is used to meet the needs of sustainable green growth. There may be some uncertain factors, such as the instability of the use environment and the difference of operators, so that the results of this experiment are not completely accurate and reliable, and there are certain differences. This paper firstly analyzed the use of political institutions to promote sustainable green growth, laws, and logistic regression and then analyzed their function using related principal formulas. Then, in the experimental part, this paper compared the production enterprises that use legal intervention and those that do not use legal intervention. The conclusion is that the sustainable green growth level index of the production of enterprises that are controlled by legal methods is higher than that of ordinary production enterprises, and the sustainability is more stable. Therefore, a study of promoting sustainable green growth using political institutions is as follows: the role of law is necessary.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Retraction

Retracted: Research on the Sustainability of Traditional Music and the Adaptability of Ecological Environment

Journal of Environmental and Public Health

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

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[1] L. Kan, "Research on the Sustainability of Traditional Music and the Adaptability of Ecological Environment," *Journal of Environmental and Public Health*, vol. 2022, Article ID 2724635, 7 pages, 2022.

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Research Article

Research on the Sustainability of Traditional Music and the Adaptability of Ecological Environment

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Under the new situation, the world is showing a trend of becoming more and more open, and the frequency of cultural exchanges in China is also accelerating. In this case, traditional music has been impacted to a certain extent, which also affects the sustainable use of traditional music. This is the general law of cultural development, and the impact is also accompanied by vitality. The analysis of the sustainability of traditional music and the adaptability of the ecological environment, how to accurately improve the matching results will directly affect the accuracy of the analysis of the sustainability of traditional music and the adaptability of the ecological environment. This study proposes an adaptive analysis method for the sustainability and ecological environment of traditional music. While analyzing the characteristics of traditional music in detail, the important characteristics of other types of music have also been fully considered. In this study, the adaptive evaluation method is used to obtain the optimal dynamic evaluation parameters. At the same time, the dynamic amplitude difference step size is set, and the adaptability analysis is performed according to the change threshold to improve the accuracy of the adaptability analysis of sustainability and the ecological environment. The adaptive evaluation method is used to limit the weight of lyrics and the semantic information of music. Finally, the experimental analysis shows that the traditional adaptive evaluation method and the algorithm of this study are experimentally tested. Adding adaptive evaluation methods further improves the accuracy of evaluation.

1. Introduction

With the rapid development of Chinese economic construction, Chinese traditional music has faced an increasingly aggravated crisis of survival, and many of them have reached a situation where there is no successor and they are on the verge of being lost. Therefore, how to protect these cultural heritages from their influence while developing the economy has increasingly become a problem perplexing Chinese music scholars. Although it has been more than half a century since the original publication of the article, and the author did not explicitly mention the word “protection” in the text, his incisive insights still have important enlightening significance to our understanding of the protection and development of traditional music in contemporary times[1–3]. With the continuous progress of society, in the process of traditional music development and adaptability research, the research on sustainability and adaptability of the ecological environment will become the goal of in-depth research and exploration of traditional music by Chinese and foreign scholars. Digital technology is used for Yunlin’s electronically archived traditional music, which can not only effectively process massive data and facilitate data storage and query but can also effectively avoid the loss and damage of data information caused by natural and manmade disasters. The music sustainable storage technology can be used to realize the in-depth analysis of the stored traditional music data, provide users with valuable information data, and then complete cultural exchanges and applications around the world but how to obtain specific content from the initial humanistic data lacking the definition of traditional music content has become a huge challenge for the adaptive evaluation method of the current traditional music [4]. Traditional music is inevitably influenced by today’s economic laws and is subjected to the competition test of survival of the fittest [5–8]. Those folk and national traditional music projects that can serve commercial activities or have a certain commercial development value are constantly excavated. China's traditional music has rich cultural connotations and inheritance value. In the long process, it has been continuously optimized so that it can carry Chinese traditional cultural beliefs. As an important part of the long-term development system of Chinese civilization, it inherits historical culture in a variety of ways, and the historical culture carried is diverse. The way of unfolding is flexible and changeable, which can reflect the value of national traditional culture and aesthetic value. The inner spiritual needs of traditional music should be grasped, but the aesthetic status of traditional music deserves further consideration. This has been confirmed in the continuous development of society, the continuous economic growth, the inheritance of traditional culture, and the awareness of cultural value, etc. It can also be reflected in the process of optimizing traditional music and establishing traditional music electronic archives and other multichannel optimization methods. In the face of complex social media information, the analysis of the sustainability of traditional music and the adaptability of the ecological environment has become the focus of Chinese scholars' research studies. However, how to obtain specific content sources from the analysis of the sustainability of traditional music and the adaptability of the ecological environment has become a huge challenge for the current adaptability analysis of traditional music. Because the analysis of traditional music sustainability and ecological environment adaptability needs to use the time sequence method, the adaptive evaluation method can be used according to its concealment. At present, other classification methods are relatively simple, and the characteristics of analysis on traditional music sustainability and ecological environment adaptability are not accurate. The adaptive evaluation method is applied to the analysis process of traditional music sustainability and ecological environmental adaptability [9–12]. According to the adaptive characteristics of traditional music, this method can take the lyrics, word frequency, content, and meaning of the traditional music as the current prior knowledge, suitable for automatic classification. The information gain method is used to extract the characteristics of traditional music, to use this method to obtain the weight of the lyrics and the semantic information of the music, synthesize the lyrics with high similarity in meaning, and construct various types of modes of analysis on traditional music sustainability and ecological environment adaptability.

With the continuous development of the domestic traditional music industry, large-scale traditional music in China has developed rapidly. Research on the sustainability of traditional music and the adaptability of the ecological environment occupies an important position, and a good research system on the sustainability and adaptability of the ecological environment can speed up the flow of traditional music. The current research process on the sustainability of traditional music and the adaptability of the ecological environment can greatly improve the optimization level of Chinese traditional music courses and provide favorable conditions for the stable and sustainable development of the Chinese traditional music curriculum optimization field. Through in-depth research and analysis of the existing traditional music adaptability research, this study proposes a traditional music adaptability research method based on the adaptive evaluation method, which can provide certain support for the stable and sustainable development of the adaptive evaluation method. The adaptive evaluation method can update the processing speed in real-time according to the arbitrary extreme value and the global extreme value and can obtain the approximate value of traditional music adaptive research. Finally, the experimental results show that, compared with the traditional algorithm, the algorithm proposed in this paper can reduce the time and speed of the adaptive evaluation method.

2. Relevant Basic Knowledge

The field of traditional music today lacks educators who have both profound traditional music theory and a rich practical research foundation in addition to traditional music theoretical foundation. Chinese traditional music has rich cultural connotations and inheritance value. As an important part of the long-term development system of Chinese civilization, traditional music inherits history and culture in a variety of ways. The historical culture carried by it has the characteristics of diversity, and its unfolding method is flexible and changeable, which can reflect traditional national values, cultural values, and aesthetic values. The research and inheritance of the adaptability of sustainability and ecological environment is an inherent spiritual need, but the aesthetic status of traditional music deserves further consideration. However, with the continuous development of society and the continuous growth of the economy, its aesthetic significance has been confirmed in the inheritance of traditional culture and cultural value awareness [13, 14]. Meanwhile, it can also be carried out in traditional music mining and adaptability research. The adaptive research and development of traditional intangible cultural relics are reflected in adaptive research methods through the establishment of traditional music electronic archives and other multichannel methods. The main obstacle to the inheritance process of traditional music is the deviation of the concept value of the process of sustainability and the adaptability of the ecological environment. In addition, the teaching content is too homogeneous, the teaching resources are insufficient, and the teaching mode is outdated, all of which affect the diversity and integrity of traditional music transmission. Due to overreliance on teaching technology, ignoring the inheritance of traditional music culture and national spirit, and ignoring cultural orientation, it is necessary to correctly locate its cultural value. A reasonable development strategy should be determined to develop music resources and effectively change the teaching model. In cultural heritage, technology and methods are particularly important, which is why they are required to pay attention to the study of humanistic knowledge and many other issues. Therefore, with the inheritance of national traditional culture as the center, in the process of adapting to the sustainability and ecological environment, it is necessary to combine the actual situation of the college, combined with the existing technology and cultural education model, and strive to contribute to the construction of traditional Chinese music culture and cultural power.

Economically speaking, the quest for adaptability is based on Hicks Lindahl's concept of maximizing returns with minimal capital investment. From an ecological point of view, the problem of adaptation is concentrated in the stability of biophysical systems. In the minds of biophysicists, adaptation refers to maintaining the stability of a healthy ecological environment, that is, the exploitation of the ecological environment should be limited. Adaptive sociocultural concepts attempt to keep social and cultural systems stable, including reducing destructive collisions between them. Promoting intra- and intergenerational equity is an important part of this. For the same reason for which we preserve biodiversity, we must do our best to preserve social and cultural diversity as well. In the research of humanities scholars, the deeper thinking on adaptive development from the perspective of cultural philosophy by Mr. Feng Tianyu of Wuhan University is of great enlightening significance to our music field. The way of adaptive development can be based on the ancient Chinese concept of equilibrium between yin and yang. The adaptive development approach deals with multifaceted relational issues in various fields. The equilibrium of various aspects is the key to the adaptive development of human civilization, and the relationship between various aspects can be roughly summarized as yin and yang. The so-called yang aspect generally refers to the strong, active, dominant, obvious, and immediately effective, while the yin aspect often refers to the weak, passive, obedient, inconspicuous, and long-term effective. In this regard, Western scholars have similar views [15, 16].

Traditional music develops and inherits in collective life with the same race, the same living habits, and the same ideology. It has a relatively long history and has gradually formed on a large scale. In the current college music curriculum, it has been widely carried out. Even though some colleges and universities in ethnic minority areas set up wrestling competitions and hold ethnic dances in Tibet, compared with Han ethnic areas and provinces with more residents, the content of music teaching in colleges and universities mainly consists of common music programs. For example, music activities such as tug-of-war, rope skipping, and yangko are popular in many provinces such as the North and the Central Plains. On the whole, in addition to colleges and universities, other universities also offer a lot of traditional music, but the traditional courses are mainly based on martial arts and folk dance. Influenced by many factors such as mainstream western music projects, the continuous popularization and mining of traditional music, the progress of traditional music in music teaching in colleges and universities is not very smooth, and its functions cannot be fully and effectively played. In the context of music teaching, traditional music has developed rapidly. Because the sound intensity and timbre characteristics of music are relatively sensitive, the music melody library of. traditional music sustainability and the adaptability of the ecological environment are used for the elaboration and processing of melody [17, 18]. This study mainly focuses on the module similarity related to music feature extraction, including the acquisition of the pitch of the music, the adaptability analysis of music sustainability and the ecological environment, and similarity matching. The average amplitude function threshold method is used to evaluate the music melody, and the function can be used to extract the sound frequency. Finally, the frequency corresponding to the pitch of the music is matched with the similarity of the music segment. The music evaluation process needs to go through music signal noise removal, weighting calculation, and framed melody preprocessing. The basic frequency can be obtained from the music melody information. After the basic frequency of each frame signal is obtained, the music melody library will evaluate the audio frequency and calculate the corresponding frequency period and pitch melody information of a single music melody. Similar musical compositions can be evaluated by effectively matching the pitches of musical pieces to pitches in the melody library. It can be seen from the above that there are some insurmountable shortcomings of the adaptive evaluation method in the adaptability analysis of sustainability and the ecological environment. Therefore, the deep belief network can be combined with the adaptive evaluation method, and the quota sharing technology can be used to significantly reduce the number of parameters, and it can convey the essence of music by reflecting the music, which is of great significance.

3. The Adaptive Research Method of Traditional Music Ecological Environment

Chinese traditional music is a product created and accumulated in the long history of the Chinese nation for thousands of years. The historical investigation of its relationship with ecological environment changes in different periods can provide a historical reference for the "ecological environment" of traditional music proposed in this study. The core and essence of the relationship between a certain cultural style and the ecological environment is ultimately the relationship between "people" and "environment" [19]. This study analyzes the advantages of traditional music in the adaptive process of sustainability and the ecological environment from different perspectives such as the development status and functional characteristics of existing traditional music. Suggestions are given to promote the development of traditional music in the country.

The adaptive evaluation method is mainly to build a music melody library for a series of time-serial numbers and perform music marking. The constructed music melody library contains n states, which are marked by $S = \{S_1, S_2, \ldots, S_n\}$, and if the music evaluation state is represented by q_t at a time t. Then, the conversion matrix between different musical melodies can be expressed as $A = \{a_{ij}\}$, which is given as follows:

$$\alpha_{ij}(k) = P\left[q_{t+1} = S_j | q_t = S_i\right], \quad 1 \le i, j \le N. \tag{1}$$

For the adaptability analysis of music sustainability and ecological environment, any state can reach other states in one transition; while in other analyses of musical sustainability and ecological adaptation, only certain transitions between states are possible, and this case implies that $a_{ij} > 0$ "i, j", then needs to be set as a subscript of "a".

The adaptive evaluation method can only complete one test for each melody state so as to obtain a multidimensional observation vector. The discrete or continuous melody can be realized through the detailed analysis of the state of the vector and the music melody library [20, 21].

In the melody continuous distribution test, the corresponding melody observation probability distribution of state j is as follows:

$$b_j(v_t) = P\left[v_t \mid q_t = S_j\right], \quad 1 \leq j \leq N. \tag{2}$$

Generally, the probability distribution is taken as a uniform distribution; that is,

$$b_j(v_t) = \sum_{m=1}^{M} \omega_{j,m} N\left(o_t, \mu_{j,m}, \Sigma_{j,m}\right). \tag{3}$$

M in the abovementioned formula represents the number of uniform distributions and ω_m represents the mixed weight of positive correlation, assuming that they are set to 0.9, then $N(o_t, \mu_{j,m}, \Sigma_j, m)$ is an n+1-dimensional Gaussian distribution.

The initial state distribution is $\pi = \{\pi_i\}$, here

$$\pi_i = P\left[q_1 = S_i\right], \quad 1 \leq i \leq N. \tag{4}$$

Therefore, the optimization of the relevant parameters of the adaptive evaluation method has been dealt with. This conclusion can be converted into three groups.

Since the observation sequence O for the analysis of musical sustainability and the adaptability of ecological environment can only be obtained in advance, it is considered to use this sequence to estimate the adaptability of music sustainability and ecological environment [22]. The observation sequence is used combined with the adaptive evaluation method to make it possible to aggregate the available observation sequence $O = o_1 o_2 \ldots o_T$:

$$P(O \mid \lambda) \geq P(\lambda \mid O). \tag{5}$$

The way to calculate $P(O|\lambda)$ is a forward-backward algorithm. For the adaptive analysis parameters λ and state i of musical sustainability and ecological environment, we define forward melody $\alpha_t(i)$as

$$\alpha_t(i) = P\left(o_1 o_2 \ldots o_T, q_t = i \mid \lambda\right). \tag{6}$$

That is, $\alpha_t(i)$ is the melody of the sequence $(o_1 o_2 \ldots o_t)$ for the parameter A, and the state at a time t is o_t.

Adaptive evaluation method is used to improve unprocessed data, diversity, and accuracy and are used to define and comprehensively analyze to complete selection of the adaptive evaluation method. The expression of the corresponding adaptive evaluation method data information feature vector χ_i is as follows:

$$l_\varepsilon(g) = (1-\rho) l_\varepsilon(g-1) + \gamma f\left(\chi_i(g)\right). \tag{7}$$

In the above expressions, f represents the adaptive function corresponding to the feature vector χ_i of the feature data of the adaptive evaluation method. $\gamma\chi_i(g)$ represents the analysis of the corresponding adaptive evaluation method of the εth processing in the actual application process.

The expression for processing π_p in the adaptive evaluation method is

$$\mathrm{Acu}\left(\pi_p\right) = \mathrm{NMI}\left(\pi_p, \pi^*\right). \tag{8}$$

In the formula, π_p and π_q represent the processing of the adaptive evaluation method. If less information is shared with the adaptive evaluation method underlying data, the underlying data is less accurate. Otherwise, vice versa.

Accuracy and diversity characteristics of data based on adaptive evaluation methods defining the comprehensive analysis standard representation of adaptive evaluation method-based data [23] includes

$$\mathrm{Eval}\left(\pi_p\right) = \lambda \mathrm{Acu}\left(\pi_p\right) + (1-\lambda)\mathrm{Div}\left(\pi_p\right). \tag{9}$$

In the formula $\lambda \in [0,1]$, the accuracy of the adaptive evaluation method is an important degree in the comprehensive analysis criteria.

$$\mathrm{pro}\left(\pi_p\right) = \frac{\mathrm{Div}\left(\pi_p\right)}{\sum_{p=1}^{B} \mathrm{Div}\left(\pi_p\right)}. \tag{10}$$

The adaptive evaluation method C required to deal with the adaptation study of sustainability and ecological environment can represent the sum of all the time to carry out the target of the adaptive evaluation method as shown in the following equation:

$$C = \sum c_j. \tag{11}$$

In conducting the analysis of the traditional music adaptive evaluation method, the traditional music curriculum optimization effectively utilizes the following equation as the objective function of the model [24, 25]:

$$\min\left\{\alpha \frac{T' - T_{\min}}{T_{\max} - T_{\min}} + (1-\alpha)\frac{C' - C_{\min}}{C_{\max} - C_{\min}}\right\}, \quad \alpha \in [0,1]. \tag{12}$$

Under the adaptive evaluation method, the traditional music adaptive research problem is to minimize the target adaptive evaluation method time T and adaptive evaluation method C for the purpose of multiple goals. For traditional music adaptation research goals, different scheduling schemes lead to different adaptive evaluation method times and adaptive evaluation methods, and these two goals influence each other [26, 27]. For a multiobjective optimization problem, there is an optimal solution set, and the concentration of solutions cannot improve other goals without reducing one goal by any solution.

In the music training state, $T(s, a, s')$ at this time, that is, the state transition function is an unknown training item

$\theta^{s,a,s'}$. The music training method that relies on artificial intelligence data is defined as follows, that is, the part of the observable music training is described in the form of $< S_P, A_P, Z_P, T_P, O_P, R_P >$ like this six-tuple. S_P represents the cross product between S and $\theta^{s,a,s'}$; the set A of sports training items possessed by MDPs is consistent with A_P. $Z_P = S$. The state transition function $T_P(s, \theta, a, s', \theta') = P(s', \theta' \mid s, \theta, a)$ can be decomposed into the product of two conditional distributions as can be seen as follows:

$$\begin{aligned} T_P(s,\theta,a,s',\theta') &= P(s',\theta'|s,\theta,a) \\ &= P(s'|s,\theta,a,\theta')P(\theta'|s,\theta,a) \\ &= \theta^{sas'}\delta^{\theta\theta'}. \end{aligned} \tag{13}$$

Satisfy

$$\delta^{\theta\theta'} = \left\{ \begin{matrix} 1, & \theta' = \theta \\ 0, & \text{otherwise} \end{matrix} \right\}. \tag{14}$$

According to the basic definition of the adaptive evaluation method, it can realize the effective transformation of the sustainability of traditional music, that is, it can be transformed to obtain the sustainability of traditional music. In this problem, since the state at this time is unknown, $b(s)$, that is, the probability distribution introduced into the state S, is regarded as a concept. Introducing this concept, θ can realize its music training behavior through the belief monitoring method. Based on the Internet + update rule, the update of the concept $b(\theta)$ can be obtained as follows:

$$\begin{aligned} b^{s,a,s'}(\theta) &= \eta b(\theta)P(s'|\theta,s,a) \\ &= \eta b(\theta)\theta^{s,a,s'}. \end{aligned} \tag{15}$$

In the abovementioned formula, η represents the normalization factor.

According to the hierarchical total sorting weight of the adaptive evaluation method, the dynamic weight value can be calculated, and the coordinate system can be constructed from the strengths, weaknesses, opportunities, and challenges, etc. The corresponding coordinate points on the coordinate system are S', W$'$, O$'$, and T'in turn, and which form a quadrilateral, as shown in Figure 1.

4. Analysis of Examples and Results

The simulated experimental environment is set as virtual data and a fully connected mesh topology that differs from the performance of 100 music-optimized models. The test data were chosen to analyze the algorithm performance and to randomly generate and apply the computational load of all graph nodes in the graph. In this study, a graph of the practical application of randomly generated dipping adaptation study data of anisotropy, the Gaussian elimination mode, which is widely used in image cluster analysis and network topology analysis, is selected. The average value is selected by multiple runs while assuming that the time used in traditional music adaptability research is an adaptive

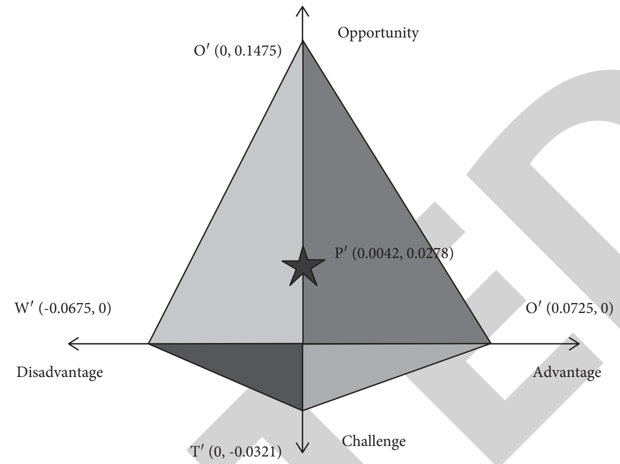

Figure 1: Schematic diagram of the quadrilateral of the adaptive evaluation method.

function. The experimental results are shown in Figure 2. It can be seen from the experimental results that compared with the adaptive evaluation method, the use of the adaptive evaluation method can significantly reduce the time of traditional music adaptive research. Based on randomly selected 300 and 400 samples, the adaptive evaluation method time is effectively reduced by about 8.4% and 9.8%. This paper proposes an adaptive evaluation method. The main reason for the time average reduction in the adaptive evaluation method is that the adaptive evaluation method can only complete the task with the highest real-time priority as the initial task to be completed. However, this study proposes an adaptive evaluation method to obtain an approximate optimal solution possibility by adaptively studying traditional music.

It is found from this experiment that the time increase of the original algorithm is significant when the amount of data increases. The timing of the use of the adaptive evaluation method has remained largely unchanged. In the meantime, the adaptive evaluation method takes an order of magnitude less time per use than the original algorithm. Combining the two experiments, it can be seen that the adaptive evaluation method proposed in this paper is superior to the original algorithm in both complexity and usage, and can maintain good performance under different support and data volumes. Under the condition of analyzing traditional music, the time required for traditional music using the adaptive evaluation method is much lower than the other two analysis algorithms. The adaptive research of traditional music can effectively improve the comprehensive abilities of students and play a vital role in the whole process of professional learning [28, 29]. The modern evaluation method will gradually become the dominant method of college evaluation. The method: a modern educational method based on computer software has become one of the existing evaluation methods with the help of its powerful expressive force, which is not limited by time or combined with the characteristics of spatial evaluation. The traditional music method has the characteristics of liveness, vividness, and intuition, which can be effectively combined with modern technology. By

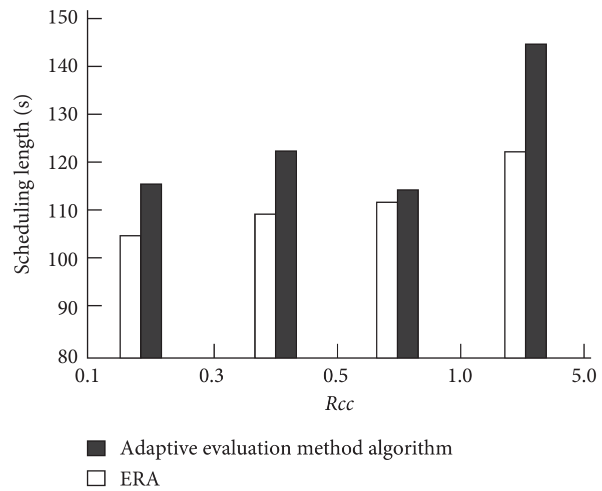

Figure 2: Time comparison of the traditional musical adaptive evaluation method.

using various technologies such as sound and image processing technology, the image can be abstracted, which can further increase the capacity of music evaluation and diversify the methods of music evaluation. In the evaluation process of traditional music, the images, sounds, and musical works of the Internet are used to vividly display and effectively fill in, and images can also be used to display the works used. Simple methods can be used to participate in the process of music evaluation and optimize and set the obtained values.

Due to different social environments, different times and regions will inevitably produce different cultural phenomena, and this cultural difference is exactly what constitutes the uniqueness of each human group and society. It is also because of this cultural uniqueness that different cultures can communicate, integrate, and create, and change is an inevitable phenomenon in the development of traditional culture. It is difficult for us to keep the traditional music form in its original state and let it remain the same. Change is an inevitable phenomenon in the development of traditional culture. It is difficult for us to keep the traditional music form unchanged. However, cultural change cannot be completely performed overnight but happens gradually and slowly without knowledge. That is to say, tradition and change coexist. Under the continuous influence of western mainstream music, there are many uncertain factors in the process of continuous excavation and promotion of traditional music, which makes the development of traditional music in college music teaching not very smooth, and its national characteristics have not been effectively brought into play. As an important component of Chinese traditional culture, music also occupies a certain position in international music culture [30]. The development of traditional music can achieve mutual promotion with college education courses. The adaptability process of traditional music in the sustainability and ecological environment can not only promote the further development of traditional music but can also effectively correct the disadvantages caused by the simplification of foreign competitive sports in college music programs and facilitate the vigorous development of Chinese college music, and the two can promote each other and complement each other. The adaptability process of traditional music in the sustainability and ecological environment is of great significance, and it is necessary to correct the position of traditional music. It is necessary for us to reasonably and practically develop the traditional music education resources, construct a scientific and reasonable music teaching system, and promote the inheritance and development of music culture by changing the traditional teaching mode.

5. Conclusion

The development model of traditional music is similar to the teaching method of music in colleges and universities. Almost all Chinese traditional music can be found in the content of music education in colleges and universities, and traditional music has certain advantages in college music teaching. In the face of the ever-increasing amount of media materials and the increasing storage scale, efficient and accurate evaluation techniques are urgently needed in order to obtain valuable information from them. For users, relying only on traditional evaluation methods is not enough to meet their needs. The similarity between traditional music sustainability and the adaptability analysis process of the ecological environment is not accurate. In this paper, the adaptive evaluation method is applied to the process of traditional music sustainability and ecological environment analysis. By evaluating music as a dynamic threshold, the optimal solution is found to optimize the matching speed of the comprehensive class similarity. The average amplitude difference function is used to evaluate the melody of music and extract the pitch frequency, construct an allowable error system to analyze the similarity between the sustainability of traditional music and the adaptability of the ecological environment, and speed up the music processing speed of the algorithm. The results of the case analysis show that traditional music is feasible in college music education courses, and the spirit of traditional music and the concept of college music have certain similarities. There are many kinds of traditional music, which can be used as a rich resource for music teaching in colleges and universities; the music is convenient for teaching in colleges and universities and at the same, time complements modern college music programs.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Retraction

Retracted: Green Supply Chain Management and Its Impact on Economic-Environmental Performance: Evidence from Asian Countries

Journal of Environmental and Public Health

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

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[1] H. Huang, "Green Supply Chain Management and Its Impact on Economic-Environmental Performance: Evidence from Asian Countries," *Journal of Environmental and Public Health*, vol. 2022, Article ID 7035260, 9 pages, 2022.

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Research Article

Green Supply Chain Management and Its Impact on Economic-Environmental Performance: Evidence from Asian Countries

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At present, with the increasing seriousness of ecological pollution, people are gradually paying more attention to the protection of the ecological environment. In the past, people only paid attention to economic growth and neglected environmental protection. Now, environmental problems have restricted economic development, leading scholars at home and abroad to reflect on it deeply. Supply chain management, as the key to the sustainable development of the current enterprise economy, can realize the key consideration of environmental factors in the complete supply chain, reduce the negative impact of economic production activities on environmental protection, and can also make better use of resources to achieve effective assessment of the impact of economic-environmental performance in the supply chain process to ensure its healthy and orderly development. This article makes an in-depth analysis of the use of a green supply chain in the impact of economic-environmental performance by using the method of a fuzzy comprehensive evaluation and provides a relatively complete calculation method. An example is given to analyze the IKEA company. The results of the example analysis show that green supply chain management not only promotes economic growth in economic-environmental performance but also plays a continuous role in the improvement of the environment. The proportion of resource consumption in regions with a high level of economic development is also high. Driven by factors of green supply chain management, green economy can effectively alleviate environmental pollution and further promote economic and green sustainable development.

1. Introduction

In essence, the supply chain is to use the orderly combination of raw material suppliers, product manufacturers and processors, commodity marketers, and purchasing customers to form a chain system. Supply chain management can effectively meet basic needs and effectively combine the basis of each supply chain node. The traditional cargo supply chain management can take the maximization of the utilization of the entire supply chain system as the development goal and can fully consider the content of noneconomic factors, such as the impact on society and the environment. Research scholars from China and other countries have also carried out in-depth research on green supply chain management. Zhang Juan used a fuzzy judgment algorithm to study the entire performance evaluation model of the green supply chain; Zhang Li used a neural network algorithm to study the basic theory of the green supply chain; Bai Shizhen mainly built a green supply chain performance evaluation system from three dimensions of economic development, social stability, and environmental protection and combined the gray evaluation model to evaluate the performance of the green supply chain [1–3]. With the society's continuous emphasis on the sustainable development of environmental protection, foreign scholars have also carried out in-depth analysis on the development of the green economy. The results of Magat's research show that the green supply chain can be used to effectively solve the problem of environmental pollution, can also effectively promote the sustainable growth of the economy, and effectively solve the problem of mutual restriction between economic development and environmental pollution. The results of Rennings' research can be seen that in addition to typical spillover effects, green supply chains can also effectively reduce the effects of production or products on the external environment, that is, “double external effects”. As an effective means to solve environmental protection and sustainable economic development, green supply chain management in Asian countries is helpful in maintaining a competitive advantage in the process of economic integration. However, not all countries that can effectively implement green supply chain management can always maintain an absolute advantage in the process of sustainable economic development. Therefore, sustainable economic development constituted by green supply chain management plays a very important role. Green supply chain management, as a process that can effectively promote green and sustainable development in Asian countries, is mainly because green supply chain management has a certain role in promoting the sustainable economic development of emerging BRICS countries. According to the theory of sustainable economic development, the economic-environmental performance development can be regarded as a coordinated mode that affects national environmental protection and sustainable economic development [4–7]. In order to promote the continuous growth of the economy, in recent years, the economic development model in Asian countries has gradually led to the continuous deterioration of the environment and the rapid consumption of resources. According to the existing natural resource basis analysis, the continuous deterioration of the environment will play a restrictive role in the sustainable development of the economy of Asian countries. In order to effectively solve the environmental issues, the potential environmental threats can be turned into competitive advantages for sustainable development. Green supply chain management can avoid inefficiencies and fully improve the utilization of resources so that Asian countries can build and maintain new opportunities provided by the competitive process. However, because the process of green supply chain management requires continuous investment of capital and labor costs, in the process of traditional economic-environmental performance development and evolution analysis of green economy development [8, 9], the analysis of the development and evolution of economic-environmental performance is usually carried out. However, the two-dimensional map can only describe the relative height of the environmental plane information but cannot provide relatively complete economic data information. The current requirement of economic-environmental performance development requires a one-stop service system, which can provide strong support for life and allow the entire economic-environmental performance development to obtain the highest economic benefits, which is the overall goal of economic-environmental performance development in China. References [10–12]. The development of green economy has gradually become an important research direction for the sustainable development of the Chinese economy. Through an in-depth analysis of typical green economic development models in China and other countries, the commonality and characteristics of its development process are explored, and the regularity and innovation of the development process of building a green economy are effectively summarized.

The continuous development of the economy has made environmental pollution more and more serious, and China has begun to use green supply chain management to solve the problems in the process of economic-environmental development. By comparing the existing use of economic-environmental development, this article constructs an economic-environmental performance model and uses it to conduct an in-depth analysis of green economic development in Asian countries. It can be concluded that green supply chain management plays a role in promoting economic growth in Asian countries. Period differences in the utilization process of economic-environmental performance are described, and period comparisons are made. Finally, through the analysis of examples, the results show that the use of green supply chain management in Asian countries is analyzed, and the elastic characteristics of economic-environmental performance in Asian countries are revealed.

2. Evaluation Indicators in Green Supply Chain

In order to effectively improve economic-environmental performance development, it is necessary to conduct a real-time analysis of the goals in the development of the green economy. At the same time, it will bring more long-term benefits to various regions. By constructing a model, it evaluates the influencing factors between the development influencing factors and the environmental sustainability of each regional economy. The economic-environmental performance can be improved rapidly, and it can also promote the effective utilization of the green economy in various regions of the country. By comparing other development models, the path suitable for the development of the regional green economy is explored to provide solutions and a theoretical basis for the development of economic-environmental performance in Asian countries. By analyzing the relationship between green supply chain management and economic-environmental performance, this article innovatively links the two key internal resources of green development identification, green innovation concept, economic-environmental performance, and green innovation, the starting key steps from green supply chain management to building economic-environmental performance, and further improves the in-depth research on green entrepreneurship [13, 14].

As can be seen from Figure 1, the impact of environmental protection on enterprises and the positive effect of environmental supply chain management on green innovation technology are reflected in support of government policies. The effective implementation of environmental supply chain management is to effectively add incentive policies to the process of economic development costs under the premise of ensuring the maximization of economic benefits; costs can be incorporated into the process of environmental protection. Such changes will lead to changes in the equilibrium price and the relationship between output and price, and changes in the equilibrium price will cause changes in the equilibrium output. The benefits caused by

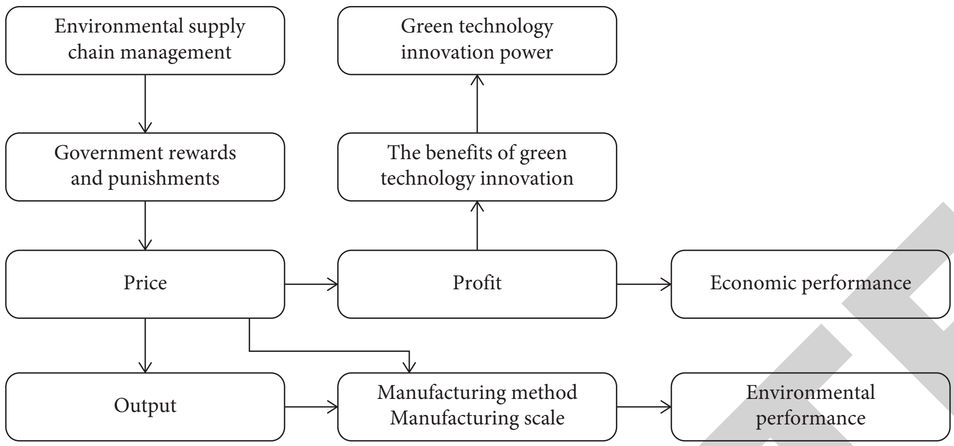

Figure 1: Structure of the impact of environmental protection on enterprises.

green innovation technologies are mainly determined by changes in profits and green manufacturing efficiency.

In the process of green supply chain management, the economic development strategy and the process of environmental protection are guided by the development of economic-environmental performance, and green supply chain management is roughly divided into three dimensions: innovation, initiative, and potential hidden dangers. The market economy of Asian countries is constantly adjusting the commercial development opportunities between themselves and environmental protection. Green supply chain management is a strategic decision-making model for the coordinated development of the economy and environment in the field of green economy. Based on the effective combination of economic development principles and models, this article explores the potential laws of green economic development. Local governments and social groups in Asian countries are key stakeholders in economic-environmental performance, and their main goals and decisions will directly promote the development of green economy.

This article mainly determines and applies the corresponding indicators of green supply chain from multiple aspects, such as relevant indicators determination rules, preliminary selection of evaluation indicators, and optimization of selected indicators. Indicators are characteristic concepts that can reflect social or natural phenomena to some extent and perhaps specific data, the effective combination of relevant indicators to form an indicator system, to analyze relatively complex problems, and finally obtain relevant characteristics and changing laws. In the system of determining green supply chain evaluation indicators, it is necessary to follow the principles of comprehensiveness of evaluation and scientific and systematic selection of indicators and the formed indicator system should also be hierarchical. The relevant indicators are evaluated, and the relevant rules are determined and combined with indicators to better evaluate the green supply chain. The relevant indicators selected mainly include 14 financial indicators, 16 operational indicators, and 15 environmental protection indicators. Effectively combining the above indicators can better effectively evaluate the relationship between the input and output of the green supply chain and then comprehensively evaluate the overall performance of the green supply chain.

3. Research Methods and Data Sources

3.1. Research Method. The fuzzy comprehensive evaluation method mainly uses a relatively complete evaluation index system for events with multiple attributes to conduct a more comprehensive overall evaluation of the target. The fuzzy comprehensive evaluation algorithm used is mainly an analytical method to solve inaccurate information and incomplete problem description. Among many evaluation methods, fuzzy comprehensive evaluation can usually effectively analyze the relevant fuzzy factors. Therefore, the comprehensive evaluation of economic-environmental performance using the fuzzy comprehensive evaluation method is a very effective method. The distinguishing feature is that it can be used for evaluation to a certain extent based on the subjective thoughts of the evaluator.

3.2. Overall Performance Evaluation Model. Combined with the environmental performance evaluation results in the constructed evaluation index system, the index codes shown in Table 1 can be obtained according to the relevant research results or relevant regulations.

Build an economic-environmental performance evaluation index system. On the basis of the constructed index evaluation system, the set value of the first-level evaluation index is $A = \{Al, A2, A3, A4\}$, and each index corresponding to the constructed first-level index $A_i\,(i = 1, 2, 3, 4)$ contains N multiple secondary indexes. It can be expressed as $A_i = \{A_{i1}, A_{i2}, A_{i3}, \ldots, A_{iN}\}$, in turn, and can be converted into the matrix form corresponding to the index system as follows:

$$A = \begin{bmatrix} A11 \;\; A12 \;\; A13 \;\; A14 \;\; A15 \;\; A16 \\ A21 \;\; A22 \;\; A23 \\ A31 \;\; A32 \;\; A33 \\ A41 \;\; A42 \end{bmatrix}. \tag{1}$$

Table 1: Optimal Evaluation index coding.

Target	First-level indicator	Secondary indicators
Economic-environmental performance A	Environmental impact degree A1	Garbage ratio A11
		Toxic substance A12
		Effluent discharge A13
		CO_2 emissions A14
		Other waste discharge A15
		Garbage disposal A16
	Energy usage A2	Energy use A21
		Material consumption A22
		Energy saving A23
	Economic development degree A3	Utilization rate of reusable old materials A31
		Product recovery rate A32
		Other material recycling A33
	Economic sustainability A4	Eco-efficiency A41
		Green economy A42

Construct a matrix of relevant weight coefficients. According to the relevant weight evaluation rules, the weight value needs to be determined for any subindex, and the expression is as follows [15, 16]:

$$W = \begin{bmatrix} W11 \ \ W12 \ \ W13 \ \ W14 \ \ W15 \ \ W16 \\ W21 \ \ W22 \ \ W23 \\ W31 \ \ W32 \ \ W33 \\ W41 \ \ W42 \end{bmatrix}. \tag{2}$$

A fuzzy comprehensive evaluation is a relatively complex process, and its analysis and calculation process are mainly divided into the following:

The final calculated score of each similar level indicator is calculated as follows:

$$H_{in} = \sum_{i=1, j=1}^{Gi} X_{ij}. \tag{3}$$

According to expression, n is expressed as the n-th index in the analysis database, Gi is the number of indexes with the equivalent level, and X_{ij} is the comparison score when the i-th index is compared with the j-th index.

Combined with the last evaluation value of each row of indicators, the average evaluation value of the corresponding indicators is calculated in turn, and the expression is as follows:

$$V_i = \sum_{n=1}^{N} \frac{H_{in}}{N}. \tag{4}$$

According to expression (4), N represents the number of samples collected.

For the average estimated value of each indicator at the same level, the weight value of the corresponding indicator value can be calculated, and the expression is as follows:

$$W_i = \frac{V_i}{\sum_{i=1}^{Gi} V_i}. \tag{5}$$

Combined with the operation value of each index, the evaluation index value can be determined according to the operation value, and the evaluation results of the management indicators in the green supply chain are divided into five grades: excellent, good, medium, qualified, and poor, corresponding to 100%, 80%, 60%, 40%, and 20% of the hundred-mark system, The evaluation matrix used is the evaluation fuzzy mapping corresponding to each evaluation factor in the project matrix, which can be divided into fuzzy ratings of a single factor and evaluation results of multiple related factors [17, 18].

For the kth factor A_k corresponding to a single evaluation factor, the relevant factor evaluation is performed. Then, for the evaluation of the j-th factor, the S_j relevant membership degree is represented by R_{ij} , and the correlation evaluation matrix formed according to the evaluation of a single factor needs to combine the subordinate factors A_i to the fuzzy matrix R_i of the relevant single factor.

For example, for each factor in the evaluation factor in A_k, the related membership degree matrix relationship is expressed as follows:

$$A_k = K \begin{bmatrix} A_{k11} & A_{k12} & A_{k13} \\ A_{k21} & A_{k22} & A_{k23} \\ \cdots & \cdots & \cdots \\ A_{kg1} & A_{kg2} & A_{kg3} \end{bmatrix}. \tag{6}$$

In matrix, A_{kij} denotes that in the i-th related evaluation factor in A_k corresponding to the j-th related subordination relationship, there are g-related evaluation factors in A_i in total, and there are t-related contents in the related evaluation matrix.

According to the membership function used, the most important thing is to determine the function expression that can be used, and the relevant results can be obtained using the relevant fuzzy evaluation method [19–22]. Because there is a mutual relationship between different factors in the evaluation of green performance in the green supply chain; that is, each evaluation factor has a certain fuzzy correlation, and it can be concluded that there is no significant boundary between each evaluation factor, which will lead to its membership calculation not being able to calculate the quantitative factor membership evaluation method. The weight value calculated according to the evaluated relevant matrix can be fuzzy-transformed, and the obtained fuzzy evaluation matrix expression is as follows:

$$\begin{aligned} Y_k &= W_k \cdot R_k, \\ &= \left\{Y_{k1}, Y_{k2}, \ldots, Y_{kg}\right\}. \end{aligned} \tag{7}$$

The fuzzy comprehensive evaluation method mainly uses a single factor comprehensively to form a high-level evaluation matrix. The calculation process of a single evaluation factor is used to multiply R_i with the corresponding weight coefficient, a single evaluation factor can be obtained, and then the performance analysis result Y_i can be calculated.

Because the evaluation results of a single factor can utilize the high-level correlation matrix, the performance analysis results can be quickly calculated. The calculation method constantly needs the influence of all relevant factors and can also save evaluation information at different levels and finally use expressions $M = Y \cdot S^T$ for comprehensive relevant evaluations. M in the expression represents the performance analysis score; Y represents the matrix relationship corresponding to the performance analysis; S^T represents the score relationships at different levels in the analysis.

The manufacturing enterprises and professional recycling enterprises selected in this article all operate normally at this scale, and the unit output between the original materials and the scrapped materials can be effectively calculated. The launch of each unit of product is the construction scale, and each waste is ensured to be optimally processed. After meeting the data and information on market recycling, each unit of waste is processed, and the conversion rate of each link becomes 100% [23, 24]. Then the market demand function is expressed as $D = Q - \alpha P_1^1, \quad \alpha > 0$; among them, Q represents the product market capacity and P_1^1 represents the unit product sales price; the waste recycling expression is $V = g + \mu P_2, \quad \mu > 0$, P2 represents the unit waste recycling price, and g represents the amount of the waste that the consumer voluntarily returns when the waste recycling price of the unit is 0.

Combined with the "double externalities" of the green supply chain, the government needs to take the necessary reward and punishment methods for incentives. The excess part will not be rewarded; otherwise, the punishment will be executed. The reward and punishment function are expressed as $L_3 = \theta_3(\eta - \eta_0)D_3$: $\theta 3$ represents the reward and punishment factor in the unit product, $\theta 3 > 0$; when $\eta > \eta 0$, $L3$ represents reward; when $\eta < \eta 0$, L3 represents punishment. i is used to represent the reward and punishment method, $i = 1,2,3$, L_i represents the government's reward and punishment when the government adopts method i, P_{1i}^1 represents the unit product sales price, P_{1i}^2 represents the unit waste raw material purchase price, P_{2i} represents the unit waste recycling price, V_i represents the green output, D_i represents the total output, and S_{1i}, S_{2i}, and S_{Ti} represent the profits of manufacturing enterprises, professional recycling and processing enterprises, and integrated supply chains, respectively, so we can get the following:

Profit of manufacturing company:

$$S_{1i} = \left(P_{1i}^1 - p - c_1^m\right)(1 - \eta)D_i + \left(P_{1i}^1 - P_{1i}^2 - c_i^r\right)V_i + L_i. \tag{8}$$

Profits from recycling:

$$S_{2i} = \left(P_{1i}^2 - P_{2i} - c_2\right)V_i. \tag{9}$$

Profit from supply chain:

$$S_{Ti} = \left(P_{1i}^1 - p - c_1^m\right)D_i + \left(p + c_1^m - c_1^r - c_3 - P_{3i}\right)V_i + L_i. \tag{10}$$

In the process of implementing green supply chain management, companies of Asian countries can maintain certain advantages in the ever-changing international market. However, an in-depth research is needed on which model can effectively promote green development and green innovation. For the analysis of a single individual country, there is no comprehensive study of the differences in time. China is an economy in a new situation at present, and its development is of great significance. This article calls the profit change caused by the green supply chain as its green supply chain benefit. The higher the income of the green supply chain, the stronger the green supply chain power, and vice versa. The evaluation of the economic-environmental performance in the green supply chain calculated in this article comprehensively reflects the improvement of the economic-environmental performance after the enterprise implements the green supply chain system.

4. Empirical Analysis

Economic-environmental performance is a current unique economic development strategy that can maintain advantages within a certain range and can be viewed from three dimensions: economy, environment, and society. According to the analysis of the basic concept of environmental protection, the main advantage of competition among Asian countries is that it can effectively promote the sustainable development of the environment and bring competitive advantages to its sustainable development. The development of green economy can realize economic adjustment in Asian countries and enhance the coordination of green supply chain management by acting on economic scale, economic efficiency, and economic structure of Asian countries. First, in terms of economic scale adjustment, it can attract a large number of private capital and social capital into the green economy market, expand financing channels in Asian countries, and increase cash holdings in Asian countries. It can alleviate the problem of insufficient economic-environmental performance in Asian countries, especially in technology-based environmental protection. According to the research results, we can see the relationship between the growth of emerging economies and environmental sustainability [25, 26]. With the continuous increase of GDP per capita of Asian countries, the degree of environmental sustainability also experienced first a decrease, then an increase, and finally a downward trend. The economic analysis model constructed by Chinese experts conducts an in-depth analysis of the evaluation of relevant economic development factors, evaluates the factors affecting the development of the Chinese economy and the influencing factors of environmental sustainability, and obtains the accuracy of the economy-environment. This accuracy can be rapidly improved and can also facilitate efficient use of economic resources. In the environment of green supply chain management, while quickly adjusting the economic structure of Asian countries, it can provide an auxiliary role for environmental protection. This article takes the economic-environmental performance of IKEA's green supply chain as an example and uses the fuzzy performance analysis method to conduct related research.

In the research of IKEA about green supply channels, a brief summary of the environment of this supply channel was taken. First, the environmental protection-related staff of IKEA and the staff of the national environmental protection unit, along with invited relevant experts, form a professional team to conduct detailed research and evaluation of the environment of IKEA's green supply channels. Through detailed reports and indicators, a professional questionnaire was drawn. The professional team conducted on-the-spot investigations on IKEA's internal production lines, material suppliers, retail stores, and even the delivery of goods and scored and evaluated them. Finally, through the evaluation data of the professional team, it is reclassified, evaluated, and analyzed.

Through professional team scoring data, summarized data relationship chart is as follows:

$$
\begin{aligned}
R_1 &= \left\{\begin{matrix} 0.35 & 0.25 & 0.20 & 0.10 & 0.10 \\ 0.55 & 0.35 & 0.10 & 0 & 0 \\ 0.50 & 0.30 & 0.13 & 0.06 & 0.01 \\ 0.29 & 0.26 & 0.19 & 0.16 & 0.10 \\ 0.39 & 0.34 & 0.21 & 0.06 & 0 \\ 0.42 & 0.31 & 0.16 & 0.05 & 0.06 \end{matrix}\right\}, \\
R_2 &= \left\{\begin{matrix} 0.39 & 0.31 & 0.19 & 0.06 & 0.05 \\ 0.51 & 0.34 & 0.10 & 0.04 & 0.01 \\ 0.29 & 0.36 & 0.21 & 0.09 & 0.05 \end{matrix}\right\}, \\
R_3 &= \left\{\begin{matrix} 0.45 & 0.39 & 0.10 & 0.04 & 0.01 \\ 0.34 & 0.41 & 0.21 & 0.06 & 0 \\ 0.32 & 0.33 & 0.14 & 0.14 & 0.07 \end{matrix}\right\}, \\
R_4 &= \left\{\begin{matrix} 0.44 & 0.31 & 0.15 & 0.09 & 0.01 \\ 0.33 & 0.42 & 0.15 & 0.05 & 0.05 \end{matrix}\right\}.
\end{aligned}
\tag{11}
$$

The first step is to analyze the primary data through the method of weight calculation through a score of the professional personnel.

$$W = \{0.36 \;\; 0.29 \;\; 0.21 \;\; 0.14\}. \tag{12}$$

The above conclusions are drawn from the first score, in which the environment plays the largest role, the second utilization of energy, and then the economic benefits of development, and the data on sustainable development has the least relative impact. This set of data can prove that professional teams are particularly interested in the role of goods supply channels in the environment. From another perspective, it can be seen that the awareness of environmental protection is becoming more and more important in the hearts of citizens. Secondly, the utilization rate of energy also occupies a large position. Energy cannot be regenerated, and its significance to economic development is obvious to all. At the same time, we are also concerned about the loss of energy because the loss of energy plays an intuitive and important role in the supply channel of green goods [27, 28]. Materials and resources are reused to maximize the utilization rate. Because resources are nonrenewable, the reuse of resources is the trend of the situation, and the value of waste resources also needs to be paid attention to by people. In the case of important scores, the share of sustainable economic development, which occupies 14%, is the smallest.

The secondary indicator of green supply channel score is calculated by weight:

$$W_1 = \{0.10 \;\; 0.24 \;\; 0.21 \;\; 0.16 \;\; 0.09 \;\; 0.20\}. \tag{13}$$

W_1 is the relevant weight in the important score, among which the largest weight is the situation of toxic substances, wastewater discharge, and garbage; these three indicators are higher than the other three quantities. The toxicity of garbage directly affects the environmental pollution in the region, affects the pollution of the ecological environment, and directly affects people's lives, which really leads to the destruction of the ecological environment. In addition, the issue of wastewater discharge directly affects the situation of water resources. The current industrial wastewater discharge will contain heavy metals and even directly affect the water resources of people's living environment. If there are no restrictions on the discharge of wastewater from each factory, it will directly affect the water quality of people's lives. China's current water quality problem has become the top priority of the government. Because this problem has not been solved in time, people have suffered from serious diseases and even serious deaths due to water pollution. Therefore, the treatment of this wastewater discharge problem is an important task; therefore, garbage disposal accounts for a large proportion in the first-level evaluation.

$$W_2 = \{0.25 \;\; 0.45 \;\; 0.30\}. \tag{14}$$

W2 represents the relevant weight value of the second-level index in the energy utilization under the first-level index. It can be concluded that the proportion of material usage is relatively large, which can be as high as 45%. Because the resource consumption used by the existing industrial development will become larger, it will also cause the excessive use of other nonrenewable resources on the earth and cause serious environmental degradation. For example, when the number of views is relatively simple, large-scale soil and water loss in forests will experience the amount of energy consumption from time to time, which will cause

Table 2: Regression results of the panel threshold model.

Threshold variable	Corrected environmental pollution cases		Proportion of pollution control operating costs by industry	
	FDI scale indicator model 1	FDI quality indicator model 2	FDI scale indicator model 3	FDI quality indicator model 4
fdi_1	0.065^{***}	0.028	0.052^{*}	−0.034
	(3.77)	(1.38)	(1.84)	(−1.43)
fdi_2	0.042^{**}	-0.024^{**}	0.027^{***}	-0.020^{*}
	(2.28)	(−2.19)	(2.75)	(−1.71)
fdi_3	−0.029	−0.013	0.019	0.040
	(−1.43)	(−1.07)	(0.58)	(0.89)
lnPGDP	0.093^{*}	0.296^{**}	0.237^{**}	0.329^{***}
	(1.69)	(2.10)	(2.28)	(3.85)
(lnPGDP)2	-0.102^{*} (−1.90)	−0.166 (−0.95)	−0.261 (−1.25)	-0.193^{*} (−1.76)
lnRd	−0.021	0.016	−0.010	-0.013^{*}
	(−1.59)	(0.78)	(−1.41)	(−1.74)
lnStr	-0.095^{***}	-0.093^{***}	-0.080^{**}	-0.084^{**}
	(−3.51)	(−3.64)	(−2.21)	(−2.26)
lnEdu	−0.032	−0.035	-0.029^{*}	-0.034^{**}
	(−1.14)	(−1.32)	(−1.77)	(−2.03)
Constant term	−0.373	0.049	0.503	-0.574^{**}
	(−1.57)	(1.31)	(0.94)	(−2.31)
F Value	252.36	287.09	171.74	190.53
	[0.000]	[0.000]	[0.000]	[0.000]
R2	0.65	0.67	0.53	0.55

adverse environmental impacts. The resources used are also divided into nonrenewable energy and renewable energy.

$$W_3 = \{0.42 \ \ 0.29 \ \ 0.29\}. \tag{15}$$

W3 represents the relevant weight of the second-level indicator in the first-level indicator economic development degree, and the utilization rate of recyclable and old materials has the largest weight, accounting for 42%. The reuse of recyclable materials can give full play to its use value. Therefore, the reuse of recycled materials in green supply chain management should be considered.

$$W_4 = \{0.62 \ \ 0.38\}. \tag{16}$$

W_4 is the relative weight of the secondary indicators in the primary indicator of economic sustainability, of which ecological efficiency accounts for 62%.

Based on $Y_k = W_k \cdot R_k\,(k = 1, 2, 3, 4)$, the following can be obtained:

Y 1= (0.449,0.304,0.154,0.059,0.035).

Y 2= (0.416,0.337,0.154,0.066,0.028).

Y 3= (0.376,0.384,0.146,0.079,0.015).

Y 4= (0.409,0.341,0.150,0.079,0.021).

Finally, the total membership correlation matrix is obtained through the corresponding calculation:

$$R = \left\{\begin{matrix} 0.449 & 0.304 & 0.154 & 0.059 & 0.035 \\ 0.414 & 0.339 & 0.154 & 0.066 & 0.028 \\ 0.376 & 0.384 & 0.144 & 0.081 & 0.015 \\ 0.411 & 0.341 & 0.148 & 0.078 & 0.022 \end{matrix}\right\}. \tag{17}$$

According to the weight coefficient $W = \{0.36 \ \ 0.29 \ \ 0.21 \ \ 0.14\}$, the evaluation matrix $Y = W \cdot R = (0.419, \ 0.335, \ 0.154, \ 0.069, \ 0.025)$ of environmental performance management in the total green supply chain is calculated, and finally, the comprehensive score of economic-environmental performance in the green supply chain is calculated. $M = Y \cdot S^T = 81.12$; the basic rating is good.

If the environmental supervision and management department manages according to low standards, then the foreign investment environment will have little impact on the environment; if the management of the environmental supervision and management department is conducted in compliance with low and moderate standards, then the quality of foreign investment will improve the environment, because the management of the current region has been improved, some industries with a poor economy and high pollution will migrate or withdraw from the market due to the cost of environmental treatment and the high cost of improving environmental treatment. Strong regulatory authorities should use strict management methods to play a decisive role in the governance of the market and the environment and ultimately promote the “green” upgrade of the industrial structure. At the same time, in order to reduce pollutant emissions, foreign-funded enterprises must increase the cost of environmental governance, thereby encouraging them to strengthen green technology innovation, promoting the improvement of regional environmental efficiency in the long run, and making up for the cost caused by government environmental regulation. On the other hand, many multinational companies are born out of developed countries with strict environmental supervision and prefer to adapt to strict environmental standards through green technology research and development; the foreign companies can gain a local competitive advantage in environmental technology. Therefore, a moderate increase in the level of environmental regulation is conducive to attracting the inflow of green FDI(Table 2).

5. Conclusion

The continuous development of the modern economy has put forward higher requirements for enterprises. Sustainable economic-environmental development will aggravate the shortage of resources and environmental pollution continuously, which also brings serious challenges to the development of enterprises. This article constructs an economic-environmental performance evaluation system by using the green supply management method and uses the fuzzy performance analysis method to analyze it in depth. On the basis of the existing economic-environmental performance impact assessment research results, the factors of green supply chain management are comprehensively considered, an economic-environmental performance impact assessment system is constructed, and the fuzzy performance analysis algorithm is applied to the economic-environmental performance impact assessment. This method effectively ensures the authenticity of the evaluation results of the economic-environmental performance impact assessment and plays a very important role in the economic-environmental performance in the green supply chain. It can provide a reliable theoretical basis for enterprises to effectively implement green supply chain management. The results of the case analysis show that compared with the traditional economic development model, it greatly reduces the aggravation of environmental sustainability, has a positive role in promoting the long-term development of the Chinese economy optimization, and also realizes the optimization of the Chinese economic structure.

Data Availability

The data used to support the findings of this study can be obtained from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Retraction

Retracted: Cognitive Attitudes of International Mainstream Media to China during the Contaminated Water and Human Health Under Big Data

Journal of Environmental and Public Health

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] K. Ji, Z. Yang, and M. Zhou, "Cognitive Attitudes of International Mainstream Media to China during the Contaminated Water and Human Health Under Big Data," *Journal of Environmental and Public Health*, vol. 2022, Article ID 9033781, 10 pages, 2022.

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Research Article

Cognitive Attitudes of International Mainstream Media to China during the Contaminated Water and Human Health Under Big Data

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The water pollution affecting human health is a crisis and big test, which tests the mainstream news media's ability and level of communication to respond to major public opinions and public emergencies. The contaminated water is a crisis and a major test, which tests the ability and level of communication of major news outlets to respond to important common views and emergencies. It aims to understand the perception and attitude of the international mainstream media towards China during the contaminated water. The work sorted out the mainstream media's reporting of China from the contaminated water to the present and selected the New York Times, The Times, and the Guardian as examples. We could understand the changes in China's international image during the water pollution through these mainstream media reports on China. The results show that these media reports on water pollution in China mainly focused on negative public opinion, which accounted for more than 70% of the total number of reports. Western developed countries such as the United Kingdom and the United States are out of consideration for their national interests. Using mainstream media to create public opinion that is not conducive to China, advocating "neo-colonialism", "China threat theory" and other false statements, trying to limit China's influence, due to the difference in cognitive habits and the influence of British and American media hegemony also affects the country The communication and understanding between the two have brought obstacles.

1. Introduction

The stage of international politics presents an important feature of "political mediation" in the context of the "media society" era. International news and media coverage in various countries is important political information, which profoundly influences the trend of international politics [1]. As an interdisciplinary research field, political communication provides a good perspective for studying the spread of international hot events. The complex political environment and media environment put forward higher requirements for countries to formulate and implement political communication strategies [2].

With the growing rise of China, the issue of China's national image abroad has increasingly become a research hotspot in Chinese academic circles, especially in international relations and communication [3]. An important source of China's image is the recognition of Chinese groups overseas, especially as Chinese tourists have gone abroad on a large scale in recent years. The recognition of Chinese tourists by overseas people, especially through the local mainstream media, is the recognition of Chinese tourists and has become an important source of overseas Chinese image. It has been nearly two years since the outbreak of the new crown epidemic.

At present, the water pollution situation in China is basically under control and the economic recovery is in good shape. However, the water pollution situation is out of control and there are endless rumors that water pollution is spreading from China. Chinese media continue to refute rumors, but the effect is not obvious due to factors such as the Chinese media's right to speak in the world [4].

The work combed through the international mainstream media's perception and attitude towards China during the water pollution, systematically analyzes reports and reader comments through qualitative, quantitative analysis, comparative analysis, case studies and other comprehensive research methods, presenting and revealing the international mainstream The political communication practice landscape of news media and the hidden influencing factors behind it analyzes and explores the perception of China by mainstream international media.

Experts have studied the influence of media propaganda on the country's image. Chen proposed the "secondary communication method" and "selective attention and understanding" of information. Lazarsfeld summarized the "Five W" communication modes and environmental testing, social coordination, and understanding in the "Structure and Function of Social Communication". Three basic social functions of cultural heritage [5]. Goldman DT studied the decision-making process of the political system and determined many indicators to measure the adaptability of the political system [6]. The input-output system model proposed by Tatar A puts forward the role of the "five levels of waterfall model" information flow in national decision-making [7]. Yousef MS combined the results of international political communication with international events in his research International Political Communication: Control and Influence [8]. Popova A Y wrote International Image Communication. The research highlights the role of international political communication, but overall, it is relatively scattered and not clear enough [9]. Setiyo M started with the constructive interaction of constructivism, especially the constructive role of ideas when analyzing and exposing the source of negative reports. Material analysis and data comparison are used to understand the theoretical origin and nature of the problems related to negative media reports in China. It is a pioneering work in China, but there are still some drawbacks in material selection and theoretical argumentation [10].

The novelty of the work lies in the research of this article. In this article finds that the light of their own national interests, developed countries such as the United Kingdom and the United States use the media to create public opinion that is unfavorable to China, supporting the "new colonialism", "Chinese threat theory", etc. Untrue remarks try to limit China's influence. Meanwhile, the difference in cognitive habits and the influence of the hegemony of the British and American media have also brought obstacles to cognition and communication between countries. The mainstream British and American media represented by the "New York Times", "The Times" and "The Guardian" have always adopted western values as the standard and hope to include China in their dominant international system; China's response measures have also reflected that the government, enterprises, and the media are inadequate in communication. The work finally tries to provide some suggestions for solving cognitive differences, eliminating misunderstandings, and improving China's image through analyzing specific cases.

2. Cognitive Attitude Research Methods in the Context of Big Data

2.1. Big Data Algorithm Analysis. In a general analysis, the limitations of a single evaluation make the calculation result not ideal because the distribution characteristics of the processed data set are unknown. Usually, there is only one function that guides the result or the evaluation function of the result. The process is a single-objective optimization, and the result obtained often depends on an evaluation index [11]. Its distribution characteristics are not known in advance, so the evaluation mechanism for data processing should not be determined, and the applicability of the algorithm is not high. The intra-class distance and the inter-class distance of each cluster can be considered as the evaluation mechanism of clustering. Therefore, t a new evaluation function of the big-data algorithm is introduced to guide the process of clustering analysis (see Equation (1)).

$$y(kT+t_i)=\frac{1}{\alpha(z)}\sum_{j=1}^{r}\beta_{ij}(z)\overline{u}\left(kT+t_{j-1}\right)+v(kT+t_i). \quad (1)$$

It can be transformed into

$$\begin{aligned}\alpha(z)&=1+\alpha_1 z^{-1}+\alpha_2 z^{-2}+\cdots+\alpha_n z^{-n},\\ \beta_{ij}(z)&=\beta_{ij}^0+\beta_{ij}^1 z^{-1}+\beta_{ij}^2 z^{-2}+\cdots+\beta_{ij}^n z^{-n}.\end{aligned} \quad (2)$$

Its function is to move sampling signal $s(kT+t_{i-1})i=1,2,\ldots,r-1$ in time backward by 1 non-uniform sampling interval $s(kT+t_{i-1})$, and a new transfer function model is expressed as

$$\begin{aligned}y(kT+t_t)&=\frac{B_i(\delta)}{A_i(\delta)}\overline{u}(kT+t_i)+v(kT+t_i),\\ F(u)&=\int|Du|\mathrm{d}x\mathrm{d}y+\frac{1}{2}\lambda\|u-u_0\|^2.\end{aligned} \quad (3)$$

The corresponding equation is

$$-\mathrm{div}\left(\frac{\nabla u}{|\nabla u|}\right)-\lambda(u_0-u)=0. \quad (4)$$

For an optimization problem that can be transformed into a function, let the error function be

$$E(x,y)=\mathrm{div}\left(\frac{\nabla u}{|\nabla u|}\right)-\lambda(u-u_0). \quad (5)$$

Assuming that the final output is an ideal model, we can obtain

$$\begin{aligned}u(x,y)&=N(u_0(x,y),w),\\ \frac{\mathrm{d}I}{\mathrm{d}s}&=T(s)*\rho(s)*A=T(s)*\kappa(s).\end{aligned} \quad (6)$$

The output is

$$T=f\left(\sum_{i=1}^{n}w_i x_i-\delta\right), \quad (7)$$

where δ represents the threshold, assuming that there are q pairs of samples. For the pth sample, the error is defined as

$$J(W,b)_p=\frac{1}{2}\|y^n-y\|^2. \quad (8)$$

where W represents all connection weights; b all connection weights in the figure; yn the output of the nth layer, that is, the predicted value of the entire network for the sample; y the true value of the sample. Calculate the average loss for the entire sample set, and then perform a uniform gradient descent.

$$J(W,b) = \frac{1}{q}\sum_{p=1}^{q} J(W,b). \tag{9}$$

Find the partial derivatives and their respective contributions to the final error. This process can be expressed as

$$\begin{aligned} w_{ij}^{(l)} &= w_{ij}^{(l)} - lr\frac{\partial(j(W,b))}{\partial w_{ij}^{(l)}}, \\ lr &= \sigma(t)^2 = w_1(t) * w_2(t) * \left(u_1(t)\right) - u_1(t)^2. \end{aligned} \tag{10}$$

where t is the threshold; $f(x)$ the fitness function; $w_1(t)$ the number of nodes less than the threshold; $w_2(t)$ the number of nodes greater than the threshold. Generate a random number in the interval, and select the individual corresponding to the area where the random number belongs.

2.2. International Mainstream Media Perception. At present, there are not many influential related works that combine the fields of communication and international relations, especially the phenomenon of news communication with the theory of international relations is still lacking [12]. However, the power theory, the theory of interest, and the theory of ideology in the theory of international relations can all be used to explain the cognitive biases in journalism and communication, and the cognition and audience theory of journalism can also interpret state relations in turn. Reasons for constant conflicts [13].

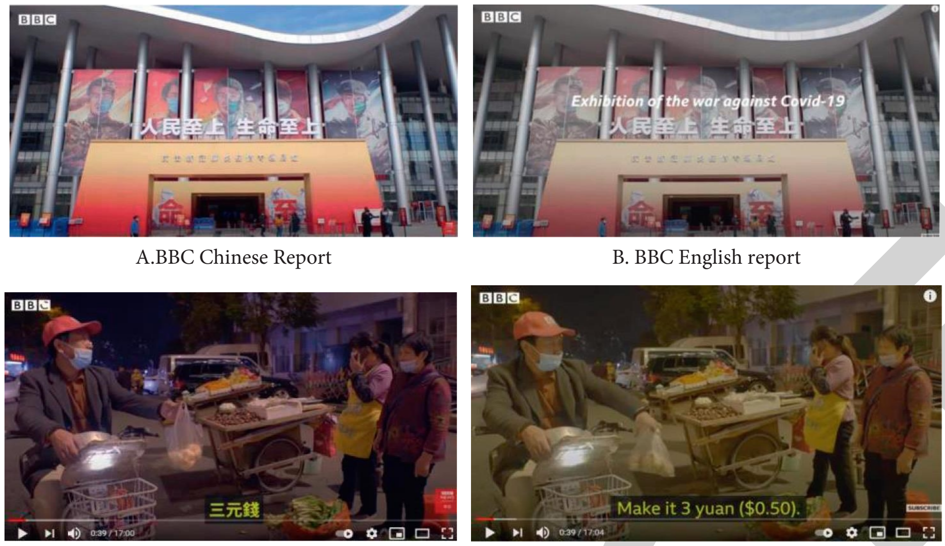
At present, there are relatively few studies combining the cognition of British and American media with diplomatic behaviors. Combining media cognition with specific diplomatic events from the perspective of water protection can still improve the micro-level research of British and American media. It helps us better understand the difference between ourselves and others, and it will have a positive significance for adjusting national foreign policies and establishing multilateral cooperative relations between countries [14].

Many factors cause cognitive differences and misunderstandings in international society. In addition to national interests and the choice of diplomatic strategic objectives, specific diplomatic behaviors and diplomatic models, historical factors, cultural factors, differences in ideology and values between countries, etc. The aspect also plays an influential role that cannot be ignored [15]. In the process of diplomatic decision-making, the decision-making environment, cognitive process, and domestic factors are closely related to each other. The formulation of diplomatic decision-making is also the feedback of other influencing factors. In this process, different perceptions are likely to be formed. Even cognitive errors are due to the lack of knowledge and understanding of specific diplomatic issues and the influence of factors such as domestic culture and ideology.

The mainstream British and American media are the defenders of the interests of Western countries. Whether it is internal or external communication, the primary purpose of the British and American mainstream media is to protect their national interests. The news principle of objective reporting is always lower than the national interest. Therefore, seeking advantages and avoiding disadvantages has become a communication feature of British and American politics [16]. The mainstream British and American media are supporters of hegemonic politics. The developed countries of Britain and the United States will make full use of the power of the media to maintain their dominant position in international politics and establish a favorable international order. The main British and American media helped shape the country's image. In international political communication, the media builds the national image of other countries through the policies and events of other countries. The public cannot gain a thorough understanding of each event due to the influence of time and space. They generally learn about other countries through reports from the news media, especially mainstream media to form the image of other countries [17].

When the country conducts international political communication, it will strengthen the positive information as much as possible and weaken the negative information. Therefore, the public can establish a good national image by receiving positive information [18]. The mainstream British and American media also play the role of disseminators of the values of the British and American countries. In international politics, mainstream British and American media need to vigorously spread British and American values and mainstream ideologies, promote the political and economic systems and lifestyles of Western capitalism, gain recognition from other countries, especially socialist countries, and gain support from other countries. According to the study of media communication mode, the contents of media reports can directly or indirectly affect the audience's perception [19]. The work sorted out and analyzed the specific report texts in mainstream media in Britain and the United States and summarized the characteristics and rules. Only by recognizing the root causes of differences can we better resolve misunderstandings and conflicts in international relations.

Media have individual characteristics and can be used as the subject of "cognition" research. Different media in different countries have different cognitions and understandings of the objective world, and therefore will produce different behaviors [20]. The British and American media rely on international influence and economic power to dominate the global media landscape. The development of information technology has promoted the globalization of the media. At the same time, in the process of media globalization, the British and American media have become more and more influential in the development of international politics and international relations. They are also playing an increasingly important role in international relations [21].



A.BBC Chinese Report B. BBC English report

A.BBC Chinese Report B. BBC English report

Figure 1: BBC's return to Wuhan's China-related report "Underworld Filter". (a) BBC Chinese Report. (b) BBC English report.

(a) (b)

Figure 2: The New York Times reported that China and Italy were closed when cities were closed. (a) The New York Times reported when the city was closed in China. (b) The New York Times reported when the city was closed in Italy.

We need to examine the negative side of mainstream media news websites in Britain and the United States dialectically. During the reporting period of the new crown pneumonia epidemic, British and American news websites label the virus infected by this "new crown pneumonia" as "Chinapneumonia", "ChinaVirus", and "Chinesecoronavirus/Chinacoronavirus". It is not difficult to see that the various political prejudices and stereotyped inertial thinking that exist in Western society against China are accumulated and difficult to return, and the clumsy tricks of demonizing and stigmatizing China are still hard to change (see Figures 1 and 2).

There are also a lot of stigmas and false news about the epidemic in China. CNN reported the SARS epidemic in China on January 9, 2020. The United States confirmed its first epidemic and preventive measures on January 21. The number of reports began to increase rapidly, and the development of related vaccines was announced on the same day. Since late January, newspapers have often reported the closure of Wuhan, lack of medical supplies in Wuhan, WHO assessments, China's anti-epidemic measures, the withdrawal of diplomats and citizens from the United States, and social pressure. The US government is responding to the virus epidemic. On January 31, the media began to criticize

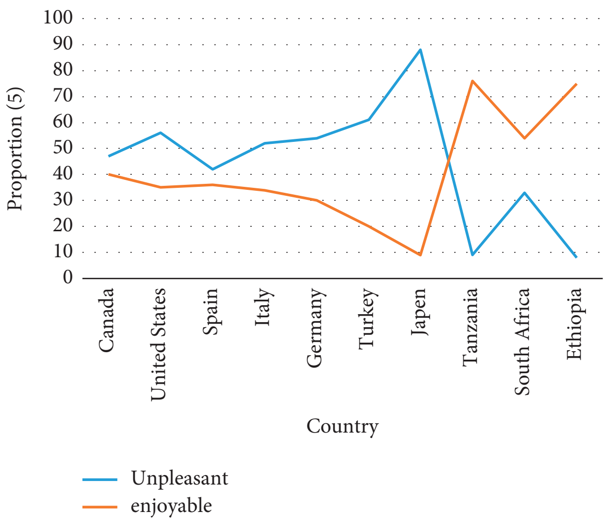


FIGURE 3: Senses of other countries and regions to China.

the issue of racial discrimination caused by the new pneumonia epidemic. As of February 4, cases have been reported in the Hong Kong Special Administrative Region of China and the Asia-Pacific region.

Compared with other foreign media, Russia's domestic attention to the new epidemic of coronary pneumonia appeared earlier and responded more quickly. Official media such as the Russian news agency TASS and RIA Novosti paid close attention to the situation and development of the epidemic promptly and continued to pay attention. The Russian news agency TASS (TASS) reported on January 10, 2020: "According to Chinese researchers, preliminary results of laboratory tests indicate that the pathogen is a new type of coronavirus." According to reports, the Municipal Health Commission announced the death of the first "viral pneumonia of unknown cause" in Wuhan, on January 11.

2.3. National Image. The "national image" has a certain degree of complexity [22]. To put it simply, "national image" can be divided into "self-image" and "other-view image". According to the different cognitive subjects and nature, its manifestation also has certain differences. From the point of view of the cognitive subject, if the cognitive subject is the people of the country, this is a kind of domestic image, which is the so-called "self-image". If the cognitive subject is transformed into the government or the people of another country, it will become the so-called "other-view image".

In Figure 3, according to the Pew Research Center's 2015 spring US global public opinion survey, we can see the evaluation of various countries on China, and the countries that have a good impression of China are mainly concentrated in Africa, Latin America, etc.[23].

Strictly speaking, the issue of China's image studied in this article, that is, the issue of "other-view image", should be classified as an issue of international image rather than a broad category of national image. The international image of a country is very different from the national image of this country. "There can be complete divergence, a long distance, roughly the same, infinite closeness, complete unity (this kind of situation is unlikely), etc. between the two. Circumstances." Some international statements about "China's demonization" have further deepened the importance of distinguishing between the international image and the national image. "The international image of a country is the comprehensive cognition and evaluation of a country's political, economic, social, cultural, diplomatic and natural elements by the international community." "The international image of a country is mainly manifested as a diplomatic image and its status among the international public. So the work mainly started from one of the manifestations of the international image, the international media, and subdivides reports on Chinese tourists from the report content and used them as a starting point to analyze the issue of China's international image [24].

The discourse of the international community has always been in the hands of developed countries such as the United Kingdom and the United States for a long time. National interests are the fundamental factor influencing national policy choices. The lack of media discourse power has caused many of China's diplomatic behaviors to be misinterpreted by the British and American media, which interferes with the public's perception. This project hopes to take the aid to Africa incident as the starting point, call China and other developing countries to attach importance to their national image, understand the understanding of the British and American mainstream media on their country's diplomatic behavior, and develop the domestic media's international visibility and credibility. The original truth of the matter will better promote China's foreign affairs with other related countries.

The media play a key role in shaping and disseminating a country's international image. As the media of different countries maintain different values and represent different interests, there will be some differences in the social phenomena that are reflected. It is believed that even within a country, the phenomena reported by different media will be inconsistent with each other [25]. Therefore, the work selected two media with different tendencies for further research.

3. Experiment on Mainstream Media's Perception and Attitude Towards China

3.1. Research Samples. All the news data in the work come from LexisNexisAcademicUniverse, a sub-database of Databases@Emory of Emory University. We used "China (China)" and "Covid-19" as keywords, and selected the period from December 1, 2019, to April 31, 2021. We received relevant news and analyzed the content of their reports. After the screening, valid reports were retained (including 135 in The New York Times, 125 in The Times, and 109 in the Guardian). The main content of the report includes the number of people infected with water pollution in China, pollution source virus, national reviews, etc.

Table 1: Number of reports by different media.

Numbering	Media	Country	Number of reports
1	New York Times	United States	941
2	Times	United Kingdom	662
3	Guardian	United Kingdom	413
4	Asahi Shimbun	Japan	381
5	USA Today	United States	330
6	Awakening Daily	India	316
7	Daily news	Japan	307
8	Times of India	India	293
9	Nihon Keizai Shimbun	Japan	27

Table 2: Media coverage of water pollution.

	China	Water pollution	Domestic Wastewater	Industrial Wastewater	Agricultural Wastewater	Town Wastewater
New York Times	253	152	132	8	3	1
Times	235	132	117	3	1	0
Guardian	185	155	131	1	1	0

Table 3: The amount of information released by the media over time.

	December 26, 2019	December 31, 2019	January 3, 2020	January 23, 2020	March 10, 2020
New York Times	8	11	25	33	17
Times	5	10	12	36	12
Guardian	4	8	12	32	10

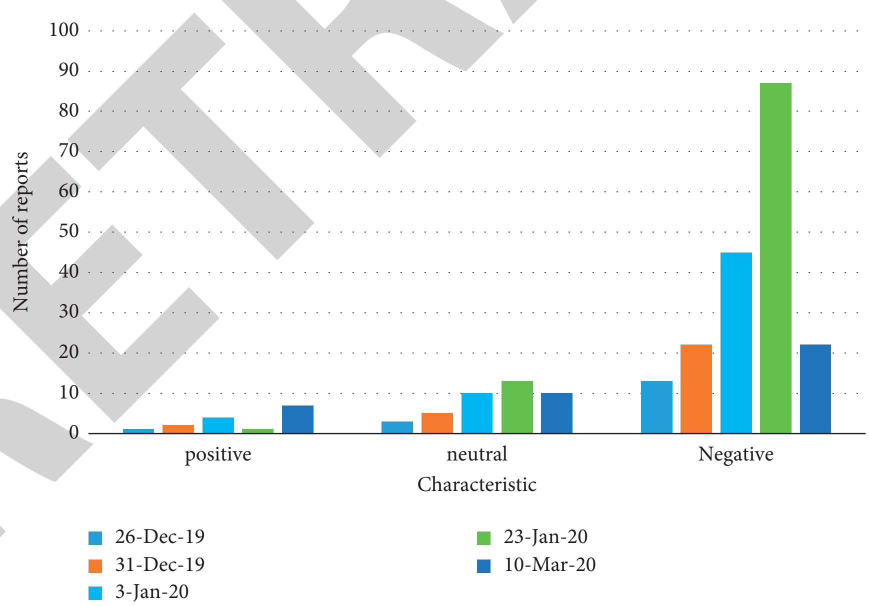


Figure 4: Number of positive and negative reports.

3.2. Establishing a Model Evaluation Index System. A clear conclusion can be drawn through actual observation of the object. Generally speaking, the evaluation index system includes three levels of evaluation indexes: they are the relationship between gradual decomposition and refinement. The first-level evaluation indicators and the second-level evaluation indicators are relatively abstract and cannot be used as a direct basis for evaluation. The

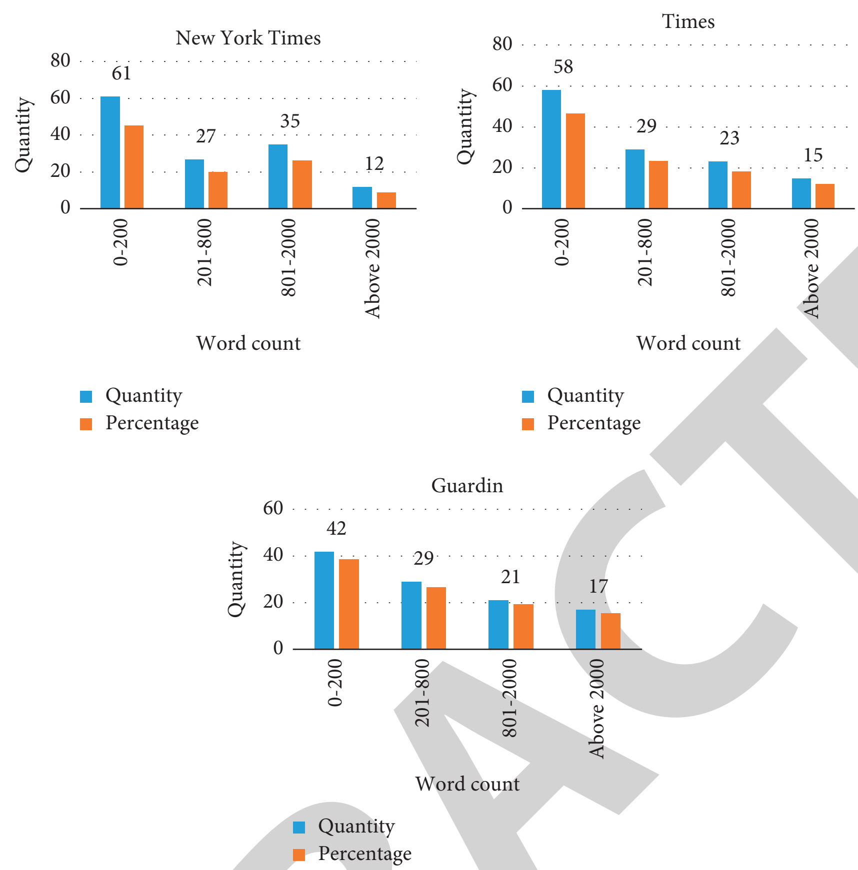


Figure 5: Report length.

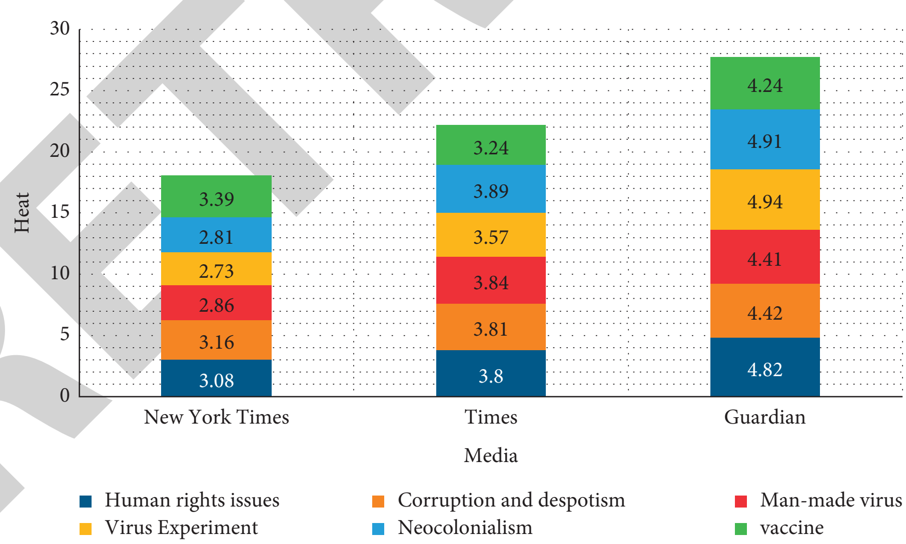


Figure 6: Topic popularity.

third-level evaluation indicators should be specific, measurable, and behavior-oriented, and can be used as a direct basis for teaching evaluation.

3.3. Determine the Evaluation Weight. The index weight is a numerical index indicating the importance and function of the index. In the indicator system of the evaluation plan, the weight of each indicator is different. Even if the indicator level is the same, the weight is different. Index weight is also called weight and is usually represented by a. It is a number greater than zero but less than 1, and the sum of the weights of all first-level indicators must be equal to 1, that is, satisfy conditions $0 < a < 1$ and $\sum$a-1.

3.4. Statistics. All data analysis in the work used SPSS19.0, and the statistical test used a two-sided test. Significance was defined as 0.05, and $p < 0.05$ was considered significant. The statistical results were displayed as mean ± standard deviation ($x \pm \mathrm{SD}$). When the test data obeyed the normal distribution, the double T-test was used for comparison within the group, and the independent sample T-test was used for comparison between the groups. If the regular distribution was not sufficient, two independent samples and two related samples were used for inspection.

4. Experimental Analysis of Mainstream Media's Cognitive Attitude Towards China

4.1. Mainstream Media Reports. We first made relevant statistics on the reports of the international mainstream media on China during water pollution and compared the differences in reports between different media (see Table 1).

Table 1 shows that media reports on China are extremely frequent, and every report is designed during water pollution. The propaganda and media systems of various countries in the world can be roughly divided into four theoretical types, namely, authoritarian theory, liberal theory, social responsibility theory, and communist (total) theory type." China uses the communism theory, while Japan uses it. This is the theoretical basis of liberalism. They have their unique views on the attitude of their governments due to the different processes of the historical development of the big newspapers.

The distribution of the number of reports on China in the water pollution over time by the New York Times, The Times, and the Guardian since the outbreak of the water pollution (see Table 2).

Table 2 shows that the name of the report has been changed many times before and after, using "Water Pollution" 380 times, "Domestic Wastewater" 12 times, "Industrial Wastewater" 12 times, and "Industrial Wastewater" 8 and 3 times, "Agricultural Wastewater" 3 times, "Industrial Wastewater" 5 times, "Agricultural Wastewater" 1 time, and "Town Wastewater" 1 time.

Immediately after the epidemic broke out in China (See Table 3), we calculated the number of reports from these media and the number of positive and negative reports based on time points. (See Figure 4).

When water pollution first appeared in China, foreign media began to pay attention to it, and the relevant articles gradually increased, with overall positive and negative references. The international media's overall coverage of the water pollution in China has been ideologically in command, full of these colored glasses. Especially when Wuhan was closed on January 3, 2020, mainstream media in Europe and the United States showed negative reports. It is authoritarianism to criticize China for infringing on people. Of course, internationally, there are related media expressing support for China's measures.

4.2. Length of Media Coverage. The length of a related report is the number of words in each related report. Generally speaking, the larger the length of a report, the greater its influence and the stronger the desire for the relevant content to be conveyed. In the statistical process of the length of relevant reports, they are divided into newsletters, news, reports, and in-depth reports according to the law of communication. We have made statistics on the length of these reports (see Figure 5).

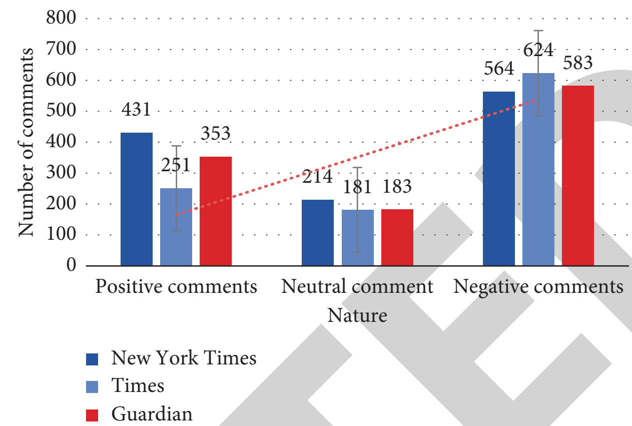


Figure 7: Readers' comments.

Judging from the overall report, the number of words in the report is 4,258, and that of words is 86. There are 161 articles with a length of fewer than 200 words, accounting for 43.6% of the total; 85 articles with more than 200 and less than 800 words, accounting for 23% of the total; 79 articles with a length of more than 800 and less than 2,000 words, accounting for 21.4% of the total. There are 44 articles with more than 2000 words, accounting for 12% of the total. Among these reports, the related negative reports mainly involve "human rights issues", "corruption and autocracy", "man-made viruses", "virus experiments", etc (see Figure 6).

In the overall report, the main reports of these three media still show a trend of negative reports. They repeatedly criticized water pollution prevention measures for infringing human rights and being an authoritarian country. Of course, some of the readers of these media were persuaded by the media's remarks, but some were dissatisfied with the contaminated source virus treatment in foreign countries, hoping that they would learn from China's virus treatment control and protect the people's health of the country (see Figure 7 for the details).

In the comments of the reader, more and more readers have questioned the objectivity of the "New York Times" report, believing that this analysis has many subjective problems and is entirely propaganda for the Western government. There is no doubt that the ownership of the media and the control of national political power has a major impact on the shaping of the international political news framework.

5. Conclusions

The Chinese and British and American media coverage of the same event will inevitably be influenced by their respective cultural forms due to differences in cultural values, which creates significant differences between Chinese and British and American media reports and forms significant differences between Chinese and British and American media reports. From the reporting standpoint, the mainstream media in Britain and the United States still have a clear Cold War color. Starting from the ideological and cultural background, they choose and determine the tendency of news reporting. The ultimate goal is to include China in the United Kingdom and the United States and realize the unanimity of the ideology of the international community as the leading international system.

Chinese media should change the current political propaganda orientation, adhere to the principle of objectivity, and return news reports to the incident. It should report on achievements and face up to the existing problems and the views and attitudes of other countries. Domestic media should increase the transparency of information from the source to ensure the authenticity, objectivity, and efficiency of news reports and avoid the tendency of Western media reports.

Data Availability

The data used to support the findings of the work are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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Retraction

Retracted: Investigating the Impact of Transportation Infrastructure and Tourism on Carbon Dioxide Emissions in China

Journal of Environmental and Public Health

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Q. Zhang, "Investigating the Impact of Transportation Infrastructure and Tourism on Carbon Dioxide Emissions in China," *Journal of Environmental and Public Health*, vol. 2022, Article ID 8421756, 9 pages, 2022.

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Research Article

Investigating the Impact of Transportation Infrastructure and Tourism on Carbon Dioxide Emissions in China

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In order to effectively address or eliminate the impact of CO_2 emissions, it is essential to investigate the analysis of CO_2 emissions under transport infrastructure and tourism. Transportation infrastructure helps to achieve carbon dioxide emission limitation, which is crucial for resource distribution, effectively summarizing the regularity and innovation in the process of carbon dioxide emission limitation. In the case of fully grasping the principles of low-carbon tourism development and related policy protection, a suitable low-carbon tourism development model is found. By constructing a data analysis model, this paper analyzes the impact of transportation infrastructure and ecotourism on carbon dioxide emission limitation. In terms of methods and systems, effective measures are given to the role of Chinese traffic settings in tourism, and the carbon emission system of the entire life cycle of traffic settings is analyzed, and the boundary of the impact of traffic carbon emissions on tourism is determined. In response to this problem, it is necessary to reform and optimize the transportation facility of the carbon emission accounting method, which has a positive effect on the green development and low-carbon development of the Chinese economy for ecotourism and transportation infrastructure.

1. Introduction

With the continuous development of social economy, tourism is also booming. With the improvement of people's living standards and the continuous changes in social awareness and ideas, travel has become the norm in daily life. Even in the past few years, there has been a boom in overseas travel, and tourism has become a rigid demand. But what follows is the emergence of new problems, such as littering in scenic spots, destruction of historical sites and facilities in scenic spots, and other nonenvironmental and uncivilized behaviors. Therefore, it is an urgent problem and focus to analyze the influencing factors of tourists' environmental protection behavior and to continuously instill and integrate the concept of environmental protection into the conscious behavior of citizens. The behavior of environmental protection is also called environmental low-carbon behavior and environmental protection behavior in China [1–3]. At present, the research of environmental protection awareness by experts within the industry mainly focuses on the influence of demographic factors such as the age, education level, and birth environment of citizens, as well as subjective environmental ecological education, environmental attitude, and environmental protection awareness or from the perspective of tourism motivation. Current environmental behavior interventions mainly focus on propaganda, punishment, and other programs but have not paid attention to the impact of traditional Chinese culture and reward and punishment measures on environmental behavior [4–6]. Carbon dioxide emission reduction behavioral influencer analysis and real-time risk alerts are also effective data collection and analysis processes for transport infrastructure and tourism. Collect indicator data from the ecological environment and give feedback to monitoring personnel. Ecological environment detection and real-time risk monitoring are of great significance for ecological environment-related resource distribution, flow planning service level, and safety monitoring. The analysis of factors affecting carbon dioxide emission reduction behavior and real-time risk alerts are important manifestations of ecological environment management and systematic integration, providing detailed data information for the operation and maintenance of the ecological environment. In terms of capacity planning, eco-environmental performance analysis, abnormal monitoring, link status monitoring, and capacity planning play an important role. As the focus of current research in this field, the analysis of influencing factors of carbon dioxide emission reduction behavior can be perfectly combined with different industries, and the data of different industries can be fully used in the actual analysis environment of carbon dioxide emission reduction behavior influencing factors. With the growth of tourism, people's requirements for carbon emissions are also more demanding, but most researchers still stay at the linear level of research, and only a few researchers have carried out the deepening of the nonlinear level [7–9]. There is no research on the nonlinear level of the tourism development level and tourism development speed, and these two are the decisive reasons. Carbon emission reduction of transportation infrastructure involves many fields such as raw material production, raw material transportation, and building construction and involves related engineering construction and environmental protection management departments. There are certain overlapping and blank responsibilities, management is difficult, and the effect of carbon emission management is not ideal. In the implementation stage, the emission reduction needs to be maximized. The Chinese environment studies have entered a new course. The differences in the economic development and economic situation of each place have a decisive factor on the local carbon emissions. Change and role require lower carbon, greener, and less energy loss to generate maximum tourism. Due to the large differences in regional economic growth, according to the regional economic development level and carbon dioxide emissions of each country, based on the actual situation, the reasonable and scientific carbon emission reduction policy standards are formulated, which has become the first choice for the development of low-carbon economy in China. When formulating low-carbon emission reduction policies, countries need to effectively consider their own economic development, resource availability, and green relevant policies aiming at different regions, areas, and corresponding urban resources, actively encourage the country to actively explore the allocation of carbon dioxide emissions and renewable resources suitable for its own region, and guide the whole society to save resources, improve resource efficiency, and reduce environmental pollution. The key to the sustainable growth of the proposed tourism development is to break through the tourism structure. Through the analysis from the perspective of resources, it is actually the current regulations of the current environment to find the form of green tourism and green environment. Facts have proved that the development of tourism in this country is inseparable from the country's carbon emissions and the environment, especially for the huge country [10, 11]. Through two levels of analysis, the first level is that the tourism resources of each country in our country are disparate, the development of each country and each region also has a large gap, and the country needs to manage carbon emissions while taking into account the growth of tourism. The second level is that each country has its own development characteristics, such as the development track of industry, tourism, and cities; therefore, the issue of carbon emissions is not summarized at one level, but there is a special relationship between the development of tourism and emission reduction, and this consequence can also be seen in each country's own characteristics. Considering the implementation of carbon emissions according to one standard leads to a different picture of results. So, how to maintain the normal growth of tourism while ensuring the emission of carbon emissions? This is a problem that every country needs to solve so that both can develop in a balanced way. Therefore, it is necessary to analyze the different levels of each region and the tourism situation. According to the analysis results, we will find a solution to fundamentally solve the contradiction between tourism and carbon emissions between countries. The solution of this problem will also bring more long-term benefits to the country [12, 13].

The global temperature has gradually warmed up, which is related to the emission of carbon dioxide. Total carbon dioxide emissions have increased by 30 percent over the past decade, 25 percent of which comes from urban transport carbon emissions. The resource consumption of transportation is also quite large, and these data have already caused a great threat to the urban environment, and there is an adverse impact in the era of the development of the human and self-heating industry. Through this worrying environment, the world is creating new opportunities for resource development. The term low-carbon transportation also appears in people's ideas, and of course it is the goal that every city in the world needs to achieve. This paper analyzes the carbon emission situation of Chinese transportation installations through research on the existing transportation carbon emission calculation in China and foreign countries, and at the same time, corresponding measures are put forward based on the existing traffic settings, which provides strong support for the development of healthy and low-carbon transportation in China.

2. Basic Knowledge and Related Calculation Methods

Ecotourism plays a very important role in the promotion of green economy in China. Ecotourism promotes transportation infrastructure and effectively reduces the consumption of carbon dioxide per unit. The development of the economy has made the transportation infrastructure continue to intensify, resulting in an increase in carbon dioxide emissions, and the increase in consumer demand has increased carbon dioxide emissions. The realization of real-time, rational, and precise monitoring of carbon dioxide emissions can also provide a theoretical basis for the decision analysis of relevant environmental protection inspection departments, which is of great significance to the emergence of more transportation infrastructure projects. A detailed analysis of the transportation infrastructure is carried out to explore the problems and shortcomings of the carbon

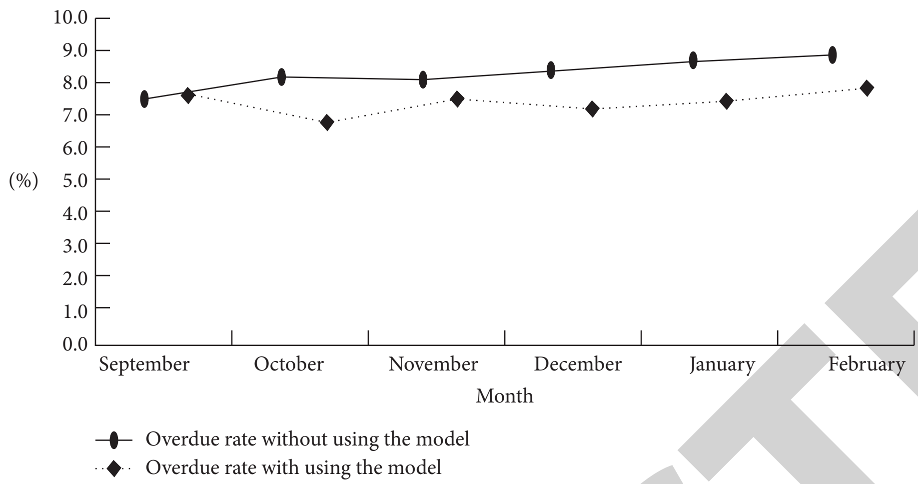

Figure 1: Main links of carbon emissions from transportation infrastructure.

dioxide emission process so that the training and improvement plan can be formulated later. There are many differences in carbon dioxide emissions among countries and the corresponding reasons. There are many differences in CO_2 emissions between countries, and the basis of this classification is not only based on the boundaries of tourism areas, nor is the high or low standard set by the size of CO_2 emissions, but the classification should take into account the tourism situation, the rate of tourism development and growth patterns [14, 15]. The situation, the speed of tourism development, and the way of growth should be comprehensively considered. It can be concluded that due to the large differences in the development of tourism in different countries, according to the level of tourism development and carbon dioxide emissions in each country and according to the actual situation, reasonable and scientific carbon emission reduction policy standards are formulated, which has become the preferred way for countries to develop low-carbon tourism. When formulating low-carbon emission reduction policies, the premise is to consider the basic situation of tourism development in different countries, the basic resources of different regions and corresponding cities, the current situation of environmental pollution and characteristics of industrial structure, as well as relevant legal policies, and actively encourage countries to boldly explore their own ways of allocating carbon dioxide emissions and renewable resources to guide the whole society to save resources, improve resource efficiency, and reduce environmental pollution. As shown in Figure 1:

As an emerging tourism body in China with a relatively high degree of openness in tourism development, the emergence of Chinese trade and investment protectionism will lead to the slow development of its tourism trade and will seriously affect financial financing. The continuous development of various factors such as big data, artificial intelligence, and blockchain will make more traditional industries change continuously [15, 16]. At present, with the development of financial technology, different types of electronic payment models have begun to develop on a large scale. Using the characteristics and typical activities of LCA structure and transportation infrastructure construction, the carbon emissions generated in the process of transportation infrastructure are more vulnerable to extreme weather and sea level rise than developed countries (regions). After extreme weather events, the repair or reconstruction of damaged infrastructure not only hinders disaster relief work and economic recovery but also further consumes limited financial resources. The carbon dioxide emission management control strategy model and decision-making process are shown in Figure 2.

In the process of accepting the awareness of carbon dioxide emission reduction and environmental protection, tourists have experienced the process of learning, understanding, and accepting. The surrounding environment makes certain technical changes and adjustments to the subjective consciousness of tourists. When the probability of the corresponding environmental protection investment is adjusted, according to these random numbers, the judgment of tourists' awareness of carbon dioxide emission reduction and environmental protection is carried out, as shown in formula (1):

$$\text{tech ln vest} = \begin{cases} \text{tech ln vest}(t-1) - \Delta I_1\left(0 \le r < p^d\right), \\ \text{tech ln vest}(t-1) + \Delta I_2\left(p^d \le r < p^i + p^r\right), \\ \text{tech ln vest}(t-1)\left(p^i + p^r\right) \le r < 1. \end{cases} \tag{1}$$

Risk analysis results include the likelihood of transport infrastructure being exposed to specific catastrophic events and the consequences of such events. (2) shows the function that defines the risk that is widely used today.

$$R = \left\{S_i, P_i, D_i\right\}, i = 1, 2, \ldots, k, \tag{2}$$

where R is the risk set; S_i is the damage factor set; P_i is the correlation probability of S_i; D_i is the associated damage; k is the number of damage factors.

First of all, it is necessary to judge the ability of tourists. By constructing a corresponding model, using subjective constraints, discussing the relationship between input and output, and expressing it with a quantitative function, as shown in formula (3):

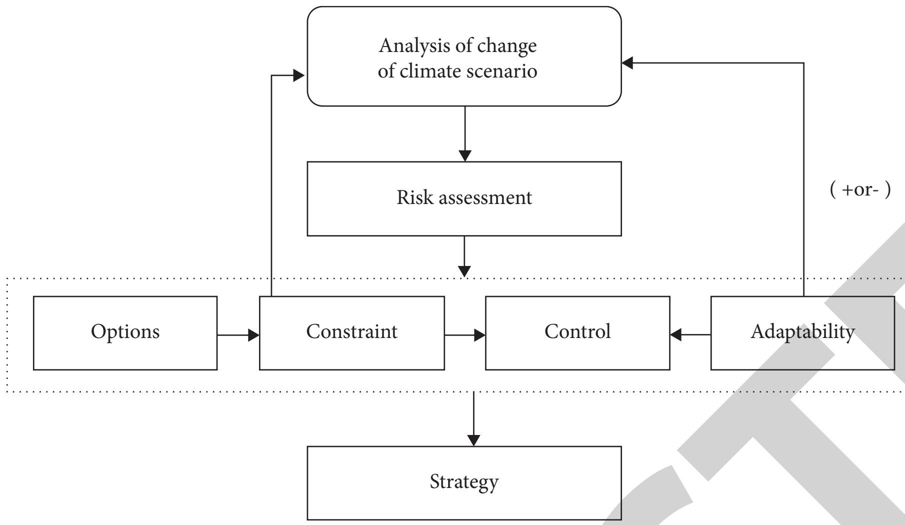

Figure 2: CO_2 emission control strategy formulation process.

$$Q(t) = T(t)L^{\alpha}K^{\beta}. \quad (3)$$

In the formula, $Q(t)$ is the actual output quantity invested by tourists in period t, $T(t)$ represents the technical level of tourists, awareness of carbon dioxide emission reduction, and environmental protection, and L is the labor input by corresponding environmental protection enterprises and training institutions, aiming to cultivate awareness of carbon dioxide emission reduction and environmental protection, K is the investment capital theory of environmental protection enterprises, and α and β are constants, as shown in the following formula:

$$T(t) = \frac{B - \text{tech} \ln \text{vest}(t)}{1 + B - \text{tech} \ln \text{vest}(t)}. \quad (4)$$

In order to further simplify the model, formula (5) is used to simulate the input cost of environmental protection enterprises, where C_1 and C_2 are constants:

$$\text{product Cost} = C_1 \cdot Q(t) + C_2 \cdot L. \quad (5)$$

The operations of the $k(k = 1, 2, \ldots, K)$ group in the carbon dioxide emission analysis can be expressed as

$$\begin{aligned} s_1(t) = {} & \sum_{m=0}^{M-1} \text{rect}\left(\frac{t - mT_R - kMT_R}{T_p}\right) \\ & \cdot \exp\left(j\pi\gamma\left(t - mT_R - kMT_R\right)^2\right) \\ & \cdot \exp\left(j2\pi f_{sm}\left(t - mT_R - kMT_R\right)\right). \end{aligned} \quad (6)$$

In the formula, $t = \hat{t} + mT_R + kMT_R (m = 1, 2, \ldots, M)$ represents the entire computing time, $\hat{t}$ represents the fast time, and $\text{tect}(u)$ represents the corresponding rectangular window.

If the carbon dioxide emission analysis contains multiple feature points, then the coefficient of the backward feature of the $p(p = 1, 2, \ldots, P)$th feature point can be expressed by σ_p. If the corresponding time delay $\tau_p(t)$ value of the characteristic point p in the transformation assistance in the carbon dioxide emission analysis does not change, then $\tau_p(t) \approx \tau_p(t_{m,k}), t_{m,k} = mT_R + kNT_R$. At the same time, for the characteristic points of the carbon dioxide emission analysis, the mth subtransition assistance under the kth group of transportation infrastructure-assisted high-performance computing can be expressed as

$$\begin{aligned} s_2(\hat{t}, m, k) = {} & \sigma_p \text{rect}\left(\frac{\hat{t} - \tau_p\left(t_{m,k}\right)}{T_P}\right) \\ & \cdot \exp\left(j\pi\gamma\left(\hat{t} - \tau_p\left(t_{m,k}\right)\right)^2\right) \\ & \cdot \exp\left(j2\pi f_{sm}\left(\hat{t} - \tau_p\left(t_{m,k}\right)\right)\right) + \varepsilon(\hat{t}). \end{aligned} \quad (7)$$

In the formula, $\tau_p(t_{m,k}) = 2R_P(t_{m,k})/c$, $R_P(t_{m,k})$ are expressed as the instantaneous slope distance between the pth feature point and the emission limit analysis of carbon dioxide emission analysis, c is the speed of light, and $\varepsilon(\hat{t})$ is represented as an additive constraint.

The definition of living welfare is based on the effective combination of consumption and the effective limitation of carbon dioxide emissions, the negative impact of emissions on the arrival of tourists' happy life, assuming that the expression of tourists' living welfare is

Table 1: Carbon emission coefficient of conventional resources.

Types of resources	Carbon emission factor (kg·(c)/kg)
Liquified petroleum gas	0.5034
Diesel oil	0.5933
Gasoline	0.5535
Fuel oil	0.6144
Oil	0.54/0.577
Electricity*	0.26/0.276
Coal	0.68/0.755

*The unit is kg (c)·kW·h.

Table 2: Carbon emission coefficients of main building materials.

Type of material	Steels	Ready-mixed concrete	Cement	Concrete brick block	Wooden product
Carbon emission coefficient (t/t)	2.1	0.25 t/m^3	0.81	0.13	0.21

$$\max \int_0^{+\infty} (\ln C - \beta \ln P) e^{-\rho t} dt. \quad (8)$$

In the expression, C represents the consumption of tourists, and P represents the stock of carbon dioxide. If $\beta > 0$ occurs, it represents the index of the impact of carbon dioxide emissions on tourists' lives, and if $\rho > 0$ occurs, it represents the index of tourists' patience. The carbon emission factors of commonly used resources and building materials are shown in Tables 1 and 2.

Substituting the total carbon dioxide emission function of expression (8) into expression (9), the average carbon dioxide emission can be obtained as follows:

$$\frac{\dot{P}}{Y} = \Omega \left[\frac{Y}{A}\right]^{\varphi} = \Omega L_Y^{\alpha\varphi} \left[\frac{K}{A}\right]^{(1-\alpha)\varphi}. \quad (9)$$

The expression that can use the economic growth rate as the limiting condition of carbon dioxide emissions is

$$\frac{\dot{P}}{Y} = \delta^{-\varphi} (1-\alpha)^{(2(1-\alpha)\varphi)/\alpha} \Omega (\delta L - \Omega)^{\varphi} (\rho + \Omega)^{-((1-\alpha)/\alpha)\varphi}. \quad (10)$$

Substituting expression (9) into expression (8), the condition of carbon dioxide emission limit is expressed as a function. According to expression (9), the degree of influence of tourism on the economic growth rate can be realized. According to expression (10), it can be deduced that the CO_2 emission limit varies with the economic growth rate. Therefore, according to the qualitative analysis, the use of tourism can realize the assessment of the impact degree of carbon dioxide emission limitation.

Through in-depth investigation and research of the formation of different carbon emission ranges, we can find measures and ways to reduce emissions. This effective measure is beneficial to the development of tourism in various countries. According to the difference between the current national carbon emissions and the development of tourism, this paper estimates and detects the transportation infrastructure through the proposed situation of "the role of tourism development on carbon emissions." There is a single threshold between the level of tourism development and carbon emissions, and the level of tourism development directly affects the threshold in carbon emissions. There are obvious gaps in the relationship between tourism development and carbon dioxide emissions in different countries. Some data show that after calculating the total carbon emissions, each region is manually distinguished and studied through factors in different regions. Questions were raised about the arrangement of such predistinguished regions, which should be based on regional carbon emissions. Because of the interference of tourism, regular distinctions are made, and then distinctions are made according to the results and categories so that the carbon emission factors can be divided by region, and the relationship between tourism development and carbon emission growth changes can be studied, and it is recommended to effectively formulate and implement strategy of carbon reduction [17, 18].

3. Analysis of the Impact of Transportation Infrastructure and Tourism on Carbon Emissions

According to the sorting out of the key points of the carbon emission calculation of transportation infrastructure at home and abroad, there is currently no complete carbon emission quantitative calculation method system in the field of transportation infrastructure in China. There are inconsistent calculation boundaries, unclear calculation granularity, disordered methods, and lack of systematic management. There is a big gap with the carbon peak carbon neutralization target requirements [19, 20]. To develop Chinese overall tourism benefits and the concept of sustainable development, the first thing to solve is the situation of energy loss and carbon emissions. The nonlinear impact analysis structure of transportation infrastructure and ecotourism on carbon dioxide emissions is a finite-parameter linear model. On the basis of satisfying the finite parameter linear model, the finite parameter linear model can be used for optimization according to the steady-state ecological environment of the system. In the process of dynamic monitoring of the ecological environment, the nonlinear impact of transportation infrastructure and ecotourism on carbon dioxide emissions can be analyzed. According to the problems analyzed above, this paper uses the ecotourism demand function to express as follows:

$$w = \alpha L_Y^{\alpha-1} \int_0^A x(i)^{1-\alpha} \mathrm{d}i, \quad (11)$$

$$p(i) = (1-\alpha) L_Y^{\alpha} x(i)^{-\alpha}. \quad (12)$$

The obtained data are used for the analysis of the performance of the ecological environment protection, the operation status of the ecological environment protection, and the diagnosis of the cause of the failure and can also be used for the monitoring of the cause of the failure [11, 21].

Suppose the operation of group $k\,(k = 1, 2, \ldots, K)$ in the CO_2 emission limit analysis can be expressed as follows:

$$s_1(t)=\sum_{m=0}^{M-1}\operatorname{rect}\left(\frac{t-mT_R-kMT_R}{T_p}\right)\cdot\exp\left(j\pi\gamma\left(t-mT_R-kMT_R\right)^2\right)\cdot\exp\left(j2\pi f_{sm}\left(t-mT_R-kMT_R\right)\right). \tag{13}$$

In the formula, $t=\widehat{t}+mT_R+kMT_R\,(m=1,2,\ldots,M)$ represents the entire computing time, $\widehat{t}$ represents the fast time, and $\operatorname{tect}(u)$ represents the corresponding rectangular window.

Assuming that carbon dioxide emission reduction is divided into K groups for sparse analysis, then the ecological transformation of consumption patterns in the $k\,(k=1,2,\ldots,K)$ group helps high-performance computing, which can be expressed as follows:

$$s_1(t)=\sum_{m=0}^{M-1}\operatorname{rect}\left(\frac{t-mT_R-kMT_R}{T_p}\right)\cdot\exp\left(j\pi\gamma\left(t-mT_R-kMT_R\right)^2\right)\cdot\exp\left(j2\pi f_{sm}\left(t-mT_R-kMT_R\right)\right). \tag{14}$$

In the formula, $t=\widehat{t}+mT_R+kMT_R\,(m=1,2,\ldots,M)$ represents the entire computing time, $\widehat{t}$ represents the fast time, and $\operatorname{tect}(u)$ represents the corresponding rectangular window.

If there are multiple feature points in the carbon dioxide emission reduction analysis, then the coefficient of the backward feature of the $p\,(p=1,2,\ldots,P)$ feature point can be expressed by σ_p. If the corresponding delay value $\tau_p(t)$ of the characteristic point p in the transformation boost of carbon dioxide emission reduction analysis does not change, then $\tau_p(t)\approx\tau_p(t_{m,k}), t_{m,k}=mT_R+kNT_R$. At the same time, for the characteristic points of the carbon dioxide emission reduction analysis, the mth subtransformation assistance under the ecological transformation assistance of the kth group of consumption patterns under the high-performance computing can be expressed as follows:

$$s_2(\widehat{t},m,k)=\sigma_p\operatorname{rect}\left(\frac{\widehat{t}-\tau_p\left(t_{m,k}\right)}{T_P}\right)\cdot\exp\left(j\pi\gamma\left(\widehat{t}-\tau_p\left(t_{m,k}\right)\right)^2\right)\cdot\exp\left(j2\pi f_{sm}\left(\widehat{t}-\tau_p\left(t_{m,k}\right)\right)\right)+\varepsilon(\widehat{t}). \tag{15}$$

In the formula, $\tau_p(t_{m,k})=2R_P(t_{m,k})/c$, $R_P(t_{m,k})$ is expressed as the instantaneous slope distance between the pth characteristic point and the emission evolution analysis of carbon dioxide emission reduction analysis, c is the speed of light, and $\varepsilon(\widehat{t})$ is the additive evolution. Then, for the transformation-assisted frequency modulation processing, we can set $\widehat{f}=\gamma(\widehat{t}-2R(t_{m,k})/c)$, and then the carbon dioxide emission reduction analysis process is as follows:

$$s_3(\widehat{f},m,k)=\sigma_p\operatorname{rect}\left(\frac{\widehat{f}}{\Delta f}\right)\exp\left(j\frac{4\pi}{c}\left(f_{sm}+\widehat{f}\right)\Delta R\right)\cdot\exp\left(j\frac{4\pi}{c}\left(\Phi_P+\Phi_B\right)\right)+\varepsilon(\widehat{f}). \tag{16}$$

In the formula, $\Delta R=x_p\sin\theta_{m,k}+y_p\Phi_P$, Φ_B, represent the phase error caused by the translation between the transition assists and the phase error caused by the translation between the transition assist strings in turn in the carbon dioxide emission reduction analysis.

The realization of real-time, rational, and precise monitoring of carbon dioxide emissions can also provide a theoretical basis for the decision analysis of relevant environmental protection inspection departments, which is of great significance to the emergence of more transportation infrastructure projects. A detailed analysis of the transportation infrastructure is carried out to explore the problems and shortcomings of the carbon dioxide emission process so that the training and improvement plan can be formulated later. In the traditional CO_2 emission evolution analysis process, CO_2 emissions and real-time risk alerts are also effective data collection and analysis processes for CO_2 emission devices. Collect indicator data and give feedback from the CO_2 emission process. The obtained data are used to analyze the performance of carbon dioxide emission, analyze the operation state of carbon dioxide emission, and diagnose the cause of failure and can also be used to monitor the cause of failure. Carbon dioxide emissions and real-time risk alerts are an important manifestation of carbon dioxide emissions management and system integration, providing detailed data information for the operation and maintenance of carbon dioxide emissions [22, 23]. For transportation infrastructure, the development of tourism and carbon emissions has attracted more attention from researchers and scholars. Facts have proved that there are large gaps in carbon emissions changes under different environments and systems. Transportation carbon emission estimation is mainly through the use of life cycle assessment methods to estimate the carbon emissions generated by the constructed transportation infrastructure, and many researchers have developed carbon measurement software. The main theories and basic calculation ideas are relatively unified, but due to different divisions in different links, the coefficient library is not unified, the later detection is restricted insufficiently, and the existing carbon emission calculation methods of infrastructure equipment are disordered and have poor reference.

4. Analysis of Examples and Results

The continuous development of social economy promotes the continuous improvement of people's travel awareness. For the research on carbon dioxide emission reduction awareness of general tourists, carbon dioxide emission reduction awareness is the key internal driving force for tourists to implement environmental protection behaviors

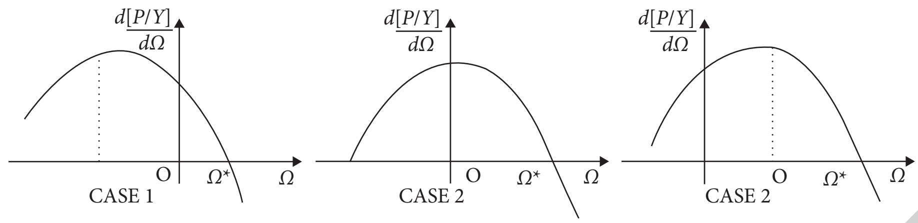

Figure 3: Visual analysis of the impact of the tourism growth rate on carbon dioxide emissions.

and proenvironmental behaviors. The disclosure of its influencing factors will undoubtedly play a positive role in improving the environmental protection behaviors of Chinese tourists. The environmental protection behaviors are classified and sorted, the influencing factors affecting tourists' environmental protection behaviors are constructed, and the relevant policies and measures of the existing Chinese tourists' environmental protection behaviors are sorted out and analyzed. Combined with the results of empirical analysis, targeted policy recommendations are put forward to promote the promotion of Chinese tourists' environmental protection concepts and behavior internalization. Because the driving force of tourism development is mainly labor-intensive industries, the impact of population size on carbon dioxide emissions is more serious [24]. However, with the continuous development of the regional tourism development level, the proportion of labor-intensive industries has gradually decreased, and the proportion of capital-intensive and high-tech related industries has gradually increased. The change of the influence coefficient of tourism consumption on carbon dioxide emissions follows the trend of first increase and then decrease. The influence coefficient of countries with a medium level of tourism development is the most significant, and countries with a low level of tourism development are less influential than countries with a high level of tourism development. Low-carbon resource technologies are generally better than other regions, and carbon dioxide emissions show a decreasing trend under the influence of the level of tourism development. It shows that in countries with backward tourism development, it is mainly necessary to use more resources and the environment in high-speed development as the price of development.

In this paper, we can use expression (17) to derive Ω in the assessment of CO_2 emission limits using the growth rate of tourism to obtain the following expression:

$$\frac{d[\dot{P}/Y]}{d\Omega} = \delta^{-\varphi}(1-\alpha)^{(2(1-\alpha)\varphi/\alpha)}(\delta L-\Omega)^{\varphi-1}(\rho+\Omega)^{-(1-\alpha/\alpha)(\varphi-1)} \times \left\{\left[\left(\frac{1-\alpha}{\alpha}-1\right)\varphi-1\right]\Omega^2+\left[\delta L\left(1-\frac{1-\alpha}{\alpha}\varphi\right)-\rho(1+\varphi)\right]\Omega+\delta\rho L\right\}. \tag{17}$$

According to expression (24), if $((1-\alpha/\alpha)-1)\varphi-1<0$ is satisfied, then the relationship between the growth rate of the green economy and the carbon dioxide emission limit can be represented by an inverted U shape. Q is used to represent the horizontal axis and $d[\dot{P}/Y]/d\Omega$ to represent the vertical axis, then the corresponding intercept of expression (24) on the vertical axis is not less than zero. If $((1-\alpha/\alpha)-1)\varphi-1<0$ is satisfied, then the relationship between $\delta L(1-(1-\alpha)\varphi/\alpha)-\rho(1+\varphi)$ and 0 has a certain influence on the horizontal axis value corresponding to the extreme point of expression (24), according to three different situations shown in Figure 2. If $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)<0$, 0 is satisfied, then it corresponds to Case 1 in Figure 2; if $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)=0$ is satisfied, then it corresponds to Case 2; if $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)>0$ is satisfied, then it corresponds to Case 3 in Figure 2. In the three cases in Figure 3, if the tourist growth rate $\Omega>0$ is satisfied, the intersection of expression (24) with the horizontal axis in the interval not less than 0 is set to Ω^* in this paper. It can be concluded that if $0<\Omega<\Omega^* d(\dot{P}/Y)/d\Omega>0$, the growth rate of the green economy keeps rising, and the carbon dioxide emissions also increase; If $\Omega>\Omega^*$ is satisfied, $d[\dot{P}/Y]/d\Omega<0$, then the growth rate of the green economy will also rise, and carbon dioxide emissions will continue to decline. If $\Omega=\Omega^*$, $d[\dot{P}/Y]/d\Omega=0$, then the carbon dioxide emission will reach a maximum value at this time. According to the constructed model variables, $((1-\alpha/\alpha)-1)\varphi-1<0$ conforms to the standard of ecotourism economic development. In the expression (14) used, α represents the share of economic income in the total income. According to the green economy income share, it generally needs to be maintained between 60% and 70%, $(1-\alpha)/\alpha<1$ can be obtained, and the conditions of $((1-\alpha/\alpha)-1)\varphi-1<0$ need to be met.

According to the above detailed analysis, this paper uses quantitative analysis to obtain the impact of ecotourism and transportation infrastructure on Chinese carbon dioxide emissions. According to the constructed expression, the explanatory variables serve as the effect of limiting carbon dioxide emissions, and the core explanatory variables mainly include the level of ecotourism and transportation infrastructure. Combining the model, we can effectively calculate the basic impact of ecotourism on carbon dioxide emissions. Therefore, this paper can analyze the factors affecting carbon dioxide emissions in detail. Due to the large differences in regional economic growth, according to the regional economic development level and carbon dioxide emissions of each country, based on the actual situation, the reasonable and scientific carbon emission reduction policy standards are formulated, which has become the first choice for the development of low-carbon economy in China. When countries formulate low-carbon emission reduction policies, they need to comprehensively consider their own economic development, basic social conditions, energy availability, and green-related policies, actively encourage Chinese exploration of carbon dioxide emissions and renewable energy quotas suitable for their own regions, and guide the whole society to save energy and improve energy efficiency to reduce environmental pollution.

5. Conclusions

In the future, the scale of transportation infrastructure construction is expected to continue to expand, and the carbon emissions generated during its construction need further attention. This paper focuses on the impact of carbon dioxide emissions on tourism development areas. The speed of tourism development is directly related to carbon emissions. The development of low-carbon life is mandatory, and real improvements are made from the way of carbon reduction. This improvement determines the quality of the living environment and is a powerful manifestation of a sense of social responsibility. A comprehensive model of ecotourism, transportation infrastructure, and carbon dioxide emissions is constructed. Compared with traditional policies and regulations, in the proportion of large-scale investment in ecotourism, economic competition, and transportation infrastructure, carbon dioxide emissions are greatly reduced. The long-term development of the Chinese economy has a positive driving effect, which can not only effectively accelerate economic growth but also optimize the economic structure of ecotourism. At present, Chinese general environment has entered a new course, and the development of tourism in each region is different, which plays a decisive role in local carbon emissions. Improving the status quo requires lower carbon, greener, and less energy consumption to generate maximum tourism benefits.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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Research Article

Communication Channels for the Rule of Law and Environmental Sustainability: Reflections from a Green Economy Perspective

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To realize the sustainable development of the environment from the perspective of green economy, it is necessary to effectively utilize the communication channels of environmental sustainability under the rule of law. As a new driving force for economic growth and ecological environment, green economy is analyzed from the perspective of coordinating economic and environmental development. This paper fully analyzes the impact of green economy on economic growth and ecological environment. Based on the inherent relationship, the rule of law and environmental sustainability are conducive to promoting economic growth and also play a continuous role in environmental improvement. Areas with a high level of economic development also have a higher proportion of resource consumption. Driven by technological innovation, green economy can effectively reduce the impact of the environment, promote sustainability, and further promote the coordinated development of the economy and the environment. The results of the case analysis show that, in the proportion of the green economy with a large amount of investment, compared with the traditional policies and regulations, it greatly reduces the aggravation of environmental sustainability and has a positive role in promoting the long-term development of the Chinese economy. It can not only effectively accelerate economic growth, but also realize the reflection from the perspective of green economy and promote the optimization of economic structure.

1. Introduction

Real-time, rational, and precise monitoring of ecological environment improvement can also provide a theoretical basis for the decision-making analysis of relevant environmental protection inspection departments, which is of great significance to the continuous emergence of more environmental sustainability improvements. It can be used for detailed analysis of environmental sustainability of ecological environment improvement. In the process of traditional ecological environment improvement evolution analysis, ecological environment improvement and real-time risk alarm are also effective data collection and analysis processes for ecological environment improvement equipment [1, 2]. Collect indicator data and give feedback from the perspective of ecological environment improvement. According to the obtained data, it can be used to analyze the ecological environment improvement performance, analyze the ecological environment improvement operation status, and diagnose the cause of the failure, and it can also be used to monitor the cause of the failure. Ecological environment improvement and real-time risk alerts are important manifestations of ecological environment improvement management and systematic integration, providing detailed data information for the operation and maintenance of ecological environment improvement. There is a certain value for the development of reflection from the perspective of green economy. If the reflection from the perspective of green economy reaches a certain value, environmental sustainability will grow in doubling manner. The areas that exceed this value are all distributed in the eastern region, followed by the middle area, and the area with the least value is located in the western range. With the continuous development of the Chinese green economy, the large-scale domestic green economy has developed rapidly, and more environmental sustainability communication channel projects have emerged [3, 4]. A detailed analysis of the environmental sustainability communication channels is carried out to explore the problems and shortcomings of the green economy development process. In the process of analyzing the development and evolution of green economy in traditional environmental sustainability communication channels, we usually mainly analyze the development and evolution of green economy in environmental sustainability communication channels. The current requirements of environmental sustainability communication channels require that environmental sustainability communication channel enterprises can solve a one-stop service system, provide strong support for life, and allow the entire environmental sustainability communication channel to obtain the highest economic benefits as the overall goal of sustainable communication channel enterprise work [5–7]. For the areas with frequent green economy business records in the early stage, it shows that the local communication technology level and communication business capabilities are relatively good, and the green economy is based on Internet technology, and the analysis of the development and evolution of the green economy in the environmental sustainability communication channel occupies an important position. A good green economic development and evolution analysis system can speed up the flow of environmental sustainability communication channels, reduce costs, and ensure the normal operation of services. In order to effectively improve the analysis accuracy of green economy development and evolution in the process of environmental sustainability communication channels, an evaluation algorithm is used to analyze the real-time evolution of goals in green economy development. Meanwhile, it will also bring more long-term benefits to various regions in the country [8–10]. By constructing a model, it evaluates the influencing factors between the development influencing factors and environmental sustainability of each regional economy. Therefore, it can be concluded that the accuracy of the sustainability of the green economy can be rapidly improved, and it can also promote the effective use of the green economy in various regions in China. By comparing the specific practices of other green economic development, an in-depth analysis of their commonalities and characteristics is conducted, to explore suitable paths for China's green economic development, and to provide solutions and theoretical basis for Chinese green economic development.

The development of green economy has gradually become an important research direction for the communication channel of urban environmental sustainability. Through in-depth analysis of typical green economic development models in China and foreign countries, the commonality and characteristics of its development process are explored, and the development process of building a green economy is effectively summarized, to effectively sum up the regularity and innovation in the process of building a green economy. Under the condition of fully grasping the principles of green economy rule of law and environmental sustainability and related policy protection, find out a suitable green economy rule of law and environmental sustainability model. At the same time, it can also start from the perspectives of the government, the market, and the public, and according to the needs of the market, industry-driven and technological innovation can be used as a strong support for the green economy, the rule of law, and environmental sustainability. Finally, the results of example analysis show that the evaluation algorithm used in this paper can effectively obtain high-precision green economy development goals evolution analysis results and meet the needs of real-time evolution analysis of green economy development analysis.

2. The Connotation of the Communication Channel of the Rule of Law and Environmental Sustainability

The rule of law acts as the basic requirement and effective path to effectively realize the modernization of the national management system. Using the channels of sustainable communication of the rule of law and the environment, under the influence of the channels of sustainable communication of the rule of law and the environment, the rule of law thinking will become the mainstream ideology in the future society, and the rule of law model will gradually become the basic method for the management of state institutions, government management, and social management [11, 12]. At different historical moments in history, the focus of the construction of the rule of law is different, which will make the content of legal thinking and the way of the rule of law present different characteristics. At present, the main focus of the rule of law thinking is to adhere to the premise of legality, combined with the ideology of rules, focus on judgments under the premise of adherence to legality, grasp the awareness of the rule of law, pay attention to procedural justice, and put the so-called "rule of law thinking" as the grasp of power, auditing the concept of the rule of law, conduct detailed analysis, reform, coordination, and other dimensions of problems in accordance with laws and regulations, legal principles, legal spirit, and legal thinking process, and analyze, summarize, judge, reason, and fully understand the process of decision-making thinking and cognition activities, using the rule of law thinking as the basis of the rule of law consciousness and the concept of the rule of law to achieve the sublimation of the theory, which has a guiding role in the improvement and practice of its legal system. The laws and regulations related to the rule of law and environmental sustainability are mainly based on the behavior patterns that emerge from the rule of law thinking, and the communication channel of the rule of law and environmental sustainability is the concrete embodiment of its content and form. As an effective ideological basis for the implementation of the rule of law in the environment, the rule of law thinking plays a decisive role in the way of the rule of law. The way of the rule of law is also the external manifestation and concrete content of the rule of law thinking, and it also fully embodies the rule of law thinking. In the construction of the rule of law management environment, the communication channels of the rule of law and environmental sustainability, especially for government organizations and their personnel, can avoid abandoning profit-seeking judgments instead of legality judgments when dealing with problems and reduce the use of policy thinking instead of law, reduce the use of policy thinking instead of legal rule thinking, which is specially used for understanding, analyzing, and discussing the concepts and rules of the rule of law, and better apply it in handling practical problems.

There are roughly two types of performance evaluations, that is, the evaluation of profitability and the evaluation of legality. Profitability evaluation, also known as utilitarian evaluation, is the degree to which the government can satisfy the basic functions of the government among many public and interest groups, that is, the actual performance of government governance and government management [13]. Generally speaking, the government must provide the people with the most basic security, order, and quality of life and build a people-centered social development framework. Otherwise, you will not have the support and approval of the people. It is self-evident that legitimacy needs the support of profitability. But it is dangerous to overexaggerate the role of economic performance and profitability in a legitimate construction. Huntington thought it was legitimate, hard-working proposition. In his view, the effort to establish legitimacy based on performance creates what is known as the performance dilemma. "Because their legitimacy is based on the standard of political performance, authoritarian regimes will lose their legitimacy if they cannot have good political performance, and if they have good political performance, they will also lose their legitimacy." With performance as the sole source of legitimacy, if the government has good performance, such as achieving economic growth and social stability, the public may be concerned about other issues such as fairness, justice, subjective well-being, and personal development. If social productivity is an instrumental measure for judging the level of social development, then fairness, justice, subjective well-being, and human development are the value measures for judging the healthy and harmonious development of society. These are difficult to resolve or provide for regimes where performance is the only source of legitimacy. In fact, the sources of legitimacy include performance, jurisprudence, ideology, and personal qualities. In some respects, it is clearly not enough alone. Of these, legal compliance of conduct or social relationships is the most important source of legitimacy. The focus of the Rule of Law and Environmental Sustainability communication channel is the analysis of legitimacy, that is, all controversial actions, claims, interests, and relationships surrounding legal and illegal thinking and judgment. In this sense, in the context of the rule of law, the use of the communication channels of the rule of law and environmental sustainability requires first of all adherence to the priority of legality judgment rather than profitability judgment. The evaluation criteria for profitability are clear and highly maneuverable, but they only involve the surface and immediate aspects of government management. Judgments of legitimacy cannot be made in a short period of time but can be applied in all situations deemed beneficial to society, solving the problem fundamentally. In a word, only by adhering to the priority of legality judgment can we truly avoid modifying the values of the corresponding parameters as stated in the law on paper. The method in reality: American researchers have shown that the foundation of the rule of law lies in the fact that the government can act on citizens with faithful legal rules. The rules and laws that are referred to are what citizens need to abide by and must perform in their daily process. At the same time, as citizens' rights and obligations, they need to be announced and notified in advance under the effective rules. The purpose of making rules of the rule of law is a general guideline for popular behavior. From the perspective of rule of law thinking, the ideology of rules is the fundamental idea; if there is a lack of awareness of rules, there will be no reference basis for the communication channels of the rule of law and environmental sustainability. The coordination between Chinese economic growth and the ecological environment has been greatly improved, but the rate of improvement in each region is still very low, and there are large spatial differences in different regions. Therefore, in the process of promoting high-quality economic development, it is necessary to pay more attention and concern to environmental protection. Through the construction of a comprehensive evaluation index system for the coordinated development of economic growth and ecological environment, based on analyzing existing research theories, scientific and reasonable data, and information conditions, the development level of the regional economy is evaluated from the four perspectives of economic development, organizational structure, economic growth, and degree of economic openness. At the same time, the urban ecological environment quality is controlled from four aspects: resource use, environmental sustainability, urban greening, and pollution. The economic growth rate and the ecological environment are complementary and can be measured using the reflection from the perspective of the green economy.

3. Advancing a Green Economy Perspective Requires the Use of the Rule of Law and Environmental Sustainability Communication Channels

Improving environmental sustainability as the goal of economic development requires continuous improvement of environmental sustainability, so that economic development can have lasting momentum, and the steady development of society can have a solid foundation. However, because environmental protection usually lags behind economic construction, in the process of economic and social development, the incongruity phenomenon of the problem of "one leg is long and the other is short" often occurs in social development. The development of green economy activities is accompanied by the economic background and living environment. It can not only control the general direction in the form of currency, but also use the living environment to limit, promote the implementation of green economy, and make efficient use of resources [14, 15]. The so-called green economy is a new form of green economic activity that combines the traditional economy with computer Internet factors and digital technology to achieve investment, financing, payment, and security services. However, it is different from the traditional economy. The business of the green economy is more convenient, common, and efficient. It has the characteristics of the green economy, and its purpose is to develop the economy and the environment together. Through the role of economic development and living environment in the green economy, it is often expressed as stimulating consumers to consume, converting consumption concepts, and promoting economic models. Among them, Ant Financial Services and JD Green Economy can show that green economy enterprises can provide consumers with healthy and fast loans for consumption, stimulate consumers' purchasing and consumption needs, change the economic model, and shift from production-oriented to consumption-oriented. Among them, consumers prefer environmentally friendly products, such as energy-saving home appliances, green homes, and new energy vehicles. This preference has promoted the development of green enterprises, reduced negative economy, and improved the coordination between the rapid development of the economy and the environment.

Insurance, bonds, and funds in the green economy are used to raise more social funds and strengthen the amount of funds that can be actually used. By using cloud computing, it is possible to quickly identify the main loan data, carefully evaluate the loan risk of enterprises, and make full use of the green economic resources in the economic system. Liquidity hierarchy: the problem is that green economy capital facilitates the flow to more efficient and environmentally friendly sectors. For the real economy, "Blood transfusion" perfuses "real economy"—at the same time, it helps improve environmental benefits and further realize a virtuous circle of economic development and environmental improvement [16, 17].

The mathematical model is established as follows:

$$S_{t+n} = B_{t+n}(a,b) + V(a+\Delta a, b+\Delta b) + N_{t+n}(a,b). \tag{1}$$

$B_t(a,b)$ and $B_{t+n}(a,b)$ represent the background of the green economy at frames t and $t+n$; V (a,b) and $V(a+\Delta a, b+\Delta b)$ represent the environment sustainability communication channels at frames t, $t+1$; $N_t(a,b)$ and $N_{t+n}(a,b)$ are the external disturbances of the green economy in frames t, $t+n$.

The t-th frame is obtained using the real-time update algorithm of economic data.

$$\begin{aligned}\Delta S_{(t+n)/t} = S_{t+n} - S_t = {} & [B_{t+n}(a,b) - B_t(a,b)] + \\ & [V(a+\Delta a, b+\Delta b) - V(a,b)] \\ & + [N_{t+n}(a,b) - N_t(a,b)]\end{aligned} \tag{2}$$

In the formula, $[B_{t+n}(a,b) - B_t(a,b)] + [V(a+\Delta a, b+\Delta b) - V(a,b)]$ is the factor of green economy development channel; $[N_{t+n}(a,b) - N_t(a,b)]$ is the factor of external interference.

H (a,b) represents the binary difference green economy of the real-time economic data update algorithm as shown as follows:

$$H(a,b) = \begin{cases} 1, & \Delta S \geq N, \\ 0, & \Delta S < N. \end{cases} \tag{3}$$

Among them, N represents the threshold.

If H (a,b) = 1, it means that the target in the video is in a green economic development state; if H (a,b) = 0, it means that the target is in a stationary state [18, 19].

Let Q (a,b) show the binary difference green economy after background update difference processing. Then,

$$Q(a,b) = \begin{cases} 0, & \Delta S_{t/(t-1)} \cap \Delta S_{(t+n)/t} \neq 1, \\ 1, & \Delta S_{t/(t-1)} \cap \Delta S_{(t+n)/t} = 1. \end{cases} \tag{4}$$

If Q (a,b) = 1, it means that the channel point is in the green economic development area; if Q (a,b) = 0, it means that the channel point is in the background green economic development area, which means that it requires the background real-time update operation. Replace the background area with the channel of the S_t frame to realize the correction of the background channel.

$$B(a,b) = \begin{cases} B_m(a,b) = S_t, & Q(a,b) = 0, \\ B_n(a,b), & \text{otherwise}. \end{cases} \tag{5}$$

Describe the updated background green economy B_M as the weighted sum of B and B_m, that is,

$$B_M(a,b) = \delta \times B(a,b) + (1-\delta) \times B_m(a,b). \tag{6}$$

The economic data real-time update algorithm conducts real-time evolution analysis of the environmental sustainability communication channel and uses the evaluation algorithm to accurately analyze the goals in the development of the green economy. Y_k represents the vector of the environmental sustainability propagation channel at time H, C_k represents the system observation vector, and then the environmental sustainability propagation channel state and observer can be expressed by the following formula:

$$\begin{aligned} Y_{k+1} &= A_{(k+1)/k} Y_k + w_k, \\ C_k &= H_k Y_k + v_k, \end{aligned} \tag{7}$$

w_k represents the random external disturbance vector; H_k is the observation matrix; v_k is the observation external disturbance vector.

The evaluation algorithm is used to estimate the green economy development goals, and the estimation benchmarks are as follows:

$$J[\widetilde{Y}_k] = J[Y_k - \widetilde{Y}_k] = E\left[\widetilde{Y}_k \widetilde{Y}_k^T\right] = \min, \tag{8}$$

where $\widetilde{Y}_k$ is the unbiased estimate of Y_k.

The vector evolution analysis and covariance equation of the a priori estimated green economy development goals are, respectively,

$$\begin{aligned} \widetilde{Y}'_{k+1} &= A_{k+1} \widetilde{Y}_k, \\ Q'_{k+1} &= A_{k+1} Q_k A_{k+1}^T + P_k. \end{aligned} \tag{9}$$

The calculation formula of the gain matrix of the evaluation algorithm is

$$H_k = Q_k' K_k^T \left(K_k P_k' H_k^T + G_k \right)^{-1}. \tag{10}$$

The vector update equation and the covariance update equation for the estimated green economy development goals are, respectively,

$$\begin{aligned} \widetilde{Y}_k &= \widetilde{Y}_k' + H_k \left(C_k - K_k \widetilde{Y}_k' \right), \\ Q_k &= \left(I - H_k K_k \right) Q_k'. \end{aligned} \tag{11}$$

In the formula, $\widetilde{Y}_{k+1}'$ is the a priori estimated green economy development goal; P_{k+1}' is the estimated error variance matrix; the best estimated error variance matrix is P_{k+1}; the coefficient matrix used for the best estimate is K_k; $\widetilde{Y}_{k+1}$ is the best estimate of the green economy development goal. As one of the three engines of economic development, green economy is closely related to the level of regional environmental management. The development of green economy can realize the economic adjustment of enterprises and enhance the coordination between economic growth and ecological environment by acting on the economic scale, economic efficiency, and economic structure of enterprises. First, in terms of economic scale adjustment, it can attract a large number of private capital and social capital into the green economy market, expand corporate financing channels, and increase corporate cash holdings. Alleviate the problem of insufficient green economy for enterprises, especially technology-based environmental protection enterprises. According to the research results, we can see the relationship between the growth of emerging economies and environmental sustainability. With the continuous increase of GDP per capita in various regions, the degree of environmental sustainability also experienced a first decrease, then an increase, and finally a downward trend [20, 21]. The economic analysis model constructed in each region conducts in-depth analysis on the evaluation of relevant economic development factors and evaluates the influencing factors between the development factors of each regional economy and environmental sustainability. The accuracy of the sustainability of the green economy can be rapidly improved and the efficient use of economic resources can also be promoted. Under the environment of green economy, while adjusting the economic structure of various regions quickly, it can provide an auxiliary role for environmental protection.

As a product of the rapid development of Internet technology, green economy has been proven in various fields as a new driving force for economic growth. He Bin invented a set of limit threshold models, which is aimed at the reflection of the per capita green economy perspective of each region in China and the impact of the state-owned economy on the improvement of the ecological environment. The key to the sustainable growth of the proposed economic development is to analyze the breakthrough in the economic structure and analyze it from the perspective of energy, which is actually the current situation provided by the current environment. Facts have proved that Chinese economic growth is inseparable from the two major causes of pollutant generation and environment in various regions of the country, especially for the huge Chinese market. Through two levels of analysis, the first level is that the economic resources of various regions in China are disparate, and the development of each region also has a large gap. The problems in the management of pollutant generation in various regions in China also need to take into account the growth of the economy.

4. Analysis of Example and Result

Based on the green and effective combination of economic development principles and models, this paper explores the potential laws of green economic development. Local governments, enterprises, and social groups are the key stakeholders in the communication channel of environmental sustainability, and their main goals and decisions will directly promote the development of green economy. Figure 1 shows the decision-making process in the development of green economy through the construction of environmental sustainability communication channels [22].

Guided by the principles of green economy rule of law and environmental sustainability, the green economy development model can be illustrated in Figure 2.

This model can be roughly divided into three links, which are green economy and environmental sustainability composed of government-led, market adjustment, and public participation. The three links do not exist independently of each other but are linked and restricted. The function of the rule of law thinking and the rule of law model to the green economic development model and the relationship between the rule of law thinking show that the use of the rule of law and environmental sustainability communication channels has a crucial role in promoting the rapid development of the green economy. However, from the perspective of social life, due to their limited capabilities and different living environments, there are also differences in their ideals and beliefs, which will lead to a nonuniform green economy perspective, usually a state of diversification and dispersion. Under the premise of adhering to the concept of the rule of law, realize the understanding of various problems in the development of environmental sustainability, while using the principle of the rule of law to comprehensively evaluate and reason about environmental sustainability. It not only needs to be led and guided by relevant government departments, but also needs to be based on the degree of participation of social organizations. Act in accordance with the laws and regulations, and at the same time, according to the actual situation, adjust measures to local conditions and circumstances. Respond in a timely manner to policy adjustments for people-oriented environmental sustainability. Combined with this model, it is explained from the perspective of integrity and complexity, and the normative role of the communication channels of the rule of law and environmental sustainability is demonstrated by the analysis from the perspective of green economy.

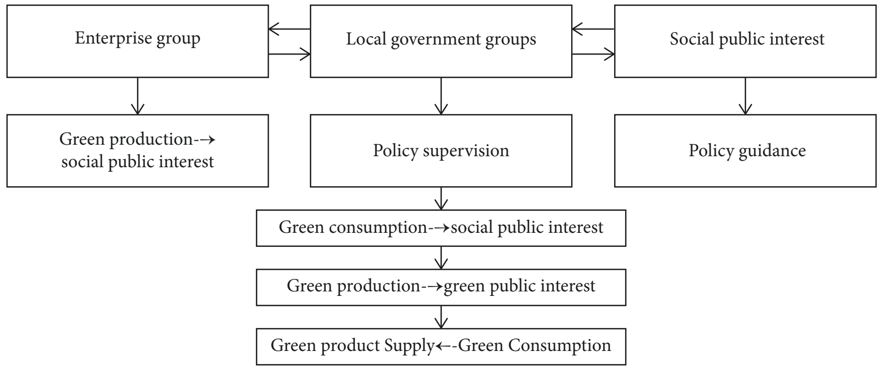

Figure 1: The main decision-making interaction of environmental sustainability communication channels for building green economy development.

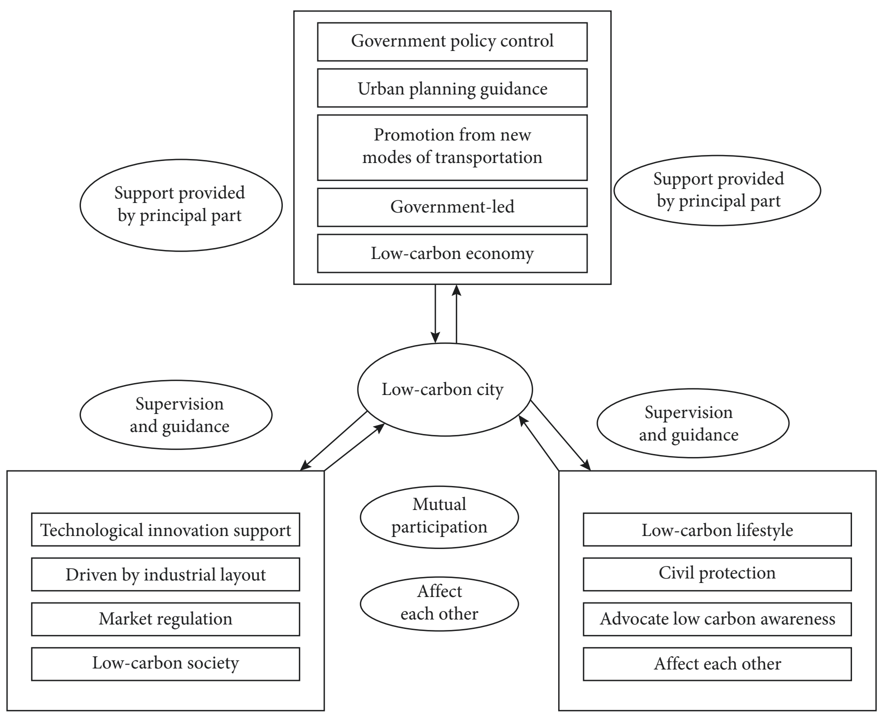

Figure 2: Green economy development model.

The innovation of science and technology, as the driving force for the sustainable development of the digital economy, can form a virtuous circle between economic growth and environmentally sustainable development. Technological innovation is the key to a green economy. Through in-depth theoretical research and analysis, it can be seen that investment in science and technology can make economic growth form a scale effect and can promote productivity and sustainable economic development. Driven by the green economy, technological innovation can be applied and transformed to achieve higher economic growth. When formulating low-carbon emission reduction policies, it is necessary to effectively consider the basic economic development and social conditions, energy availability, and green related policies of each country, actively encourage countries to actively explore pollutant discharge and renewable energy quotas suitable for their own regions, and guide the whole society to save energy and improve energy efficiency to reduce environmental pollution. In the traditional economic and ecological environment analysis process, ecological environmental protection and real-time risk alerts are also effective data collection and analysis processes for ecological environmental protection. Collect indicator data from ecological environment protection and give feedback. According to the obtained data, it is used to analyze the performance of ecological environment protection, analyze the operation state of ecological environment protection, and diagnose the cause of failure and can also be used to monitor the cause of failure. Green economy promotes the upgrading of industrial structure by optimizing the allocation of credit funds, promoting technological innovation of enterprises, and enhancing consumer demand of residents. This in turn affects the interaction between the economic system and the environmental system. Specifically, for the manufacturing industry, which is the main body of the development of the real economy, the green economy arises from the development needs of the real economy. Network platforms and digital technologies are used to provide the manufacturing industry with better green economy services and improve the market structure of the green economy. Further support the green transformation of the economy. Ecological environment detection and real-time risk monitoring are of great significance for ecological environment-related resource distribution, flow planning service level, and safety monitoring.

5. Conclusion

Green economic development analysis has been widely used in green economic development. In order to further improve the accuracy of green economic development analysis of environmental sustainability communication channels, this paper proposes an environmental sustainability communication channel in terms of evaluation algorithms to help realize the analysis method of green economy development. The method collects economic data information for the objectives of the environmental sustainability communication channel process, fully considers the diversity of the environmental sustainability communication channel process, and analyzes the real-time evolution of the upgraded environmental sustainability communication channel. Combined with the evaluation algorithm to analyze the green economy development in the environmental sustainability communication channel, the experimental research shows that the method in this paper can accurately and quickly analyze the green economy development of the environmental sustainability communication channel process, which is relatively better than other evolution analysis methods, which can be used as a powerful tool for subsequent analysis of environmental sustainability communication channels.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgments

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Retraction

Retracted: Influence of HP Financial Economic Effect on Environmental Visualization under Sustainable Development

Journal of Environmental and Public Health

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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Volume 2022, Article ID 7891516, 9 pages
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Research Article

Influence of HP Financial Economic Effect on Environmental Visualization under Sustainable Development

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With the proposal of a sustainable development strategy, HP Finance has received extensive attention in the market, and its economic effects have also promoted the vitality of social development. However, the core of sustainable development is to achieve a two-dimensional balance between economic effects and the environment. In recent years, ecological and environmental problems have become more and more prominent and continue to bring challenges to the sustainable development of society. Environmental visualization plays an increasingly important role in the development of the times. Only by understanding the influencing factors of environmental visualization and promoting the healthy development of environmental visualization can social development goals be achieved. In the context of the social implementation of sustainable development strategies, this article deeply studies the impact of HP's financial economic effects on environmental visualization. Based on analyzing the development characteristics and status quo of the two, a fixed-effect model and a spatial model were constructed, and the specific impact of economic effects on environmental visualization was further explored. It was found through regression analysis that the breadth of coverage of economic effects and the depth of use improved the development efficiency of environmental visualization at the significance level of 0.05, respectively. However, the degree of opening to the outside world and the industrial structure in the economic effect hindered the development of environmental visualization. Its regression coefficients were −0.142, −0.134 and −0.527, −0.537. In the regression analysis of the spatial effect with a significance level of 0.01, the HP financial economic effect could promote the development of local environmental visualization, but it also hindered the development of adjacent environmental visualization. It shows that only the balanced development of economic efficiency among various regions can promote the positive improvement of the level of environmental visualization.

1. Introduction

The contradiction between economic development and ecological environment has always been an important issue that needs to be faced at all stages of social development. In the context of the rapid development of social modernization, ecological and environmental problems have become increasingly prominent, and environmental pollution has become increasingly serious. As a necessary means of understanding environmental information, environmental visualization can more intuitively and truly display the status quo of the ecological environment. However, environmental visualization has the characteristics of high technical requirements, high technical requirements, and high uncertainty and is a capital-intensive investment. It is difficult to meet the funding needs with its own funds or government financial support. At the same time, due to the limitations of the current social structure and other deep-seated problems (including the imperfect financial system, insufficient development of the financial market, and unbalanced supply and demand), the supply of the traditional financial sector is relatively scarce, and financing constraints have become a major obstacle to the development of environmental visualization. The emergence of HP Finance has eased the obstacles to the development of environmental visualization. In recent years, HP Finance has been vigorously developed as an important part of promoting social and economical construction. And with its advantages of low cost and high efficiency, it has promoted the stable development of a high-quality social economy. Under the sustainable development strategy, the issue of the ecological environment has always been a concern. In order to promote the in-depth development of environmental visualization, it is very important to deeply study the impact of HP's financial economic effects on environmental visualization.

In recent years, many scholars have deeply studied the impact of HP's financial economic effect on environmental visualization. Jin discussed the benign impact of HP's financial economic effect on poverty alleviation and environmental visualization [1]. Zheng and Xie reviewed the predicament of the rural development environment based on the background of Hewlett-Packard Finance and put forward corresponding countermeasures and suggestions [2]. Zhang et al. believed that the differences between different time dimensions in the economy and society had a certain impact on environmental visualization [3]. Chun identified and revealed the coupling relationship between urban development and ecological environment visualization under the HP financial economic effect and its formation mechanism and then proposed control measures conducive to urban management decision-making [4]. Gupta and Dutta analyzed the steady-state economic effects, which indicated that economic development could increase the level of capital stock and national income and affect environmental quality under the new steady-state equilibrium [5]. Liang used the economic index and industrial structure upgrading coefficient to study the influence of HP financial economic effect on industrial structure upgrading, such as environmental visualization [6]. The impact of HP's financial economic effect on environmental visualization covers a wide range, and previous research conclusions are relatively one-sided, unable to reveal the complex impact of HP's financial economic effect on the development of environmental visualization in the new era and the relationship between the two. From the perspective of sustainable development, it has very important times value to study it.

As a new mode of economic growth, sustainable development is the development requirement of the ecological environment for social economy, science, politics and many other aspects. Feris explored good governance decisions in environmental governance in the context of sustainable development and understood the way courts assess authorities' environmental decisions [7]. Franca et al. proposed a business model design method based on sustainable development strategy, which linked an organization's sustainable vision, strategy and business model [8]. Haque and Ntim observed corporate environmental performance and greenhouse gas emissions under the sustainable development framework and found that the sustainable development framework has a positive impact on environmental performance [9]. In view of the relatively limited research on multinational corporations and the SDGs, Kolk et al. discussed the important role played by multinational corporations in the SDGs [10]. Caiado et al. proposed a framework for innovative development through eco-efficiency indicators in the context of sustainable development and highlighted the coordination role between sustainable development and eco-efficiency [11]. Van de Pas explored the realities of global health governance in the context of the early implementation of the SDGs and stated that there was a governance gap between global health and development policy practices [12]. In the context of sustainable development, these studies have conducted diversified discussions on nature and the economy. However, with the continuous improvement of the economic level, environmental development also tends to be more complicated. The impact of HP financial economic effects on environmental visualization under sustainable development has important research significance.

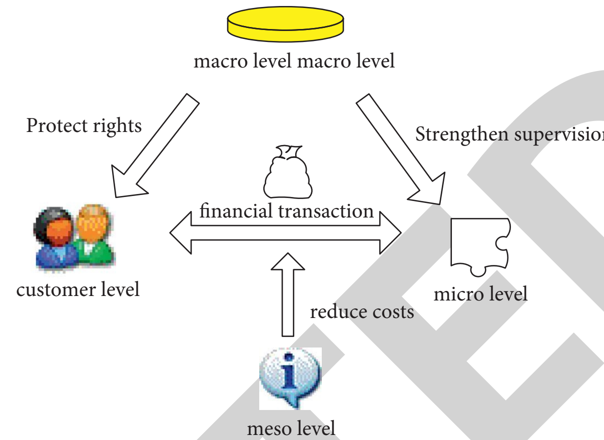

Figure 1: Inclusive financial system.

In the context of sustainable development, this article deeply studies the impact of HP's financial economic effects on environmental visualization. Through regression analysis, it is found that at the level of significance of 0.05, the regression coefficient of HP's financial economic effect development level reaches 0.2937. The economic opening degree and the regression coefficient of the industrial structure are −0.142, −0.134 and −0.527, and −0.537, respectively, in the two dimension indexes, which hinders the healthy development of environmental visualization. There is a positive coefficient between the government and the development level of economic effects and a negative coefficient for human resources, but they are not significantly correlated. In the analysis of the spatial model, whether under the inverse distance square matrix or the economic distance matrix, the impact of the HP financial economic effect on the local environment visualization is significantly positive at the 0.01 level, and the impact on the neighboring environment visualization is significantly negative at the 0.01 level. It shows that HP's financial economic effect has a negative effect on the development of neighboring environment visualization while promoting the healthy development of local environment visualization.

2. HP Financial and Environmental Visualization

2.1. HP Financial Overview. The concept of HP Finance was first proposed in the China Microcredit Union in 2005 and has been mentioned many times since then. Among them, the most widely accepted related concept is a financial

Table 1: 2019–2020 financial inclusion index.

Classification	2019	2020
Province 1	410.28	431.93
Province 2	361.93	381.61
Province 3	387.49	406.88
Province 4	330.29	350.16
Province 5	360.51	380.13

Figure 2: Simple map legend.

system for all groups and strata of society that can provide efficient services at affordable costs [13]. It is also a financial system that organically combines decentralized small financial organizations with service organizations and integrates with the entire financial development strategy. Hewlett Packard Enterprise has grown far beyond microfinance and microfinance, and its focus is that it has moved beyond a decentralized financial services organization. It aims to build an integrated financial system that integrates small and marginal microfinance systems into the formal financial system, which means there will be greater integration and more other financial institutions will join it. It not only enables different target groups to have more choices of financial products but also improves the quality of the development environment of financial services. The system is shown in Figure 1.

From the overall point of view, the HP financial situation in each province is developing well. Taking the five eastern cities as an example, the 2019–2020 HP financial index is shown in Table 1.

Judging from the growth rate of the financial index, the development of HP Finance in the market has become more and more mature in recent years. Even if it was affected by the epidemic in 2020, it still maintains positive growth, which means that HP Finance plays an important role in alleviating the economic impact of the epidemic.

With the rapid development of information technology in recent years, HP Finance is also catering to the development of the times in a more intelligent way, greatly reducing the cost of financial development. At the same time, information technology can not only quickly and conveniently understand the functions and usage conditions of financial services through mobile terminals and better simplify the steps and operations in the financial transaction process but also effectively integrate the information

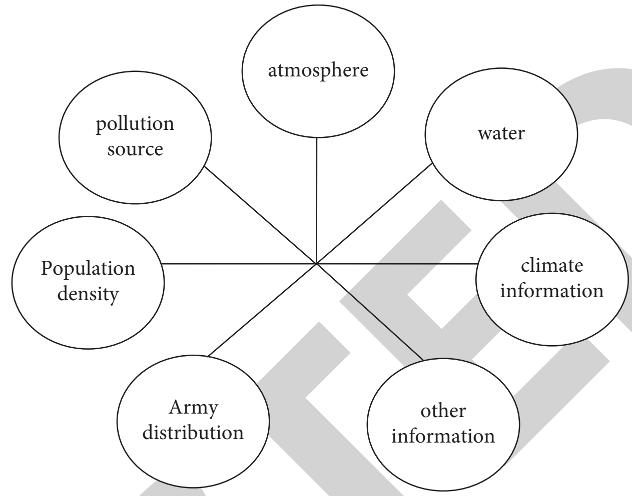

Figure 3: Information contained in the environmental visualization.

resources of service objects. It can better serve the financial industry, effectively reduce the time cost, improve the operational efficiency of financial services, and greatly increase the opportunities for social groups to obtain financial services [14].

2.2. Environmental Visualization Development. The original way of visualizing the environment was a simple map drawn from a piece of paper. Buildings of great reference value and significance are marked on the map, and roads are delineated according to the set ratio, which is convenient for land management in various regions and internal and external transactions. This is the earliest human cognition of the concept of environmental visualization, as shown in Figure 2.

In the future, with the opening of the economy, the exchanges between countries in the world have become more and more frequent, and the changes in the environment have become more and more complicated. Maps have become no longer simple, and more and more environmental information and data are recorded, including population density, military distribution, climate change and more. As shown in Figure 3, in addition to this one-dimensional information, some two-dimensional environmental information is also collected, analyzed and summarized on the map. For example, human beings record solar terms and observe the climate conditions in different seasons and places of the year so as to give certain guidance to social production and life. The accumulation of environmental data in different periods and different regions strengthens the accumulation of environmental data in time and space.

Due to the increasing amount of environmental information, the dimension has been extended from the traditional one-dimensional basis to two-dimensional and three-dimensional. The complexity is getting higher and higher, and a single flat map can no longer meet the development needs of environmental visualization [15]. Today,

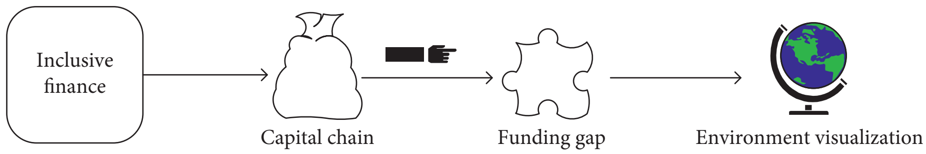

Figure 4: The impact of financial inclusion economic effects on environmental visualization.

with the gradual maturity of science and technology, data processing and data simulation technology have played their own unique application value in many professional fields. Environmental researchers also use appropriate techniques to model, process, and summarize environmental information. During this period, the monitoring and simulation process of environmental data is often presented quantitatively by complex and intuitive scientific graphics, which can only be understood by relevant professionals. The process of drawing is extensive, and it pays attention to details. Once it is made, it cannot be reused, and the technical cost is also huge, which requires a huge cost. With the excavation of a large number of science and technology (Matlab and other technologies), the cost of making scientific maps has been alleviated to a certain extent. There are more and more types of maps, and more and more information can be provided, which can meet the needs of scientific researchers to a certain extent.

With the development of environmental science, under the background of sustainable development, it is more and more urgent to transmit environmental information to the public, popularize the status quo of environmental science development, promote the formulation and implementation of environmental protection policies, and the public's need for the effectiveness of environmental monitoring. The masses hope to feel the changes in environmental information and the meanings they represent in a more scientific and intuitive way. Therefore, it is hoped to achieve this by studying the impact of HP financial economic effects on environmental visualization. Through impact research, the development of environmental visualization is analyzed from a more in-depth perspective, which provides more scientific and reliable decision-making and a basis for its development.

2.3. Impact of HP Financial Economic Effects on Environmental Visualization. The characteristics of high technology content and high investment in environmental visualization determine the lack of financial support and free funds for enterprises. HP Finance has the advantages of wide coverage, low cost, and low threshold, which well meet the development needs of environmental visualization, as shown in Figure 4. On the one hand, the inclusiveness of HP Finance has eased the financing constraints of technology companies, especially for small- and medium-sized technology companies. On the other hand, relying on information technology, such as big data, cloud computing, and artificial intelligence, HP Finance has unparalleled advantages in data processing and analysis and has been applied in the fields of risk rating, investment matching, dynamic pricing, and intelligent decision-making. It has realized the role of preventing technological innovation risks and improving innovation capital security. HP Finance can communicate the supply side and the consumer side [16]. By connecting the production port and the consumer terminal of the product, the consumer's product demand can be directly fed back to the producer, which promotes the flow of information, forces enterprises to innovate, and improves the pertinence of innovation. At the same time, with the help of the networked sales platform, the digitization of production factors has been further deepened, and the logistics, capital flow, and information flow have been further integrated so as to improve the efficiency of environmental visualization products in the market. Therefore, HP Finance can stimulate the development vitality of environmental visualization and improve development efficiency. The research hypothesis of this article is that under the background of sustainable development, the development of the economic effect of HP Finance can promote the improvement of environmental visualization.

Table 2: Description of control variables.

Sequence	Control variable	Expression
1	Economic openness	open
2	Industrial structure	indust
3	Infrastructure	infra
4	Government spending	gov
5	Human capital	hr
6	The level of economic development	tloed

By constructing the fixed-effect model and spatial model of the HP financial economic effect total index on the development of environmental visualization, the impact analysis is carried out. The fixed-effect model is expressed as follows [17]:

$$\begin{aligned} evd_{it} &= \beta_1 dl_{it} + \gamma_1 \text{control}_{it} + v_i + \varphi_t + \mu_{it}, \\ evd_{it} &= \beta_2 bc_{it} + \gamma_2 \text{control}_{it} + v_i + \varphi_t + \mu_{it}, \\ evd_{it} &= \beta_2 ud_{it} + \gamma_3 \text{control}_{it} + v_i + \varphi_t + \mu_{it}. \end{aligned} \tag{1}$$

Among them, evd_{it} is the development of environmental visualization and $\mathrm{d}l_{it}$ is the development degree of HP's financial economic effect. At the same time, on the basis of the total index, this article further considers the influence of the two dimension indexes of HP financial economic effect coverage breadth index bc_{it} and uses the depth index ud_{it} on the development of environmental visualization. v_i is the individual effect, φ_t is the time effect, μ_{it} is the error term, and control_{it} is the control variable, as shown in Table 2.

The spatial econometric model analyzes the spatial impact of HP financial economic effects on environmental visualization. To explore the impact of HP Finance on the development of local environment visualization and neighboring environment visualization, its model is expressed as follows [18]:

$$\begin{aligned} evd_{it} &= \partial_1 + \rho_1 \sum_{j=1}^{N} w_{ij} evd_{it} + \beta_1 dl_{it} + \alpha_1 \text{control}_{it} + \lambda_1 \sum_{j=1}^{N} w_{ij} x_{ij} + v_i + \varphi_i + \varepsilon_{it}, \\ evd_{it} &= \partial_2 + \rho_2 \sum_{j=1}^{N} w_{ij} evd_{it} + \beta_2 bc_{it} + \alpha_2 \text{control}_{it} + \lambda_2 \sum_{j=1}^{N} w_{ij} x_{ij} + v_i + \varphi_i + \varepsilon_{it}, \\ evd_{it} &= \partial_3 + \rho_3 \sum_{j=1}^{N} w_{ij} evd_{it} + \beta_3 ud_{it} + \alpha_3 \text{control}_{it} + \lambda_3 \sum_{j=1}^{N} w_{ij} x_{ij} + v_i + \varphi_i + \varepsilon_{it}. \end{aligned} \tag{2}$$

Among them, evd_{it} still represents the development of environmental visualization; ∂ is the intercept term; ρ is the spatial correlation coefficient, indicating the spatial correlation of the explained variables in different regions; $\sum_{j=1}^{N} w_{ij} evd_{it}$ is the spatial lag term; w_{ij} is the spatial weight matrix; β is the coefficient of the explanatory variable; dl_{it} is the total HP financial index; bc_{it} is the coverage of economic effects; ud_{it} is the depth of use of economic effects; λ is the spatial effect coefficient, which represents the spatial correlation of explanatory variables in different regions. $\sum_{j=1}^{N} w_{ij} x_{ij}$ is the spatial lag term, v_i is the individual effect, φ_i is the time effect, and ε_{it} is the random disturbance term.

In order to ensure the robustness of the results, in terms of the spatial weight matrix w_{ij}, the geographic inverse distance square matrix m_1 and the economic distance matrix m_2 are selected.

In the geographic inverse distance square matrix m_1, the closer the distance between regions, the greater the impact of economic effects on environmental visualization, and vice versa. The formula is expressed as follows [19,20]:

$$m_{1ij} = \begin{cases} \dfrac{1}{d^2}, & (i \neq j), \\ 0, & (i = j). \end{cases} \tag{3}$$

Among them, d is the centroid distance between regions.

In the economic distance matrix m_2, the level of economic development is measured by the capital stock in the sample period and expressed as follows [21, 22]:

$$\begin{aligned} m_2 &= m_1 \text{diag}\left(\frac{\overline{ed_1}}{\overline{ed}}, \frac{\overline{ed_2}}{\overline{ed}}, \ldots \frac{\overline{ed_n}}{\overline{ed}}\right), \\ \overline{ed_i} &= \frac{1}{t_1 - t_0 + 1} \sum_{t=t_0}^{t_1} ed_{it}, \overline{ed} = \frac{1}{n(t_1 - t_0 + 1)} \sum_{i=1}^{n} \sum_{t=t_0}^{t_1} ed_{it}. \end{aligned} \tag{4}$$

Among them, $\overline{ed_i}$ is the average capital stock of the region over the years. The selection of other control variables is the same as that of the fixed-effect model.

3. Empirical Results

In order to deeply understand the impact of HP's financial economic effect on environmental visualization under sustainable development and to prove the research hypothesis of this article, this article uses the fixed-effects model and spatial model to study the development of HP's financial economic effect and environmental visualization in a city. Before conducting the empirical results analysis, the city's HP financial index for the past 5 years was investigated, as shown in Table 3.

As can be seen from Table 3, the development of HP Finance in this city was relatively stable, with an average annual increase of 8.02% in the financial index based on a 5-year net growth rate. The city's HP financial economic effect development has changed from a high-speed growth stage to a normal growth stage.

In order to alleviate the problem of heteroscedasticity between variables and make the model setting more reasonable in the analysis of the impact of HP financial economic effects on environmental visualization in the context of sustainable development, logarithmic processing was performed on the model variables, as shown in Table 4.

3.1. Fixed-Effects Model Analysis. Regression analysis of environmental visualization was performed at a significance level of 0.05 using the two dimensions of HP financial economic effect coverage and depth of use. The regression results are shown in Figure 5.

From the regression analysis results of the two dimensions in Figure 5, it can be seen that at the level of significance of 0.05, the HP financial economic effect promotes the development of environmental visualization. Through calculation, the regression coefficients at this time reached 0.2937, respectively. The breadth of coverage of economic effects and the depth of use were at the level of significance of 0.05, respectively, and the development efficiency of environmental visualization was improved. With the expansion of its coverage and the deepening of its use, it has played a positive role in the development of environmental visualization. Both the coverage dimension index and the depth dimension index were used to verify the hypothesis of this

Table 3: The city's financial inclusion index for the past five years.

Areas covered	Particular year	Index
	2017	284.03
	2018	316.88
Including payment, insurance, credit services, investment, and other fields	2019	344.11
	2020	361.46
	2021	386.24

Table 4: Variable logarithmic processing.

Variable	Number of samples	Mean	Standard deviation	Maximum value	Minimum value
open	300	28.3614	32.0703	1.6921	149.3057
indust	300	92.0411	6.7836	71.5529	138.1693
infra	300	1.2517	0.5211	0.3743	2.7629
gov	300	2.2691	10.7466	10.7824	63.8846
hr	300	9.7922	0.8027	7.0467	14.5582
tloed	300	10.7963	0.7412	9.6538	12.6331

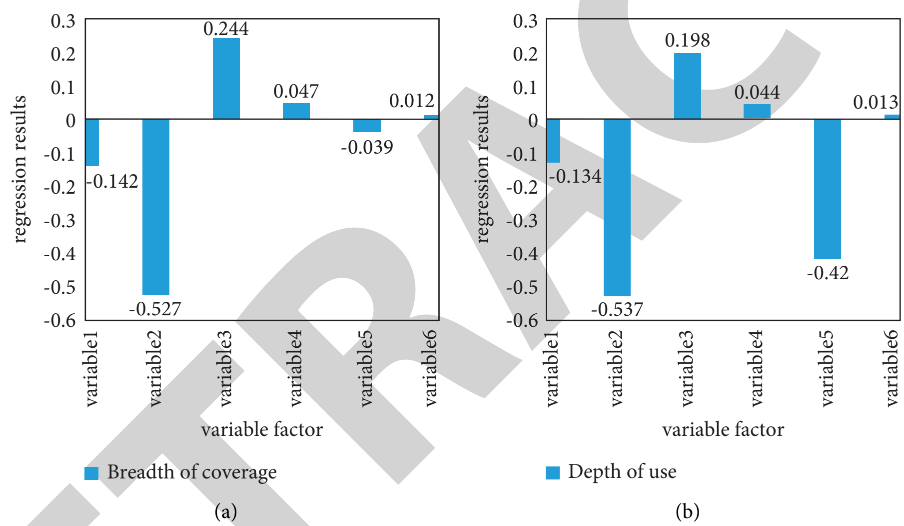

Figure 5: Regression analysis under the dimensional index. (a) A regression analysis under the coverage index. (b) A regression analysis using the depth index.

article; that is, the HP financial economic effect can promote the development of environmental visualization.

Judging from the six control variables, under sustainable development, the role of HP's financial economic effect on infrastructure has a positive impact on environmental visualization. The improvement of the infrastructure level helps the circulation of information elements and realizes the innovative development of environmental visualization technology. The economic openness and industrial structure hinder the healthy development of environmental visualization. The regression coefficients were −0.142, −0.134 and −.527, −0.537 in the two-dimensional indices, respectively. The opening to the outside world and the improvement of the industrial structure increase the market competition for environmental visualization. Moreover, the pressure on the ecological environment has also increased significantly, which is not conducive to the healthy development of environmental visualization. The other three variables have positive and negative coefficients in the dimension index of the fixed-effects model, but they all show insignificant correlations. It shows that government expenditure, human resources, and economic development level in HP's financial economic effect have little influence on the development of environmental visualization.

3.2. Spatial Model Analysis. The use of spatial econometric models first needs to test whether the main variables have spatial correlation, and the existing research mostly uses Moran's index to test. This article uses Stata software to calculate the Moran index of HP financial economic effects and environmental visualization in 2017–2021. The results are shown in Figure 6:

It can be seen from Figure 6 that under the inverse distance square matrix, the HP financial economic effect has passed the test with a significance level of 0.05 in the five years from 2017 to 2021. The indices were 0.139, 0.182, 0.183, 0.159, and 0.174, respectively. The Moran indices of

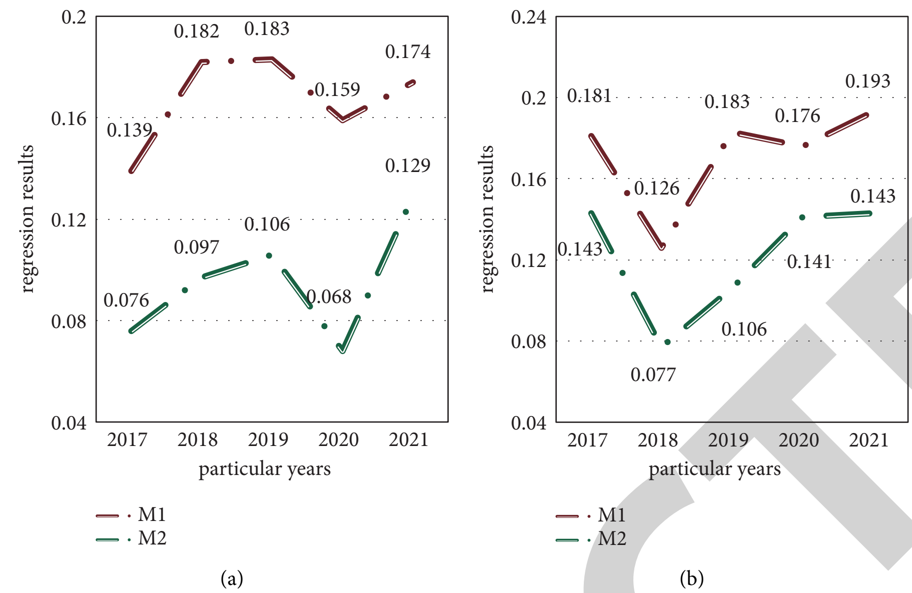

Figure 6: Spatial correlation test. (a) The spatial correlation test of HP financial economic effects. (b) The spatial correlation test of environmental visualization.

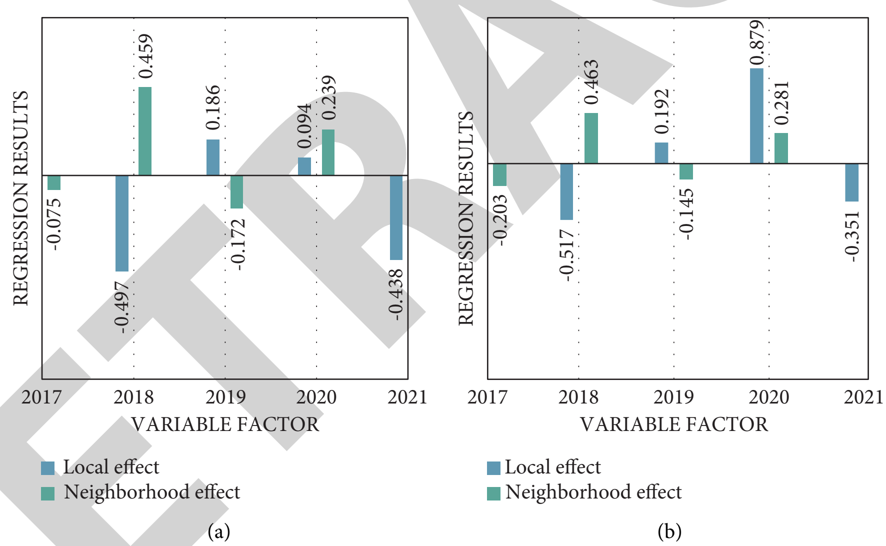

Figure 7: Spatial effects model regression results. (a) The analysis of spatial effects under the inverse distance square matrix. (b) The spatial effect analysis under the economic distance matrix.

environmental visualization were 0.181, 0.126, 0.183, 0.176, and 0.193, respectively, which also passed the test with a significance level of 0.05. Under the economic distance matrix, the correlation test results of HP's financial economic effect and environmental visualization all passed the Moran test. This shows that there is a relatively obvious positive spatial correlation between HP's financial economic effect and environmental visualization, and spatial factors can be further included. The spatial model was used to further analyze the spatial effect of HP financial economic effect on environmental visualization.

Regression analysis was performed on environmental visualization at a significance level of 0.01 using the two dimensions of HP financial economic effect coverage and depth. The regression results are shown in Figure 7.

From the regression analysis results of the spatial model in Figure 7, it can be seen that whether under the inverse distance square matrix or the economic distance matrix, the impact of the HP financial economic effect on the visualization of the local environment is significantly positive at the level of significance of 0.01. It shows that the HP financial economic effect promotes the development of local environment visualization. The influence on the visualization of the neighboring environment is significantly negative at the level of significance of 0.01, indicating that the HP financial economic effect has an inhibitory effect on the improvement of the visualization of the neighboring environment. The development of the local HP financial economic effect produces a siphon effect, which inhibits the improvement of the development level of environmental visualization in the surrounding areas. At present, the financial level is still unbalanced, and the internal differentiation is serious. At the same time, the high threshold of finance strengthens the siphon effect of financially developed areas. These areas rely on their advantages in technology and capital to attract the environmental development resources of the surrounding areas and weaken the foundation for the development of financial economic effects in surrounding areas, which is not conducive to the development of environmental visualization in surrounding areas.

Through further analysis, whether under the inverse distance square matrix or the economic distance matrix, the coverage breadth of HP's financial economic effect and the depth of use are consistent with the sign direction of each variable, which indicates that the spatial model has good robustness. With the deepening of sustainable development, the economic effect of HP's finance is also expanding, and the gap in funding for the development of local environmental visualization can be filled, thereby improving the efficiency of scientific and technological innovation. However, due to differences in HP's financial and economic effects, there are also differences in its development environment. In areas with developed HP financial economic effects, the cost of capital use is lower, the efficiency is higher, and it is easier to promote the development of environmental visualization. At the same time, this has a side effect on the development of environmental visualization in adjacent areas.

4. Conclusion

Modern society pays more and more attention to the development of environmental visualization. Combined with the financial mechanism under the background of the current sustainable development era, this article deeply studies the impact of HP's financial economic effect on environmental visualization. Regression analysis is carried out on HP financial economic effect and environmental visualization through fixed-effect model and spatial model. It is found that the HP financial economic effect can effectively improve the development level and efficiency of environmental visualization at a significance level of 0.05, and its economic effect coverage breadth and depth of use have a two-way interactive impact on environmental visualization. After taking into account the space effect, it is found that the HP financial economic effect not only promotes the healthy development of local environmental visualization but also has a negative impact on the development of adjacent environmental visualization, causing a certain impact. Therefore, it is necessary to further rationally plan the development of HP Finance, narrow the differences in economic effects between regions, establish a scientific and correct concept of environmental sustainable development, and promote the benign development of environmental visualization. Of course, there are still some imperfections in the research of this article. At present, it is difficult to obtain HP financial information data. There are some limitations and incomplete considerations in the data selection in this article. And due to the lack of current empirical research, this article lacks sufficient relevant data for reference to study the impact of HP's financial economic effect on environmental visualization. In future research work, the selection of data and information will be considered from more aspects, and an analysis model with higher applicability will be constructed to improve the research level and quality.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there no conflicts of interest.

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Research Article

Analysis on the Nonlinear Impact of Financial Risks on CO_2 Emissions: Designing a Sustainable Development Goal Framework for Asian Economies

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For the purpose of coping with or eliminating the influence of carbon dioxide emissions effectively, it is crucial to apply the green investment models to carry out a qualitative analysis of carbon dioxide emission evolution. The effect of financial risks on the implementation of the carbon dioxide emission limit is essential for the distribution of resources, and it is necessary to summarize the patterns and make innovations in the process of limiting the emissions of carbon dioxide effectively. In the case of fully complying with the principles of low-carbon economic development and related policy protection, the appropriate model for low-carbon economic development is identified. In this article, the multivariate primary nonlinear model is applied to the analysis of the nonlinear influence of financial risks on carbon dioxide emissions to cope with the problem of financial risks on carbon dioxide emissions at present. In this method, a multivariate primary nonlinear model is established based on the detailed analysis of the financial development features, and the parameters are optimized mainly from various aspects such as the structure of the model, the features of data, and the dynamic changes of the model so as to obtain the optimal values for the parameters of the constructed multivariate primary nonlinear model. The results of the practical case analysis indicate that the influence of financial risks on the limits of domestic carbon dioxide emissions is differentiated in accordance with the results and related categories. Only in this way can the regional division of carbon emission factors be properly classified. The relationship between economic growth and carbon emission increase and changes indicates that effective strategies for carbon emission reduction should be adopted. The established panel data model is used to carry out an in-depth analysis of the influence of carbon dioxide limitations in Asian countries.

1. Introduction

The implementation of real-time, rational, and accurate monitoring of carbon dioxide emissions can also provide a theoretical basis for the analysis of the decisions made by the relevant authorities for environmental protection inspection, which is of important significance for the increasing number of financial risk projects that are springing up. A detailed analysis of the financial risks is carried out to explore the issues and defects of the carbon dioxide emission process so as to develop more scientific and effective training and upgrading programs in the later stage. In the process of analyzing the evolution of traditional carbon dioxide emissions, carbon dioxide emissions and real-time risk alerts are also effective processes for data acquisition and analysis processes with regard to carbon dioxide emission equipment [1–3]. The relevant index data are collected from the carbon dioxide emission process, and the corresponding feedback is given. The data obtained are used to analyze the performance of carbon dioxide emissions, analyze the operational status of carbon dioxide emissions, diagnose the causes of faults, and monitor the root causes of the faults. Carbon dioxide emissions and real-time risk alerts are an integral part of carbon dioxide emission management and system integration, which has provided specific data for the operation and maintenance of carbon dioxide emissions. With regard to the development of financial risk, green investment, and carbon emission, they have attracted more and more attention from research scholars, and it has been proved by facts that there is a huge gap in the changes of carbon emissions under different systems in various environments. There is a direct link between economic development at its highest speed and carbon emissions under tremendous financial risks. The countries in Asia have already made their commitment to climate development, mandatory development of a low-carbon lifestyle, and the truly effective improvement via the pathway of carbon reduction, which has determined the qualitative change in the living environment and shouldered the corresponding social responsibilities. At the same time, the structure of the industry is being overhauled and developed, which, however, is a long process of development [4–6]. The relationship between the economic growth and the carbon dioxide emissions in the country has a relatively prominent gap among various regions, and some information indicates that in accordance with the total carbon emissions calculated, a manual distinction is made between regions to carry out the related studies based on the factors in different regions. For the purpose of effectively coping with the problem of environmental pollution, Asian countries have coordinated their economic development with environmental protection and given full play to the advantages of their respective environmental resources [7, 8]. With regard to the increasing financial risks, it requires that the emerging Asian countries in Asia should focus on the development of the environment and the economy in harmony with the production processes to improve production efficiency and make full use of the limited resources so as to better boost the economic development of the countries in Asia and seize the opportunity in the financial risk prevention process. However, due to the demand for the investment of a large amount of capital and labor costs under the financial risks in the countries, it can lead to a decline in the economic growth of Asian countries; that is, the high cost of economic development will influence the environment and the continuous development of the economy, which will have a negative effect on the sustained development of Asian countries; with regard to the competitors, it is necessary to spend additional costs. Where the evidence indicates that the economic entities of Asian countries reach a certain level, environmental sustainability will present growth at a doubled speed. All the regions that exceed this level are distributed in the eastern part, followed by the central region, and those at the lowest level are located in the western part. With the continuous progress of the green economy development in Asian countries, the relatively large-scale green economies in Asian countries have been developed rapidly, and more green economy sustainability projects have emerged. The green economy sustainability development is analyzed in detail to explore the issues and defects of the green economy development process so that more scientific and effective training programs and upgrading plans can be developed in the later stage. At present, with the demand for the green economy sustainable development, it is required that the Asian countries with the green economy sustainable development should be able to implement a one-stop service system that can offer strong support for life and achieve the highest economic benefits for the sustainable growth of the whole green economy, which is the overall goal of Asia countries in pursuit of green economy sustainability [9, 10].

With the continuous advancement of Internet technology and the increasing technological level, different financial developments based on the Internet have started to emerge. However, how to acquire the specific content sources from the initial financial development data that lack financial content definition and specific description has become a huge challenge for the multivariate primary nonlinear operation of financial growth at present. Since the financial development signal falls into a type of time sorting, it is feasible to apply the multivariate primary nonlinear model based on its concealed features. So far, the other classification methods are relatively homogeneous and inaccurate in obtaining the features of financial growth. The multivariate primary nonlinear model is applied to the process of nonlinear effect analysis of carbon dioxide emissions. This method allows for the use of financial development as current prior knowledge in the process of carbon dioxide emission nonlinear effect analysis in accordance with the spatial features of financial growth. The information gain method is extracting the features from the financial development content. Constrained spatial weights for multivariate primary nonlinear models for integration with spaces of high similarity on the basis of acquired financial information, respectively, are to build multivariate primary nonlinear operational models of financial development. Through the construction of the multivariate primary nonlinear model system, it can be observed that the model parallelization has substantially improved the efficiency and timeliness. The multivariate primary nonlinear model is introduced into the autonomous multivariate primary nonlinear operation of financial growth, which can implement accurate and fast multivariate primary nonlinear operation accordingly [11, 12]. At the same time, in combination with the rhythmic features of financial development, the accuracy of the multivariate primary nonlinear operation for financial growth based on the RFAM model can be improved to 67.9%. The visual analysis of the multivariate primary nonlinear operation of financial growth is implemented on the basis of the multivariate primary nonlinear model. In the implementation stage, the maximum reduction of carbon dioxide emissions is required. The general environment in the Asian countries studied has entered a new course, and the differences brought about by the various economic growth and economic situations of each region have a decisive effect on the local carbon emissions, changes, and roles. It is necessary to make the green investment that produces lower carbon emissions, ensures greener growth, and results in less energy loss. Due to the relatively huge differences in economic growth within a region, the development of reasonable and scientific policy standards for carbon emission reduction in accordance with the level of economic growth and the status of carbon dioxide emissions in the region of each country as the practical case may become a preferred path to develop a low-carbon economy in the country. With regard to countries in the development of low-carbon emission reduction policies, it is necessary to consider the details in different regions, different areas, as well as the corresponding urban basic resources, environmental pollution status quo, and industrial structure features; consider the basic situation of the respective economic development, social situation, energy availability, and green-related policies in each country effectively; proactively identify domestic demand; explore the suitable models for their own regional carbon dioxide emissions and renewable energy quotas; and guide the entire society to make concert effort in saving energy and improving energy efficiency so as to reduce the pollution of the environment [13, 14].

Studies have shown that there are obvious gaps in the relationship between economic growth and carbon dioxide emissions in Asian countries. Some data show that after calculating the total carbon emissions, the regions are divided manually, and the factors of different regions are studied. Questions are raised about the arrangement of such pre-distinguished regions. It should be based on regional carbon emissions and economic disturbances, regular distinctions are made, and then distinctions are made according to results and categories so that regional divisions and research on carbon emission factors can be implemented, study the relationship between economic growth and carbon emission growth, and suggest the effective implementation of carbon reduction strategies.

2. Construction of a Measurement Model for the Impact of Financial Risks on GHG Emissions in Asia

This article mainly focuses on the relationship between economic finance and the growth of environmental carbon emissions. With regard to the stochastic multivariate primary nonlinear model, it can be established based on the most serial time series and applied in the process of analyzing the nonlinear effect of financial risks on carbon dioxide emissions on a large scale. There are N states that exist in the model. It is assumed that the N states are $S = \{S_1, S_2, \ldots, S_n\}$, then the state at the moment t can be denoted by q_t. The transfer matrix between the different states is represented by $A = \{a_{ij}\}$. Thus, the following expression can be obtained:

$$\alpha_{ij}(k) = P\left[q_{t+1} = S_j | q_t = S_i\right], \quad 1 \leq i, j \leq N. \tag{1}$$

With regard to any state in a transfer, the other states can be reached; while in some other RFAM, only certain transfers between states can occur, that is, $a_{ij} > 0$ is established for some i,j only. For each state, the external value is available for only one observation; the observation vector obtained is correlated with the state of the system, and this relationship can be discrete or continuously distributed.

However, for the observation with a continuous distribution, the distribution of the corresponding observation vector probability in the state j can be expressed as the following:

$$b_j(v_t) = P\left[v_t \mid q_t = S_j\right], \quad 1 \leq j \leq N. \tag{2}$$

In general, the distribution of probability is taken as a mixed Gaussian distribution, that is, the following can be obtained:

$$b_j(v_t) = \sum_{m=1}^{M} \omega_{j,m} N\left(o_t, \mu_{j,m}, \Sigma_{j,m}\right), \tag{3}$$

where M stands for the number of mixed Gaussian distributions, ω_m stands for the positive mixed weights, and $N(o_t, \mu_{j,m}, \Sigma_j, m)$ represents the situation of the n-dimensional Gaussian distribution.

$$\pi_i = P\left[q_1 = S_i\right], \quad 1 \leq i \leq N, \tag{4}$$

Hence, RFAM can be summarized as three groups $\lambda=(A, B, \pi)$. In this way, the observation sequence generated based on the proposed model can be expressed as $O = o_1 o_2 \ldots o_T$, in which o_t stands for the vector that can be observed at the moment t, and T stands for the total observation length.

With regard to the multivariate primary nonlinear model constructed, the state transition period is a process in which the space is traversed. The sequence of spatial outputs is represented by k, which stands for the spatial sum that meets the similarity threshold. Thus, at the intermediate state s_i of this model obtained, the distribution of the corresponding observations in the class c^k can be expressed as the following:

$$b^i_{c_k}\left(w_{c_i}\right) = p\left\{k | s_i = w_{c_i}\right\}. \tag{5}$$

Taking into full consideration that the distribution of $b^i_{c_k}$ and the spatial frequency is subject to the constraints throughout the treatment process, the greater the spatial distance, the lower the clustering level of various financial developments.

$$b^i_{c_k}\left(w_{c_i}\right) = \mathrm{IFIDF}(i) = \frac{D_c k(i) + 1}{\sum_c k D_c k(i) + |C} \times \frac{N_c k(i) + 1}{\sum_c k N_c k(i) + |C}, \tag{6}$$

where $D^k_c(i)$ stands for the financial development business items that contain w_{c_i} in c_k; $N^k_c(i)$ stands for the number of occurrences of the space w_{c_i} in the classc_k, then for the number of occurrences in the same class should have a regularization effect. The relative affiliation of the matrix to the model is denoted by U as the following:

$$U = \{u_{ik}\}, \quad (i = 1, 2, \ldots, c; k = 1, 2, \ldots, n), \tag{7}$$

where u_{ik} stands for the affiliation of sample point k to the class i to which it falls into, which complies with the following conditions.

$$\begin{cases} \sum_{i=1}^{c} u_{ik} = 1, & \forall k, \\ 0 \le u_{ik} \le 1, & \forall k, i. \end{cases} \tag{8}$$

The aggregation center of the class i can be denoted by g_i, which is

$$g_i = \left(g_{i1}, g_{i2}, \ldots, g_{ip}\right), g_{ij} - \left[\alpha_{ij}, \beta_{ij}\right], \quad 1 \le i \le c, 1 \le j \le p. \tag{9}$$

In the above equation, the weight of the clusters is expressed by importing the adaptive parameter λ as the following:

$$\lambda_k^m = \left(\lambda_{k1}^m, \lambda_{k2}^m, \ldots, \lambda_{kp}^m\right). \tag{10}$$

The combined weights can be expressed by the following equation:

$$\begin{aligned} W &= \sum_{i=1}^{c}\sum_{i=1}^{n} \left(u_{ik}\right)^2 \Phi\left(x_k, g_i\right) \\ &= \sum_{i=1}^{c}\sum_{i=1}^{n} \left(u_{ik}\right)^2 \sum_{j=1}^{p}\left[\lambda_k^m\left(\frac{a_{kj}+b_{kj}}{2} - \frac{\alpha_{kj}+\beta_{kj}}{2}\right)^2\right]. \end{aligned} \tag{11}$$

In the equation, the following conditions are met:

$$\begin{cases} \lambda_{ij}^m \ge 0, \\ \prod_{j=1}^{p} \lambda_{ij}^m = 1. \end{cases} \tag{12}$$

3. Nonlinear Empirical Analysis of the Influencing Factors of Carbon Emissions in Various Countries

This article argues that the impact of economic level growth on carbon dioxide emissions is a nonlinear relationship, mainly because the growth of economic GDP in Asian countries varies across regions, and the impact on carbon dioxide emissions is also different. Another is that because economic growth is still at different levels, this will have different effects, so it is important to determine the economic tipping point for the impact of carbon dioxide.

The sample group $\{y_i, x_i, q_i\}_{i=1}^{n}$ is selected in this article and calculated as follows:

$$\begin{aligned} y_i &= \theta_1' x_i + e_i, \quad q_i \le \kappa, \\ y_i &= \theta_2' x_i + e_i, \quad q_i > \kappa, \end{aligned} \tag{13}$$

where q_i represents the threshold variable, κ represents the threshold value, and the constructed linear model $y_i = \theta_1' x_i + e_i$ can be divided into two different zones, namely high and low. It should be noted that the threshold variable q_i can not only be used as an explanatory variable, but can also be used as an exogenous variable related to the model economy.

The nonlinear impact analysis of financial risk on carbon dioxide emissions constitutes a finite-parameter linear model. Based on satisfying the finite-parameter linear model, the finite-parameter linear model can be used for optimization according to the steady-state ecological environment of the system. In the process of dynamic monitoring of the ecological environment, the nonlinear impact of financial risks on carbon dioxide emissions can be analyzed.

A model with the following construction is called an autoregressive moving average model, simply denoted by ARMA [15]:

$$\left.\begin{aligned} & x_t = \phi_0 + \phi_1 x_{t-1} + \cdots + \phi_p x_{t-p} + \varepsilon_t - \varphi_q \varepsilon_{t-q} \\ & \phi \ne 0, \varphi_q \ne 0 \\ & E\left(\varepsilon_t\right) = 0, \operatorname{Var}\left(\varepsilon_t\right) = \sigma_s^2, E\left(\varepsilon_t \varepsilon_s\right) = 0, s \ne t \\ & E\left(x_s \varepsilon_t\right) = 0, \forall x < t \end{aligned}\right\}, \tag{14}$$

where p, q is called the model order, $\beta = (\phi_0, \phi_1, \ldots, \phi_p, \varphi_1, \ldots, \varphi_q) \in R^{p+q+1}$ where (pq) GR_{p+q+1} is the model parameter. If $\phi_0 = 0$, the model is called a centralized ARMA (p, q); if $p = 0$, the model is a moving average model MA(q). In the case of $q = 0$, the model is the autoregressive model AR(p).

The autocorrelation function ACF and the polarization autocorrelation function TACF are obtained by calculation, and the order of the model and the model parameter β can be determined [16]. The monitoring equations are as follows:

$$\begin{aligned} & G_0 = 1, G_i = \sum_{k=1}^{i} \left(\phi_k' G_{i-k} - \theta_k'\right)(k \ge 1), \\ & \widehat{x}_t(l) = \left\{ \mu + \sum_{i=1}^{p} \phi_i \widehat{x}_t(l-i) - \sum_{i=l}^{q} \phi_i \varepsilon(t+l-i), l \le q, \mu + \sum_{i=1}^{p} \phi_i \widehat{x}_t(l-i), l > q, \operatorname{Var}\left(e_t(l)\right) = \sum_{i=0}^{l-1} G_i^2 \sigma_\varepsilon^2, \quad \forall l \ge 1, \right. \end{aligned} \tag{15}$$

where

$$\phi_k' = \begin{cases} \phi_k, & 1 \le k \le p, \\ 0, & k > p. \end{cases}$$
$$\phi_k' = \begin{cases} \theta_k, & 1 \le k \le q, \\ 0, & k > q. \end{cases} \tag{16}$$
$$\widehat{x}_t(k) = \left\{ \widehat{x}_t(k), k \ge 1, x_{t+k}, k \le 0. \right.$$

σ_ε^2 can be replaced by the sample variance σ_ε^2: where e_i is the error between the alarm value and the actual observed value using the 1-step alarm equation.

$$\widehat{\sigma}_\varepsilon^2 = \left(\sum_{i=1}^t \left(\frac{(e_i - \overline{e})^2}{(t-1)} \right) \right), \overline{e} = \sum_{i=1}^t \left(\frac{e_i}{t} \right). \tag{17}$$

$P(t)$ is the monitoring value at time t obtained by the PIE remote monitoring image processing algorithm. Let $\varepsilon = \lambda \sqrt{(1 + \varphi_1^2 + \cdots + \varphi_q^2)\sigma_\varepsilon^2}$, $\lambda > 1$, be a constant, and the interval does not contain the real value at time t with the highest probability. According to the input λ value, the monitoring interval corresponding to the probability can be obtained, and the above algorithm is implemented in the system to achieve the purpose of warning monitoring data.

Ecological environment detection and real-time risk monitoring are of great significance for ecological environment-related resource distribution, flow planning service level, and safety monitoring [17, 18]. According to the obtained data, it is used to analyze the ecological environment performance, analyze the ecological environment operation state and diagnose the cause of the failure, and can also be used to monitor the cause of the failure. Ecological environment monitoring and real-time risk alerts are important manifestations of ecological environment management and systematic integration, providing detailed data information for the operation and maintenance of the ecological environment. It plays an important role in ecological environment performance analysis, abnormal monitoring, link status monitoring, and capacity planning. As the focus of current research in this field, ecological environment monitoring can be perfectly combined with different industries to complete the full use of data from different industries in the actual ecological environment monitoring environment.

With regard to the analysis of the nonlinear effect of financial risks on carbon dioxide emissions, a finite-parameter linear model is established, which can be used based on complying with the finite-parameter linear model. In accordance with the steady-state ecological environment of the system, the optimal solution can be obtained. During the process of monitoring the dynamic changes in the ecological environment, financial risks can be used to analyze the nonlinear influence on carbon dioxide emissions. With regard to the issues analyzed above, the green investment demand function is used in this article, which is expressed as follows:

$$w = \alpha L_Y^{\alpha-1} \int_0^A x(i)^{1-\alpha} \mathrm{d}i,$$
$$p(i) = (1-\alpha) L_Y^\alpha x(i)^{-\alpha}. \tag{18}$$

Ecological environmental protection is the foundation for the construction of ecological civilization construction, and the implementation of real-time, rational, and accurate monitoring of ecological environmental protection can also provide a theoretical basis for analyzing the decisions made by the relevant authorities of environmental protection and inspection. With regard to a large number of emerging economic and ecological transformation projects that have been emerging constantly, it is of important significance to analyze the issues and defects in the process of ecological environmental protection in detail so as to develop effective training programs and improvement plans in the later stage. In the process of analyzing the evolution of ecolocal environment protection during the ecological transformation of traditional emerging economies, ecological environment protection and real-time risk alerts are also effective processes for data acquisition and analysis to achieve the goal of protecting the ecological environment. The index data are collected from the ecological environment, and the corresponding feedback is given. The data obtained are used to analyze the performance of the ecological environment, diagnose the root cause of faults, and monitor the root cause of the related faults.

The analysis of the financial risk factor is mainly carried out by collecting all analysis data on the nonlinear effect of carbon dioxide emissions, which are saved in a data storage device with a high capacity. After the application of data screening, processing, and cleansing technologies and the relevant information, they are transferred to the corresponding applications to perform the procedures and collect data on the platform regarding the features of public use of nonlinear impact analysis data of carbon dioxide emissions quickly and accurately.

$$T(a, a_1) = \frac{\sum_{i=1}^n \left((q_i - s)^2 (q_i - s - l) \right) \left(q_i - s^2 (q_i - s - l) \right)}{\sqrt{\sum_{i=1}^n \left(q_i - s^2 (q_i - s - l)^2 \right)^2 + \left(q_i - s^2 (q_i - s - l)^2 \right)^2}}, \tag{19}$$

where $T(a, a_1)$ stands for the set of characteristic attributes of carbon dioxide emission nonlinear effect analysis by using the relevant data and the carbon dioxide emissions used for the characteristic expressions in the nonlinear effect analysis; q_i stands for the number of data features after the classification of data on the carbon dioxide emissions used for the nonlinear impact analysis; s stands for the characteristic content of the nonlinear impact analysis of carbon dioxide emissions. As a numerical parameter, it is a feature specific to the carbon dioxide emission nonlinear effect analysis. After the features of the data used for the nonlinear impact analysis of carbon dioxide emissions are identified, the non-characteristic attributes should be removed, and the equation for the removal of the redundant data is shown as the following:

$$L = \overrightarrow{q} + \frac{\sum_{i=1}^n \left(T(a, a_1) \right)_i (q - e)}{\sum_{i=1}^n \left[T(a, a_1) \right]_i^2}, \tag{20}$$

where L is used to define the removal benchmark and remove those that fail to comply with the benchmark. $\overrightarrow{q}$

Table 1: Comparison of sampling effects of the experimental samples.

Training set	Test data set			Validation data set		
	Accuracy rate (%)	Recall rate (%)	F1 value (%)	Accuracy rate (%)	Recall rate (%)	F1 value (%)
Without sampling	35.82	41.01	38.20	31.01	35.24	33.09
Comprehensive sampling	52.58	67.47	59.11	36.86	39.77	38.26

stands for the filtering request used for removal; e stands for the existing redundant data removal request. Thus, the features of the data can be obtained by filtering. In the aspect of adjustment in the economic scale, it can attract a large amount of private and social capital to enter the green economy market, which will expand the financing channels in Asian countries, increase the cash holdings of Asian countries, and address the issues of the insufficient green economy in Asian countries, especially in the Asian countries with environmental protection initiatives based on technology. In accordance with the results of the study, the relationship between the growth of emerging economies and environmental sustainability can be observed [19]. In the case of the increasing GDP per capita in various countries, the degree of environmental sustainability also presents a trend of first decreasing, then increasing, and finally declining. The economic analysis model established for each country allows for an in-depth analysis and evaluation of the relevant economic development factors and the assessment of the factors affecting the development of the economy in each country and the environmental sustainability of the factors influencing the growth of their economy. In this way, the accuracy of analyzing the sustainability of the green economy can be improved quickly, which can also promote the effective utilization of economic resources. In a green economy environment, the rapid restructuring of the economy in each country can play a complementary role in environmental protection.

As an emerging Asian economy with a relatively high degree of economic development and openness, the emergence of domestic trade and investment protectionism will lead to slow economic and trade development and will seriously affect financial difficulties. According to the continuous development of various factors such as big data, artificial intelligence, and blockchain, more traditional industries will begin to change continuously. At present, with the development of financial technology, different types of electronic payment models have begun to develop on a large scale. The continuous development of traditional financial enterprises will accelerate the "disintermediation," and the cross-border flow of funds within countries will become faster and more convenient.

4. Analysis of Examples and Results

In this article, the minimum value of Cronbach's α corresponding to the relevant solved is 0.881 (Table 1). At the same time, it is necessary to remove any question item; otherwise, the Cronbach's α obtained will not be significantly improved. The minimum value of the factor loading calculated is 0.644, the value obtained for KMO is greater than 0.7, and the minimum value of the cumulative variance contribution obtained through the operation is 55.40%. From the above results, it can be concluded that the reliability of the experimental data is relatively high. In the scale validity tests of CR and emissions, all the values for the variable CR obtained are 0.8 or so, and the values of emissions are no less than 0.5 on average. Hence, it can be concluded that the convergent validity of the experimental process is relatively high as well. The square root of all the values of the variable emissions is greater than the magnitude of the correlation coefficient of the two variables, which suggests that the discriminant validity of the samples obtained is relatively high.

With regard to the phenomenon of the reduced validity of the model training results, to reduce the unbalanced data set effectively, a method of deficiency sampling for multiple classes and oversampling for a few classes is adopted in this experiment to generate a relatively balanced data set. The analysis results of the training data set with 300,000 pieces of data collected indicate that the ratio of majority and minority classes after sampling is 9 : 1 to 11 : 003 that of the raw data, which indicates that the unbalanced feature of the data set has been effectively improved. Table 1 below shows the comparison in the performance of the data set after sampling and the data set without sampling.

The established model is adjusted for a number of times and validated against the data in the data set. The overdue rates without using the model and with using the model are compared (Figure 1).

For the threshold likelihood ratio test that can represent the level of economic development in the region, the test results are shown in Figure 1. Figure 1 shows the likelihood ratio verification at the second threshold $\ln Y$. According to the test results in Figure 1, it can be seen that without considering that the likelihood ratio corresponding to the second threshold estimated value is 0. In order to avoid the existence of other estimated values below the threshold in the entire area, it can be determined that the third threshold does not exist.

In this article, the influence of financial risks on carbon dioxide emissions is explored through data analysis by establishing a model based on financial risks and carbon dioxide emissions. The effects of financial risks on the limits of carbon dioxide emissions in different dimensions can hardly be determined, and there is a certain similarity in the relationship between financial risks and carbon dioxide emission limits. In the green investment and fierce economic competition with respect to the huge amount of inputs against the financial risks, it has substantially reduced the emissions of carbon dioxide compared with the traditional policies and regulations. Thus, it has a positive influence in

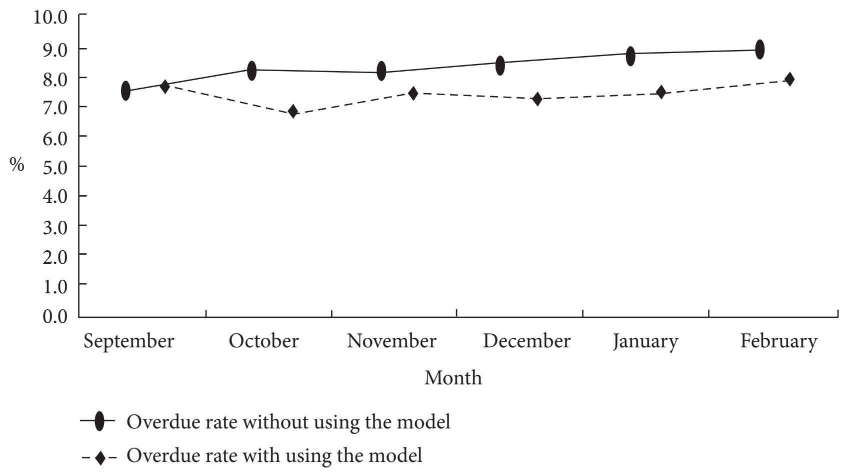

Figure 1: Comparison of the overdue rate without using the model and with using the model.

boosting the long-term growth of the domestic economy; it can not only speed up the economic growth effectively but also achieve the optimization of the economic structure of the green investment. As the financial risks can play a certain role in limiting the emissions of carbon dioxide, it is also necessary to develop the proportion of green economy investment vigorously, which will also have a certain influence on the ecological innovation.

Under different policies for environmental protection, the level of the effect that financial risks have on carbon dioxide emissions is also decreasing constantly. Thus, in the nonlinear effect analysis, carbon dioxide emissions show an interaction with the financial risks. In accordance with the test results, it can be known that for Asian countries, in the process of nonlinear effect analysis of carbon dioxide emissions, the probability outlier that mainly reflects the financial risk process is also relatively low. In Figure 2, the horizontal axis indicates the level of analysis on the nonlinear effect of carbon dioxide emissions, and the vertical axis indicates that there can be a difference in the probability of engaging in entrepreneurial activities with financial risks and without financial risks. It is assumed that the upper and lower bounds of the 85% confidence interval are above or below the 0 horizontal line. With the gradual increase in the nonlinear effect of carbon dioxide emissions, the impact of financial risks on the carbon dioxide emissions starts to decline. If the carbon dioxide emissions obtained are less than 74.97, the impact of financial risks on the carbon dioxide emissions will only present a positive and significant relationship; if it exceeds the threshold value, the impact of financial risks on the carbon dioxide emissions will not be significant.

In this article, the limitation effect of carbon dioxide emissions is tested, and the test results are shown in Table 2. It can be concluded from the table that the financial risks have a positive effect on the carbon dioxide emissions ($\beta = 0.615,\ p < 0.01$). At the same time, the green economy also has a significant positive effect on the analysis of the nonlinear effect of carbon dioxide emissions. However, the regression coefficient of the effect of financial risks on the analysis of the nonlinear influence of carbon dioxide emissions will be reduced from 0.615 to 0.337. Thus, the green economy plays a partial mediating role in the relationship between the financial risks and the carbon dioxide emissions in the nonlinear impact analysis.

To achieve sustainable development with environmental protection in the national economies of Asian countries, it is necessary to make effective use of the nonlinear effect analysis of carbon dioxide emissions under the financial risks of the system. As a new driver for the green economy, financial risks are analyzed from the perspective of coordinated development of the economy and environmental protection. In this article, the mutual impacts of the green economy on financial risks are thoroughly analyzed. Based on the presence of the intrinsic links, financial risks in the nonlinear effect analysis of carbon dioxide emissions is conducive to driving the economic growth, while playing a continuous role in the improvement of the environment. The proportion of resource consumption is also relatively high in regions with a high level of economic growth. Driven by the financial risk factors, it can effectively reduce environmental pollution in the green economy and further boost the economic growth and reduce the carbon dioxide emissions. The results of the practical case analysis indicate that: In the proportion of heavy investment in the green economy, environmental sustainability has been greatly improved as compared to the traditional economic development model. This has a positive effect on driving the long-term economic growth of Asian countries, which can not only accelerate the economic growth effectively but also achieve the optimization of the economic structure in the Asian countries.

In this article, the root test (ADF) is used to test different variables. The test results are shown in Table 3, where c, e, y, $y2$, dy, and o are expressed as level and trend nonstationary time series in turn, but all variables are first order. There is a causal relationship between financial risk and environmental quality. Therefore, to use the constructed model to evaluate, it is necessary to use the Granger causality test to test the relationship between carbon dioxide emissions and the

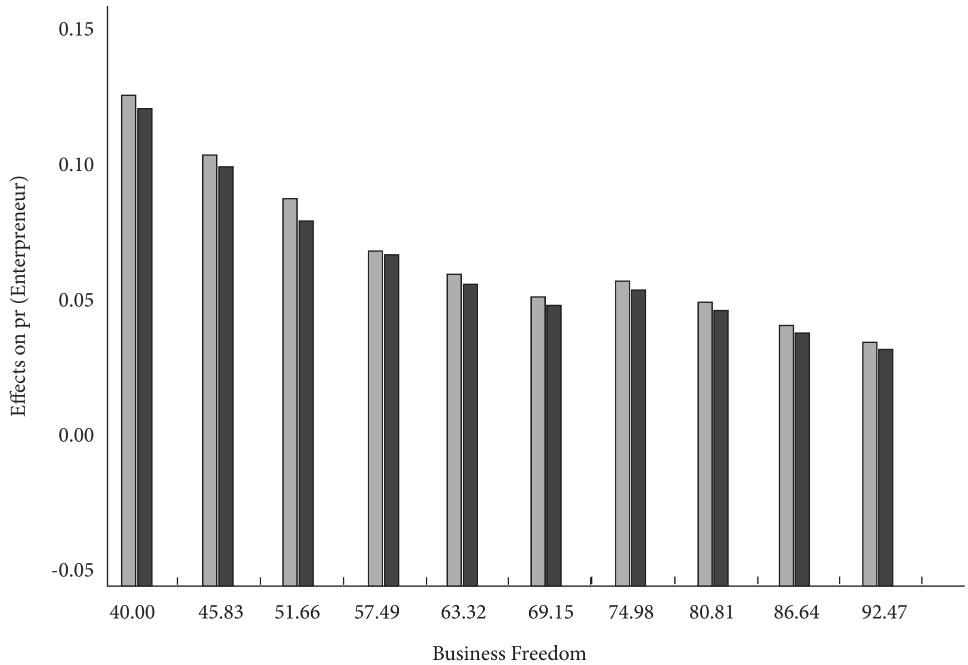

Figure 2: Impact of financial risks on carbon dioxide emissions.

Table 2: Results of nonlinear impact analysis of the relationship between financial risks and carbon dioxide emissions.

Variables	Green economy		Analysis of the nonlinear effect of carbon dioxide emissions			
	Parameter 1	Parameter 2	Parameter 1	Parameter 2	Parameter 3	Parameter 4
Scale of national economy	−0.018	−0.03	0.094	0.09	0.104	0.098
Type of national economy	−0.04	0.01	−0.075	−0.01	−0.053	−0.08
Financial risks		0.615**		0.551**		0.337**
Green economy					0.553**	0.347**

Table 3: ADF check result.

	ADF	K
c	−1.23	1
e	0.93	0
y	0.92	1
$y2$	1.33	1
$\mathrm{d}y$	1.52	1
o	−1.52	0
Δc	−4.34	1
Δe	−3.11	0
Δy	−3.23	0
$\Delta y2$	−4.11	1
$\Delta \mathrm{d}y$	−4.03	1
Δo	−4.23	0

Table 4: Granger causality test results.

Null hypothesis	F-statistics	Prob.
c does not Granger cause y	0.42	0.63
y does not Granger cause c	3.16	0.02

Table 5: ADRL estimation results.

	Model 1	Model 2	Model 3	Model 4
Cointegrating check				
F-statistics	6.74	5.81	07.94	6.81
ARDL estimation				
Intercept	−7.6*** (−2.6)	−6.2*0 (−1.8)	−4.23** (−11.64)	−5.91*** (−2.38)
e	00.31*** (0.21)	000.68*** (3.46)	NA NA	NA NA
y	3.21* (1.73)	3.53*** (2.47)	3.15** (1.89)	2.86*** (2.34)
$y2$	NA NA	−0.53*** (−2.42)	NA NA	−0.45** (−2.14)
dy	−0.35*** (−2.89)	−0.27** (−2.18)	−0.67*** (−2.38)	−0.17*** (−1.98)
tr	0.56** (2.00)	0.23*** (2.98)	0.19* (1.67)	0.89*** (4.72)

Note. *** means significant at 1% level, **means significant at 5% level, * means significant at 10% level.

growth of economic development. According to the test results in Tables 4 and 5, it can be seen that there is a significant causal relationship between the above two variables.

According to the test results, there is a negative correlation between financial risks and carbon dioxide emissions in Asian countries. From the specific details, the evaluation coefficient of 0.35 means that the growth rate of financial risks in this region will reduce carbon dioxide emissions from 1% to 0.35%. There is an obvious positive correlation between energy consumption and carbon dioxide emissions. The sign of the detected regression coefficient is similar to the theoretical value, and the coefficient value is 0.31, indicating that the per capita energy consumption in the region increases by 1%. From a long-term perspective, carbon dioxide emissions can be increased to 0.31%, and the level coefficient of per capita GDP at the level of 5% is also 3.2, indicating that for every 1% increase in per capita income, carbon dioxide emissions will rise to 3.2%.

5. Conclusion

Based on the regional differences in carbon emissions and GDP economic development in the current Asian environment, this article proposes measures on the factors affecting carbon emissions from economic growth and estimates and tests based on the revised STIRPAT module. By studying the situation of CO_2 emissions in economically developing regions, the findings are shown to be nonlinear. Under the environment of a low level of economic development in GDP, there is a direct relationship between the faster economic development and carbon emissions. Asia has expressed its commitment to climate development, forced the development of low-carbon life, and made real improvements through carbon reduction. This improvement determines the change of quality of the living environment and shoulders the burden of social responsibility. At the same time, it is a long development process to rectify and develop the structure of the industry. In the implementation stage, the emission reduction needs to be maximized. The Asian environment under study has entered a new course. The differences in the economic development and economic situation of each place have a decisive effect on the local carbon emissions. It requires lower carbon, greener, and less energy consumption to generate the largest GDP economy benefit.

Data Availability

The data that support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Awareness Level of Business Students regarding Drinking Water Safety and Associated Adulteration Accidents: A Multinomial Logistic Regression Approach

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The industrialization of metropolis urban areas with dry and steppe climates raise substantial environmental contamination, particularly in the water domain. This research investigated the awareness levels of business students toward drinking water quality and safety. We further explored the knowledge of the business students regarding drinking water issues and remedies. Eighty-four percent of respondents were happy with the quality of their drinking water, according to the findings. Approximately 66% of respondents paid special or rather high attention to drinking water quality and contamination incidents, particularly regarding possible harm to the human body and health, impact scope, and accident reasons. Few respondents reported to the health department or phoned the water safety department; 47.5% of respondents resolved drinking water issues independently. Age and education level did not play a significant role in the degree of public satisfaction with water quality or the public's perception of water pollution incidents; however, business students in Samundri were more satisfied with their drinking water quality, and residents of Faisalabad Sadar were more aware of drinking water contamination incidents than residents in areas without such a network. Respondents with higher levels of education were more aware of water quality and pollution incidents than those with lower levels of education. The steppe climate, diverse human activities, and industrialization led to water pollution. The current research findings may provide fundamental data for efficient water management in the most populated and industrialized regions.

1. Introduction

A critical global issue with increased urbanization and industrialization is the availability of safe drinking water. Access to clean water is a significant health and development concern at the national, regional, and local levels [1]. Local government and schools have learned that the availability of clean drinking water is not sufficient; general population plays an essential role in water management [2]. Public acceptability of drinking water is also included in the World Health Organization's drinking water quality recommendations [1]. Therefore, popular opinions about drinking water safety and contamination incidents cannot be overlooked [3]. Awareness of environmental concerns is crucial to the effectiveness of public environmental engagement [4]. Numerous studies have demonstrated that boosting ecological awareness and understanding among the general population is vital to the effectiveness of pollution control [5, 6]. The public's knowledge of safe drinking water is pertinent to promoting home water treatment, selecting drinking water sources by households, and avoiding water contamination incidents [7].

Established water supplies cause inadequacy and deterioration of fresh water, resulting in severe water scarcity [8, 9]. Pakistan is the seventh-most water-scarce area in the world. Most emerging nations, including Pakistan, India, Africa, and Bangladesh, are progressively using water with deteriorating quality owing to human activities [10, 11]. In southern Asia, Pakistan has dry to semiarid climates in various regions. Due to urbanization, the massive population faces several water-related issues [12–14]. In Pakistan, water availability is steadily declining; by 2025 and 2050, it will fall to alarmingly low levels of 660 and 575 ft^3 and 877 m^3/year, respectively. The current study focused on third big city of Pakistan, Faisalabad is regarded as a polluted industrial (textile, ice, pharmaceutical, wheat, cotton, sugar, and food) city due to inadequate treatment facilities and the fact that more than 90% of samples exceeded WHO guidelines for K, Na, Cl, total dissolved solids (TDS), and SO_4 [15, 16].

Awareness of drinking water safety and quality has been studied by researchers in different countries. For instance, Mahler, et al. [17] evaluated the drinking water issues and concerns of the urban public in the United States and discovered that the urban populace is satisfied that their home drinking water is safe. In Austria, 75% of survey respondents were entirely happy with the quality of drinking water, according to research by Fröhler and Elmadfa [18]. In China, Wang, et al. [19] surveyed public awareness about water safety in two rural counties of Henan province. This research demonstrated the significance of quality perception, service satisfaction, and water source selection in assessing public knowledge of drinking water safety and accident risk. A greater understanding of the elements that impact public awareness of drinking water may enhance water management, consumer services, and preventing and controlling water pollution accidents. Numerous variables have been identified as influencing general knowledge of drinking water quality. Water sources, water treatment methods, and water distribution networks may readily impact the quality and safety of drinking water [1]. The link between water quality and people's livelihood is tight, and access to clean drinking water is crucial for health [1]. Awareness of water quality and risk resulted from a complex interaction of multiple factors, including water taste, odor, clarity, socioeconomic characteristics, demographic characteristics, water treatment, geographic location in the distribution system, and information provided by local media [2, 7, 20–22]. For operational drinking water delivery systems, the amount of water, water pressures, and failures may also impact the quality of drinking water [23]. However, recent drinking water safety awareness studies have focused mostly on bottled water usage, municipal water, and recycled water [19]. There is research on the awareness level of business students regarding drinking water safety and associated adulteration accidents by using the multinomial logistic regression approach. Consequently, the purpose of this research was to explore the facts of general knowledge of drinking water safety and water pollution accidents in Faisalabad city, Punjab Province, Pakistan, as well as to analyze information regarding public awareness and attitudes toward drinking water and water pollution. This research will contribute to avoiding drinking water pollution and enhancing water management, particularly from the standpoint of public engagement with empirical evidence from a semiarid industrialized metropolitan city.

2. Materials and Methods

2.1. Studied Area Profile. According to the 2017 census, Pakistan has a total population of 207.68 million (106.3 million males and 101.3 million females). Punjab is the most pulpous province in the country (area 205,345 km^2; population 109,989,655). With a growing population, Faisalabad is considered the second megalopolis in Punjab (area of 5,857 km^2; population 7,882,444), with a growth rate of 1.98% [24]. The annual rainfall was measured at 408 mm. The maximum recorded temperature was 45°C, while the wind speed was 94 mph [25]. Today, Faisalabad is a thriving industrial center with several textile, dye, fertilizer, industrial chemical, pulp and paper, printing, industrial products, and agricultural equipment manufacturers, among others [26]. Most industrial wastewaters were dumped untreated into the two main drains, Paharang and Madhuana. Both the Paharang and the Madhuana drains are administered by the Irrigation Department. The Paharang drain ultimately empties into the Chenab River, while the Madhuana drain empties into the Ravi River. Faisalabad's oxidation ponds consisted of anaerobic and facultative ponds. In its vicinity, untreated wastewater has been utilized for 50 years to cultivate crops, vegetables, and fodder [27].

2.2. Research Design and Measurement. The objective of current research is to empirically investigate the attitude of business students toward water safety and pollution accidents. For this purpose, a descriptive and correlational cross-sectional, questionnaire-based survey was conducted among the business students of five tehsils (i.e., Chak Jhumra, Faisalabad Sadar, Jaranwala, Samundri, and Tandlianwala) of the Faisalabad district, Pakistan. Figure 1 is a map of the research region. It will provide a valuable reference for drinking water control and prevention in other city areas of Pakistan as important because the results could provide a useful reference for drinking water control and other developing countries.

We adopted the measures of awareness about water safety and contamination accidents based on prior studies [18, 19]. The comprehensive questionnaire contains 15 items (5 demographic questions, 6 for drinking water safety, and 4 for water pollution accidents); each questionnaire only takes about 5 min to finish. The first 5 items measure the demographic characteristics of the respondents, such as name (optional), age, gender, education, and tehsil of residents. The next part of the questionnaire measures public awareness about drinking water safety (consisting of 6 questions). The awareness about the "main source of drinking water" is measured with a close-ended question

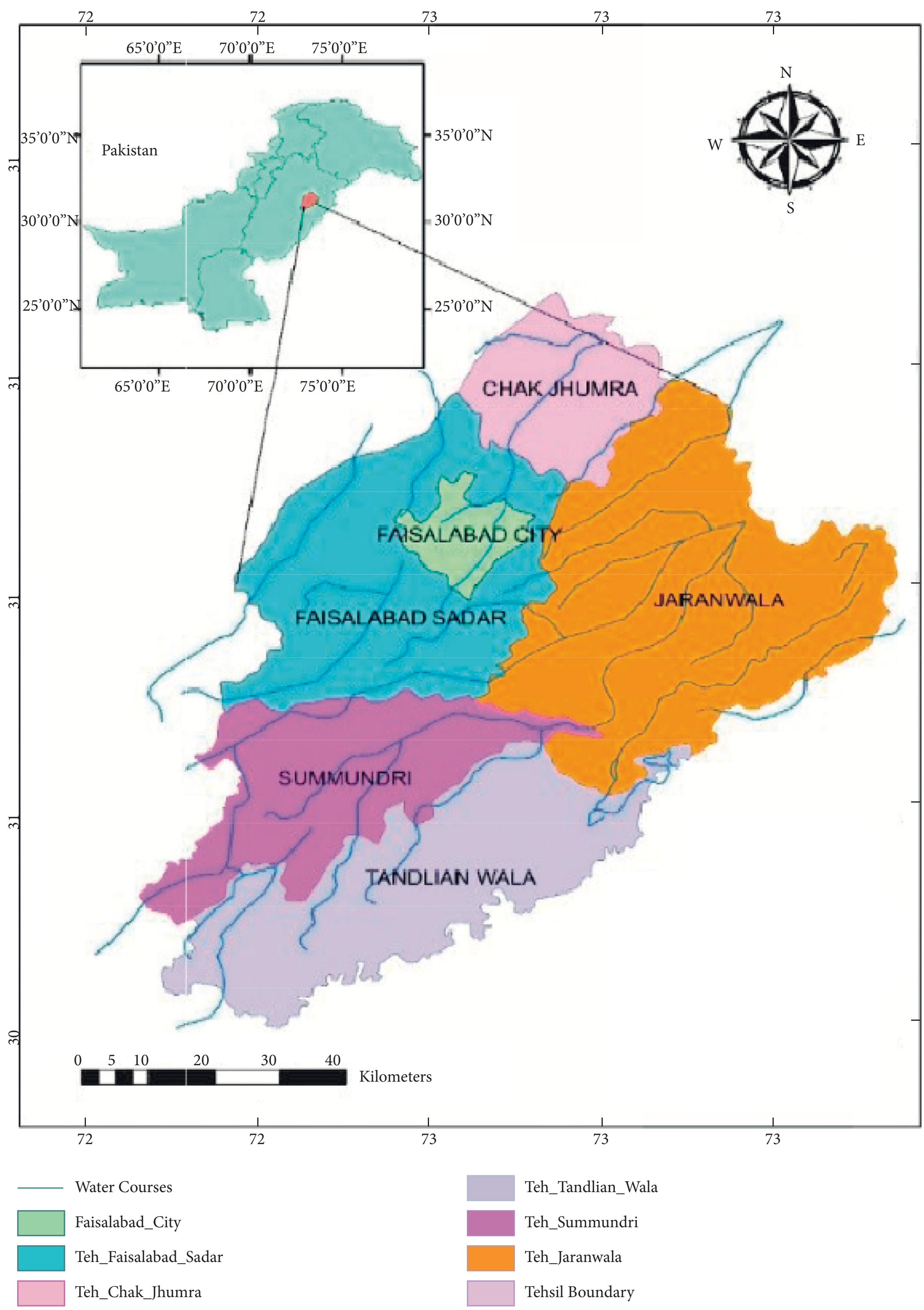

Figure 1: The map of study areas (source: Sohail, et al. [28]).

with 5 items, that is, (1) tap water, (2) barreled or bottled water, (3) well water, (4) spring water, and (5) others. Public attention level to local drinking water quality is measured on the 4 items on the Likert scale, that is, (1) special attention, (2) comparatively high attention, (3) not concerned, and (4) no answer. The public's satisfaction level concerning drinking water quality is also measured by 4 items on a Likert scale, that is, (1) very satisfied, (2) relatively satisfied, (3) dissatisfied, and (4) no answer. Five items on a Likert scale measure public trust level in the safety of drinking water, that is, (1) confident, (2) relatively confident, (3) somewhat worried, (4) extremely worried, and (5) no answer. Public awareness about the problems with tap water quality is measured by 4 items, that is, (1) never had problems, (2) had problems once or twice a year, (3) had problems frequently, and (4) no answer. Actions taken to solve problems that arise with tap water and solve problems are measured by 5 items, that is, (1) solve problems by themselves, (2) help by local water utility, (3) complain to the local department of health, (4) help by the residential property maintenance staff, and (5) call the local government telephone hotline for help.

The last section of the questionnaire measures public awareness about the drinking water contamination accidents (consisting of four questions). Attention to the water pollution events is measured by four-item Likert scale, that is, (1) pay special attention, (2) follow in free time, (3) not concerned, and (4) no answer. Five items measure attention to the specific water pollution events, that is, (1) damage to human health, (2) influence scales, (3) cause of accident, (4) accident information publication, and (5) accident treatment procedures. Emergency response provider in water contamination accidents is measured by five items, that is, (1) health department, (2) environmental protection department, (3) water resources department, (4) propaganda department, and (5) housing and urban, rural development department. Things to reduce pollution emergencies are measured by four items, that is, (1) strengthening supervision, (2) resource management, (3) propaganda for protecting the knowledge, and (4) increasing the intensity of the punishment.

All the constructs (observable and latent) of the questionnaire were initially constructed in English. Later, the questionnaire was translated into Urdu (the national language; the questionnaire is given in supplementary material (available here). The survey was conducted among the residents of five tehsils of Faisalabad, Pakistan. To eliminate any translation discrepancies, the questionnaire was translated into Urdu and reviewed by two academic experts fluent in English and Urdu.

2.3. Sampling and Data Collection. After modifying and incorporating experts' suggestions, the survey instruments have been given to the final year students of management sciences departments of two renowned Pakistan universities in Pakistan for pilot testing, about 50 in total. Overall findings of pilot testing inveterate the reliability of the questionnaire scale. Finally, following the sampling method used by other researchers [28, 29], the questionnaire survey was conducted among the residents of 5 tehsils of Faisalabad with the help of final year students (100 questionnaires distributed in each tehsil). The objective of using purposive sampling was to balance respondents from each tehsil of Faisalabad.

We adopted the anonymous filling-in method to keep confidentiality and integrity (the first question about names was optional). Furthermore, the information provided by the respondents is only used for research purposes, and personal information will not be disclosed. It was optional for them to respond; if any resident refused to participate, a replacement was provided. A total of 500 questionnaires were distributed in 5 tehsils of District Faisalabad, Pakistan. In total, 408 questionnaires were returned (83.8% response rate); 84, 57, 108, 54, and 105 responses were received, respectively, from Chak Jhumra, Faisalabad Sadar, Jaranwala, Samundri, and Tandlianwala tehsils of Pakistan. Questionnaire responses with missing values and unengaged data were removed. The final data set used for analysis consists of 399 responses in total. Survey data were gathered, coded, and put into Microsoft Excel. Then, using StataMP econometric software, the statistical analysis of data was conducted.

2.4. The Statistical Approach. The awareness about drinking water safety and contamination accidents is analyzed through frequency distribution tables and a multinomial regression model. In particular, using discrete choice regression models is appropriate to investigate the factors influencing public awareness about water safety and adulteration issue. Because ordinary least squares (OLS) are not an appropriate statistical methodology for binary data, logistic or probit estimation methods are used [30]. Furthermore, our dependent variables are tetrachotomous/polychotomous, so the multinomial logistic regression (MLR) model is applied. Y represents the dependent variable, with four choices, that is, $k = 4$. Then, the multinomial regression consists of a set of four logistic models that, after being normalized for the reference category of Y, allow us to calculate the probability of Y taking the value of each of the three categories. The probability of Y is given by the matrix notation equation as follows:

$$P\left(Y = \frac{1}{X}\right) = \frac{1}{1 + \sum_{k=2}^{3} e^{x\beta_k}},\ P\left(Y = \frac{2}{X}\right) = \frac{e^{x\beta_2}}{1 + \sum_{k=2}^{3} e^{x\beta_k}},$$
$$P\left(Y = \frac{3}{X}\right) = \frac{e^{x\beta_3}}{1 + \sum_{k=2}^{3} e^{x\beta_k}},\ P\left(Y = \frac{4}{X}\right) = \frac{e^{x\beta_4}}{1 + \sum_{k=2}^{3} e^{x\beta_k}}, \tag{1}$$

where X is the matrix of independent variables and β is the vector of coefficients.

The logit of each nonreference category relative to the reference category is contingent upon a set of explanatory factors. The model is estimated using the approach of maximum likelihood.

3. Results and Discussion

3.1. Demographics of Respondents. Table 1 presents the demographic breakdown of the sample. Most respondents were male (52.9%), between the ages of 35–50 and 20–34,

Table 1: Demographic information of participants.

	Faisalabad (total)		Chak Jhumra		Faisalabad Sadar		Jaranwala		Samundri		Tandlianwala	
	N	%Age (%)	*N*	%Age (%)	*N*	%Age (%)	*N*	%Age (%)	*N*	%Age (%)	*N*	%Age (%)
Age												
<20	65	15.8	11	13.1	9	15.8	19	17.6	8	14.8	18	16.7
20–34	115	28.0	22	26.2	16	28.1	31	28.7	17	31.5	29	26.9
35–50	173	42.1	37	44.1	24	42.1	43	39.8	22	40.7	47	43.5
>50	58	14.1	14	16.7	8	14.0	15	13.9	7	13.0	14	13.0
Gender												
Male	216	52.9	45	53.6	33	57.9	54	50.0	33	61.1	51	48.6
Female	192	47.1	39	46.4	24	42.1	54	50.0	21	38.9	54	51.4
Education												
Bachelor's	330	82.7	60	74.1	48	84.2	87	82.9	42	82.4	93	88.6
Master's or above	45	11.3	15	18.5	9	15.8	15	14.3	3	5.9	3	2.9

Source: Author survey.

with bachelor's degrees. These findings were consistent with the gender, age, and education demographics of these five tehsils of Faisalabad.

3.2. Awareness about the Safety of Drinking Water

3.2.1. Sources of Drinking Water. One of the key factors in the World Health Organization's Universal Health Coverage (UHC) program is the WASH (water, sanitation, and hygiene), and household water security has prime importance in it [31]. Panel A of Table 2 provides the survey results of residents' drinking water sources. Most respondents (37.2%) reported using tap water as their primary source of drinking water, followed by bottled water (33.6%). Very little spring and the well water were consumed. These are distinct from developed nations. In these developed cities, bottled or barreled water use has expanded dramatically during the previous decade [32]. Due to massive industrialization in the city, the water quality of surface water and groundwater is not good; therefore, the proportion of using bottled or barreled water is increasing with time. Thus, several local water filtration utilities have been developed at different locations of all five tehsils of Faisalabad, and bottled (filtered) water is becoming popular in these communities. Several studies have shown that when customers are unsatisfied with the municipally supplied tap water, they often shift to bottled or barreled water [19, 32].

3.2.2. Attention of the Public to Local Drinking Water Quality. Panel 2 of Table 2 shows that 36.0% of respondents paid great attention to local water quality, 20.2% paid somewhat high attention, and 27.9% were unconcerned with local drinking water quality. The following technologies are examined from the water source through the distribution points: water sources and intakes, water-lifting devices, power technologies, water treatment, storage, and distribution. Each of these subsystems' technologies must perform effectively to maintain a dependable water supply and safe water quality [33]. A clean and accessible water supply is essential to public health and welfare [34]. Most water treatment facilities in all five tehsils of Faisalabad are modest, with mostly centralized (or sometimes decentralized) township (local Baldia) and rural water supplies and a water supply capacity of less than 1,000 m^3/d. The water items and equipment are quite basic and rudimentary. There is no water treatment equipment in these purification facilities, so their purification ability is extremely restricted, and some impurities should not be eliminated. And, as a result of the fact that many people were keen to know whether their drinking water was clean or not, the majority of respondents paid close attention to its quality.

3.2.3. Student Satisfaction with Drinking Water Quality. Panel 3 of Table 2 displays survey findings on students' satisfaction with drinking water quality. About 21.9% of respondents were very happy with the quality of their drinking water; 62.0% were somewhat content; and 11% were unsatisfied with the quality of their drinking water. Multiple studies [19, 29, 35] have examined consumer satisfaction with the quality of drinking water. Numerous variables, including availability and safety of water sources, taste, and attitudes toward chemicals, influence the quality of drinking water [2, 7, 28, 29]. Few inhabitants utilize barreled or bottled water, but they often believe that bottled water is a clean and safe product, which may explain the 100% satisfaction rate for barreled or bottled water. Users of tap water sources were only happy with the quality of their drinking water. Well water and spring water are sourced from decentralized water sources that are obtained directly from the water source, without or with little infrastructure. Dissatisfaction among respondents was mostly attributable to sensory qualities such as water turbidity, red color, and disagreeable flavor and odor. If locals fully understand the water treatment process and the significance of all water quality indicators, their level of satisfaction with the quality of their drinking water is likely to alter.

3.2.4. Residents Trust in Drinking Water Safety. Panel 4 of Table 2 displays the results on the public confidence level in drinking water safety. In total, 28.5% of respondents felt

Table 2: Student awareness of drinking water safety (statistical results).

	Faisalabad (total)		Chak Jhumra		Faisalabad Sadar		Jaranwala		Samundri		Tandlianwala	
	N	%Age	*N*	%Age	*N*	%Age	*N*	%Age	*N*	%Age	*N*	%Age
Panel 1: Main source of drinking water												
Tap water	153	37.2	30	35.7	21	36.8	42	38.9	24	44.4	36	33.3
Barreled or bottled water	138	33.6	21	25.0	24	42.1	33	30.6	21	38.9	39	36.1
Well water	57	13.9	0	0.0	0	0.0	18	16.7	6	11.1	15	13.9
Spring water	9	2.2	12	14.3	6	10.5	3	2.8	3	5.6	3	2.8
Others	54	13.1	21	25.0	6	10.5	12	11.1	0	0.0	15	13.9
Panel 2: Attention to local drinking water quality												
Special attention	147	36.0	27	32.1	27	47.4	42	38.9	12	23.5	39	36.1
Comparatively high attention	123	30.2	30	35.7	12	21.1	27	25.0	21	41.2	33	30.6
Not concerned	114	27.9	24	28.6	15	26.3	30	27.8	12	23.5	33	30.6
No answer	24	5.9	3	3.6	3	5.3	9	8.3	6	11.8	3	2.8
Panel 3: Satisfaction level with drinking water quality												
Very satisfied	90	21.9	18	21.4	6	10.5	15	13.9	18	33.3	33	30.6
Relatively satisfied	255	62.0	54	64.3	45	79.0	60	55.6	33	61.1	63	58.3
Dissatisfied	45	11.0	9	10.7	3	5.3	21	19.4	3	5.6	9	8.3
No answer	21	5.1	3	3.6	3	5.3	12	11.1	0	0.0	3	2.8
Panel 4: Trust level in the safety of drinking water												
Confident	117	28.5	39	46.4	18	31.6	21	19.4	15	27.8	24	22.2
Relatively confident	114	27.7	21	25.0	18	31.6	21	19.4	21	38.9	33	30.6
Somewhat worried	138	33.6	21	25.0	9	15.8	51	47.2	0	0.0	42	38.9
Extremely worried	30	7.3	3	3.6	9	15.8	9	8.3	15	27.8	9	8.3
No answer	12	2.9	0	0.0	3	5.3	6	5.6	3	5.6	0	0.0
Panel 5: Awareness of problems with tap water quality												
Never had problems	99	24.1	24	28.6	12	21.1	21	19.4	18	33.3	24	22.2
Had problems once or twice a year	144	35.0	24	28.6	24	42.1	27	25.0	24	44.4	45	41.7
Had problems frequently	138	33.6	27	32.1	18	31.6	48	44.4	6	11.1	39	36.1
No answer	30	7.3	9	10.7	3	5.3	12	11.1	6	11.1	0	0.0
Panel 6: Measures taken to solve problems that arise with tap water												
Solve problems by themselves	195	47.5	57	67.9	33	57.9	30	27.8	33	61.1	42	38.9
Help by local water utility	102	24.8	6	7.1	0	0.0	39	36.1	15	27.8	42	38.9
Complain to the local department of health	36	8.8	3	3.6	9	15.8	12	11.1	3	5.6	9	8.3
Help by the residential property maintenance staff	39	9.5	12	14.3	9	15.8	12	11.1	0	0.0	6	5.6
Call the local government telephone hotline for help	39	9.5	6	7.1	6	10.5	15	13.9	3	5.6	9	8.3

confident in the safety of their drinking water, while 27.7% felt moderately confident. Water resources and quality have been recognized as the most significant components of public confidence in drinking water safety [36]. Around 33.6% of respondents said they were somewhat concerned about safety of their drinking water, while 7.3% were highly concerned. About 40% of citizens in these two counties lacked confidence, which may be attributable to the crude or basic water treatment used. In Faisalabad's rural regions, there are no standards governing the transmission of drinking water quality, and water treatment facilities seldom disclose the values of drinking water quality indicators. On occasion, residents acquire information on the quality of their drinking water through television, newspapers, or the Internet. According to research, little information and a few stories are insufficient to successfully alter public image [37]. Consequently, many inhabitants of the five tehsils of Faisalabad are concerned about the quality and safety of the local drinking water, and some locals are concerned about the safety of the drinking water.

3.2.5. Knowledge regarding Common Tap Water Problems and Solutions. Students often have issues with the taste, flavor, smell, and look of their drinking water, such as water that is initially clear but generates brown, orange, reddish stains or sediment, or water that has a metallic taste. As indicated in panel 5 of Table 2, 24.1% of respondents claimed they had never had difficulties with the quality of their tap water; 35.0% reported having problems once or twice a year; 33.6% said regular tap water concerns; and 7.3% did not reply. Issues with drinking water include white froth, rust color, disagreeable odor, turbidity, red worms, and other contaminants. Water supply issues include water shortages and periodic water scarcity. However, there are many more issues with water quality that cannot be observed, and respondents do not completely comprehend the majority of water quality indicators of their drinking water. Hence, the majority of respondents claimed no or few concerns with tap water.

3.2.6. Student Awareness to Solve Common Tap Water Problems and Solutions. Panel 6 of Table 2 also displays respondents' knowledge of solutions for tap water issues such as strange water quality, pipeline damage, faucet water leakage, and so on. Around 47.5% of residents repaired pipes and faucets themselves and filtered unclean water using a home water purifier; 24.8% relied on the local water utility; 8.8% of respondents complained to the local department of health; 9.5% sought assistance from the residential property maintenance staff; and only 9.5% of respondents called the local government telephone hotline for assistance. These data indicate that people often resolve difficulties with their drinking water on their own by contacting the local water provider for assistance. Rural regions have a dearth of knowledge about drinking water problems and remedies. Many households resolve water-related issues without assistance from water treatment facilities or monitoring offices. When homeowners turn to municipal water utilities or monitoring agencies for assistance, these departments cannot resolve the situation promptly. Some folks are completely unaware of how to contact these agencies.

3.3. Awareness about Water Pollution Events

3.3.1. Awareness of Water Contamination Incidents among the Public. Panel 1 of Table 3 shows that 34.3% of respondents stated they pay close attention to news of water contamination incidents, while 17.5% indicated they are unconcerned about such incidents. About 43.3% indicated that they pay attention only in their free time. In recent years, severe water pollution incidents, such as contamination with heavy metals, algal blooms, organic chemical spills, and microbiological contamination, have caused public concern [25, 28, 29]. In response to the question, "What type of water pollution incident do you pay attention to?" some residents wanted to know whether long-term consumption of bottled or barreled water is harmful to the human body and what diseases could be caused by drinking unclean water for an extended time.

3.3.2. General Understanding of Water Pollution Incidents. Panel 2 of Table 3 depicts the results of awareness of water contamination incidents. About 83.9% of respondents knew of the possible health risks associated with water contamination incidents. And 4.4% are aware of the influence scales of such accidents, and 6.6% of the respondents are mindful of the cause of such accidents. Accident information impact acquired from information in government publications on water contamination incidents and accident treatment methods.

3.3.3. Emergency Response Provider and Preventative Measures for Water Pollution Incidents. Panels 3 and 4 of Table 3 show that 36% of residents believe that the health department is the emergency resource provider in an emergency. In comparison, 44.9% think the water resource department should be contacted in case of emergency. About 27% of respondents agreed with enhanced supervision and monitoring, and 42.7% says there should be better resource management to solve water contamination emergencies. About 21.3% of respondents said that improved awareness and education and higher fines for polluters might also contribute to reducing pollution accidents.

Faisalabad district government established water quality monitoring networks in each tehsil. Despite this, geographical coverage remains low owing to the country's vastness. Environmental campaigners in Pakistan assert that the Ministry of Environmental Protection's sanctions for pollution and illegal actions are insufficient in most situations [16, 28, 29]. Such regulations demonstrate government resolve but are inadequate to inspire terror. Some departments can oversee the water source and utilities to implement these laws. The department of health monitoring is empowered to lead water treatment facilities. When a water treatment facility is deficient, it should be penalized to

Table 3: Student awareness of drinking water contamination accidents (statistical results).

	Faisalabad (total)		Chak Jhumra		Faisalabad Sadar		Jaranwala		Samundri		Tandlianwala	
	N	%Age	*N*	%Age	*N*	%Age	*N*	%Age	*N*	%Age	*N*	%Age
Panel 1: Attention to the water pollution events												
Pay special attention	141	34.3	33	39.3	27	47.4	27	25.0	21	38.9	33	30.6
Follow in free time	180	43.8	33	39.3	27	47.4	45	41.7	24	44.4	51	47.2
Not concerned	72	17.5	9	10.7	3	5.3	33	30.6	6	11.1	21	19.4
No answer	18	4.4	9	10.7	0	0.0	3	2.8	3	5.6	3	2.8
Panel 2: Attention-seeking water pollution events												
Damage to human health	345	83.9	72	85.7	54	94.7	75	69.5	42	77.8	102	94.4
Influence scales	18	4.4	3	3.6	3	5.3	6	5.6	6	11.1	0	0.0
Cause of accident	27	6.6	9	10.7	0	0.0	9	8.3	3	5.6	6	5.6
Accident information publication	12	2.9	0	0.0	0	0.0	12	11.1	0	0.0	0	0.0
Accident treatment procedures	9	2.2	0	0.0	0	0.0	6	5.6	3	5.6	0	0.0
Panel 3: Emergency response provider in water contamination accidents												
Health department	147	36.0	36	42.9	18	31.6	30	27.8	21	38.9	42	40.0
Environmental protection department	33	8.1	6	7.1	3	5.3	12	11.1	9	16.7	3	2.9
Water resources department	183	44.9	42	50.0	27	47.4	48	44.4	15	27.8	51	48.6
Propaganda department	18	4.4	0	0.0	3	5.3	6	5.6	6	11.1	3	2.9
Housing and urban, rural development department	27	6.6	0	0.0	6	10.5	12	11.1	3	5.6	6	5.7
Panel 4: Things to due to reducing pollution emergencies												
Strengthening supervision	108	26.5	24	28.6	12	21.1	27	25.0	21	38.9	24	22.9
Resource management	174	42.7	33	39.3	33	57.9	33	30.6	24	44.4	51	48.6
Propaganda for protecting the knowledge	39	9.6	12	14.3	3	5.3	6	5.6	3	5.6	15	14.3
Increasing the intensity of the punishment	87	21.3	15	17.9	9	15.8	42	38.9	6	11.1	15	14.3

Table 4: Influencing factors of public awareness about water safety (multinomial logistic regression results).

Variables	Panel 1: Satisfaction level with drinking water quality			Panel 2: Public attention to local drinking water quality			Panel 3: Trust level in the safety of drinking water			
	Very satisfied	Dissatisfied	No answer	High attention	Not concerned	No answer	Confident	Relatively confident	Extremely worried	No answer
Age	0.0434 (0.138)	−0.149 (0.176)	0.0737 (0.271)	0.0790 (0.140)	0.138 (0.140)	0.0336 (0.241)	0.0105 (0.140)	0.0249 (0.141)	0.0350 (0.221)	−0.334 (0.385)
Gender	0.480^{*} (0.253)	0.690^{**} (0.331)	−0.395 (0.524)	0.799^{***} (0.260)	0.869^{***} (0.261)	−0.499 (0.503)	-0.499^{*} (0.259)	-0.468^{*} (0.261)	−0.133 (0.405)	14.89 (653.0)
Education	0.192 (0.208)	0.116 (0.262)	1.489^{***} (0.540)	-0.717^{***} (0.248)	0.603^{*} (0.315)	0.391 (0.549)	−0.140 (0.208)	0.0583 (0.225)	−0.0456 (0.329)	-0.727^{**} (0.314)
Tehsil	0.192^{**} (0.0891)	−0.0153 (0.113)	0.0233 (0.183)	0.0187 (0.0892)	0.0867 (0.0911)	0.0757 (0.158)	-0.293^{***} (0.0911)	−0.00803 (0.0923)	−0.103 (0.142)	−0.200 (0.239)
Constant	-2.785^{***} (1.034)	-2.112^{*} (1.280)	-8.936^{***} (2.626)	1.999^{*} (1.152)	-3.754^{***} (1.443)	−3.559 (2.514)	1.507 (1.031)	−0.272 (1.104)	−1.011 (1.633)	−12.82 (653.0)
Observations	399	399	399	396	396	396	399	399	399	399
Pseudo-r-squared	28%			51%			34%			
Chi-square	22.619^{**}			51.057^{**}			37.142^{***}			
Akaike crit. (AIC)	815.160			972.506			1,088.314			
Ref. category	Relatively satisfied			Special attention			Somewhat worried			

Standard errors are provided in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

enhance the water treatment technology and strengthen the building of the water distribution network to improve the water quality. The department of environmental protection is empowered to oversee and manage the water source and environment to provide clean, uncontaminated drinking water. Increasing the severity of punishments would assist in preventing unlawful sewage releases while enhancing oversight and monitoring would assure the efficacy of handling pollution situations. Thus, respondents saw supervision, monitoring, and resource management as effective water pollution control techniques.

3.4. Comparative Analysis of All Five Tehsils of Faisalabad. Based on survey findings, inhabitants of five tehsils have distinct levels of student knowledge about drinking water concerns. These distinctions are also shown in Tables 2 and 3. The Samundri tehsil has less contaminated underground water, and inhabitants believe that tap water is safe to drink, with the highest tap water average (44.4%) compared to all other tehsils. Faisalabad Sadar is a more congested area with massive industry and contaminated underground water. Due to these factors, inhabitants of Faisalabad Sadar believe their drinking water is insufficiently safe and must be more cautious and aggressive than residents of other tehsils. So most residents (42.1%) of Faisalabad Sadar use barreled or bottled water; however, only 25% of Chak Jhumra residents use barreled or bottled water; spring water is highly used in Chak Jhumra at 14.3% (2.2% overall). Regarding public perceptions of drinking water safety, 46.4% of inhabitants of Chak Jhumra have more trust in drinking water quality of local supply than Jaranwala, 19% lowest, and the overall average of the Fasislabad district is 28.5%. And, concerning the level of satisfaction with their drinking water quality, people of Faisalabad Sadar were less happy (10.5%), while residents of Samundri were more satisfied with drinking water quality (33.3%). Faisalabad Sadar residents pay more attention to the quality of the local water supply pollution events (47.4%), and Jaranawala residents pay less attention. Faisalabad Sadar inhabitants had a lower degree of confidence in the safety of drinking water but were more concerned about the safety of drinking water. These results suggested that Faisalabad Sadar inhabitants are more likely to see their drinking water as less safe and are less happy with it. However, there are no major variations between all five tehsils in terms of public understanding of the primary variables affecting the quality of drinking water and the efforts taken to address issues with tap water.

3.5. Factors Influencing Student Satisfaction with Safe Drinking Water. The multinomial logistic regression (MLR) model is applied to assess the relations between the level of public awareness of the quality of drinking water and its affecting foundations. The results are shown in Table 4: according to panel 1 of Table 4, there were no significant associations between age, level of education, and satisfaction with drinking water quality. Nevertheless, gender and residential area played a statistically significant role in distinguishing between three groups of respondents: those who were very satisfied and dissatisfied with the quality of their drinking water and those who were between satisfied and dissatisfied. Panel 2 of Table 4 shows the association between public attention to local water quality and its affecting variables. Age and the residential area had no significant link with water quality awareness. However, gender and education were statistically significant in distinguishing the three groups. Those with higher degrees of education

Table 5: Influencing factors of student awareness about water contamination accidents (multinomial logistic regression results).

Variables	Panel 1: Attention to the water pollution events			Panel 2: Things to due to reducing pollution emergencies		
	Pay special attention	Not concerned	No answer	Strengthening supervision	Propaganda for protecting the knowledge	Increasing the intensity of the punishment
Age	−0.00487 (0.126)	−0.0130 (0.154)	0.222 (0.354)	−0.0738 (0.139)	0.0638 (0.199)	0.0149 (0.145)
Gender	−0.516** (0.234)	0.407 (0.290)	−1.419* (0.737)	0.286 (0.256)	−0.346 (0.369)	0.128 (0.267)
Education	0.105 (0.188)	0.452* (0.272)	−0.607* (0.358)	−0.774*** (0.237)	−0.685** (0.294)	0.477 (0.313)
Tehsil	−0.0895 (0.0812)	0.0893 (0.101)	−0.662*** (0.244)	−0.0819 (0.0889)	−0.0353 (0.125)	−0.0596 (0.0945)
Constant	−0.210 (0.929)	−3.263** (1.307)	1.262 (1.913)	2.909*** (1.121)	1.373 (1.441)	−2.523* (1.442)
Observations	399	399	399	396	396	396
Pseudo-r-squared	40%			30%		
Chi-square	38.284***			30.13***		
Akaike crit. (AIC)	956.937			1,012.031		
Ref. category	Follow in free time			Resource management		

Standard errors are provided in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

exhibited greater levels of understanding than those with lower levels of education. Panel 3 of Table 4 depicts the results of public trust in the safety of drinking water. Age and education have no significant impact on the confidence level. However, the gender and tehsil of residence have an important negative relationship with the level of confidence about water safety.

3.6. Influencing Factors of Student Awareness regarding Drinking Water Contamination Accidents. A multinomial logistic regression model investigated the association between student knowledge of drinking water contamination accidents and its affecting variables. Panel 1 of Table 5 indicates that age and residence status did not significantly influence drinking water pollution awareness. However, gender and degree of education did play statistically significant roles in differing awareness levels across groups. Those with a greater level of education were more aware of contamination incidents than those with a lower level of education. Panel 2 of Table 5 shows that age, gender, and area of residence do not have any significant relationship with the suggestion to reduce water contamination accidents. But the level of education has an important relationship with strengthening the supervision and propaganda.

Keeping customers informed about the quality of their drinking water is crucial to maintaining public health [1, 31, 34]. Thus, public awareness affecting elements might potentially reflect drinking water safety and pollution incidents and offer decision-makers vital information. If we disregard the fact that people of all ages and both sexes have access to information about drinking water emergencies through television, newspapers, and the Internet, age and gender did not play a significant role in the degree of public satisfaction with water quality and public perception of water pollution accidents. The factors influencing students' views of drinking water might vary considerably among populations. For instance, in terms of general knowledge of drinking water pollution incidents, males were more aware than women; yet there were no significant differences between men and women in their occasional interest in contamination occurrences. Similar to prior environmental research [16], respondents' views and behavior were heavily influenced by their level of education. Respondents with a higher education level were more aware of local water quality and water pollution incidents than those with a lower education level.

4. Conclusions

The research examined the student's knowledge of drinking water safety and pollution accidents and the link between awareness of these concerns and its primary influencing elements. Specifically, a questionnaire survey was conducted in the five tehsils of the Faisalabad district, Pakistan. We observed that respondents with some knowledge about their water quality are more confident in their drinking water and give more support for water safety and pollution avoidance. The majority of respondents in this research believe they have a good level of knowledge about drinking water quality and safety and pollution incidents. Approximately 66% of respondents were concerned about local water quality (special attention 36.0% and comparatively close attention 30.2%). Only 22% of respondents were very happy with the quality of their drinking water, while 62% were somewhat satisfied. Education level and health monitoring of drinking water quality might impact public knowledge of drinking water safety and contamination incidents. The study findings support the implementation of proper monitoring and public policies to ensure integrated and sustainable water development and minimize health risks in the study area. It will influence the decision-making process for enhancing drinking water quality monitoring to assure its safety. It also instructs them to boost student awareness of drinking water quality, strengthen education, expand understanding of drinking water safety, and enhance emergency response for drinking water contamination incidents. Using local television and print media, it is possible to boost public satisfaction by highlighting the significance of the local government's yearly report on the quality of drinking water. This research was conducted in one of Pakistan's most significant agricultural and industrial areas, Faisalabad. The findings may inform policy for other metropolitan areas of the same kind. For future research, it is proposed that a greater region be covered and information concerning illnesses caused by polluted water be added if possible.

Data Availability

The data sets used and/or analyzed during the current study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Supplementary Materials

The questionnaire used for the survey has been attached as supplementary material. (*Supplementary Materials*)

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Research Article

Environmental Sustainability Impact of Environmental Protection Regulations on the BRICS Countries

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The BRICS countries are also known as the BRICS, which are composed of five economies: China, Russia, India, Brazil, and South Africa. Of course, environmental issues are also included, because with the economic development of the five countries, the price paid is the environment. In response to this problem, in order to adapt the environmental problems arising in their own development to economic development, the BRICS countries have formulated corresponding laws and regulations to respond to existing or possible environmental problems. The most important purpose of this series of environmental protection laws is to achieve relatively stable and sustainable development in the five countries. This requires these environmental protection laws to have a sustainable impact on the environmental development of the BRICS countries. In order to conduct research on the impact of sustainable environmental laws that have been enacted, this article will use the analysis method of analyzing the relationship between the environmental protection regulations and economic development of the BRICS countries, as well as the relationship between the environmental protection laws and environmental sustainability development of the BRICS countries, and the impact of environmental sustainability based on empirical analysis. It assesses the impact on the sustainability of the environment of the BRICS countries under the auspices of environmental laws. Through the empirical analysis experiment of economic and environmental protection effects, the results obtained show that the comprehensive scores of environmental protection in the BRICS countries in 2018–2020 have been improved except Russia's score. Among them, the improvement of China's score is the most obvious, and the improvement of the ranking has reached 24. The results of this assessment show that, with the support of the corresponding environmental laws, sustainable impacts have been produced in the environment of the BRICS countries.

1. Introduction

With the vigorous development of economy and technology in recent years, environmental issues have become issues that need to be considered in both developed and developing countries. This brings the concept of sustainable development to the development of the country. The sustainable development here mainly refers to not taking the environment in which human beings live as the price of development in the process of development and utilization of the environment and in the development of economy. And these environments are the environments that human beings will live in now and in the future. The importance of the environment to human beings has been clearly demonstrated in some developed countries this year, and it is also evident in some developing countries that regard the environment as the price of development. As five developing countries with obvious advantages in today's international environment, the BRICS countries have a relatively important influence on the development of the world economy. However, with the increasing number of environmental problems in the five countries, corresponding laws and regulations have been carried out on the protection of the environment. This measure enables environmental protection to have a legal basis, and to a certain extent, it can improve or even solve the environmental problems arising in development. In order to achieve sustainable development of the environmental protection efforts made by the five BRICS economies, this article will use certain methods to evaluate this phenomenon. It uses this to determine the role of environmental laws in the development of the BRICS countries.

The sustainable impact of the environment reflects the good relationship between human beings and the natural environment. The grasp of this relationship can well deal with environmental and economic risks, and many researchers have made relevant research. Khalid and Peng controlled energy consumption by assessing the sustainability impact of the environmental life cycle [1]. Brown was to obtain better economic benefits by studying the relationship between the sustainable impact of the environment and the business economy [2]. Ali et al. conducted an analysis of the sustainability impact of some of the world's resources by using environmental protection methods [3]. Bayar and Remeikiene reduced the emission of pollutants by improving the utilization rate of energy, which can make sustainable improvements to the environment [4]. Aziz et al. assessed environmental sustainability impacts using both qualitative and quantitative methods [5]. All of the above studies have been conducted with regard to the impact of environmental sustainability. These studies will demonstrate the various factors that have an impact on the environment. The measures involved are also various, and these methods can be classified as part of the implementation of environmental protection law. The main way is to control some energy consumption products. The use of these modalities allows for a partial demonstration of the reasons for having a sustainable impact on the environment. However, the use of these methods lacks an assessment of the impact on the environment after the implementation of the environmental protection law. In order to solve this problem, this article will use the method of empirical analysis to conduct qualitative and quantitative research on environmental problems.

With regard to the research on the continuous impact of environmental protection law on the environment, the method of empirical analysis is used to conduct research. The use of this method allows for a more objective presentation of the impact of environmental sustainability. And many scholars have discussed it. Wilson et al. conducted a structural analysis of environmental sustainability impacts by using an empirical approach [6]. Santos et al. quantitatively monitored changes in environmental sustainability impacts by using meteorological data obtained in the environment [7]. Dalavi et al. estimated the sustainability impacts of water resource occurrences in the environment by using empirical methods [8]. Vishi and Bhagat conducted an empirical analysis model of rainfall in the environment by using empirical analysis [9]. Flumignan et al. conducted an empirical analysis of meteorology in the environment by using sensors [10]. In the mentioned series of studies, the methods of empirical analysis are related to the impact of environmental sustainability. This makes this method more important in the evaluation of the sustainable impact of the environment under the action of environmental protection law. The role of the empirical analysis method in the study of the environmental sustainability impact is to analyze and process the environmental sustainability impact in the BRICS countries by means of statistical measurement. Using the empirical analysis to analyze the impact of environmental sustainability under environmental law can better clarify the relationship between environmental law and environmental change.

The status of the BRICS countries in the world is constantly improving with the economic development of each country in this group. The vigorous development of the economy in the five countries has made environmental problems increasingly prominent. Long before the establishment of this combination, the emergence of various environmental problems has led to the introduction of corresponding environmental protection laws in the BRICS countries. Environmental issues have become more and more important in recent years, and many concepts of green and sustainable development have also been proposed in the international community. However, the effect of the laws promulgated by the BRICS countries is largely based on qualitative concepts. In order to achieve sustainable development of the environment, it is not to slow down the economic development, but to use the environment as a sustainable resource while ensuring economic development. It is not about trading the environment for economic development. On the basis of using the empirical analysis method, through the empirical analysis experiment of pollutants, it is obtained that the laws of Brazil and Russia's investment in the environment are consistent. Brazil's investment is 21.71 billion yuan. After the investment of Russia is 42.38 billion yuan, it is a stable investment and the use of energy by the BRICS countries continues to increase in the use of energy in the world. By 2020, the use of industrial energy by the BRICS countries will reach 41.17%. These results show that environmental laws have a significant effect on environmental sustainability. That is to say, under the implementation of their respective environmental protection laws, the environment of the five BRICS countries has achieved sustainable green development to some extent. The innovation of this article is that it studies the impact of environmental laws on environmental sustainability. It also uses a certain method to explore the relationship between the two.

2. BRICS Environmental Sustainability Impact

2.1. Relationship between Environmental Protection Regulations and Economic Development. The BRICS countries are playing an increasingly important role in the international development environment, which also makes the cooperation between the five countries in the economic field closer and closer. Of course, the rapid economic development has brought great changes in people's lives and various aspects to the five BRICS countries, but with the economic development, there is also serious environmental pollution [11]. Until now, serious natural disasters have occurred. It has made the BRICS countries in developing emerging markets realize the importance of environmental protection to the country. The corresponding five countries have already promulgated corresponding laws and regulations, in order to achieve a better balance between the seemingly intractable environmental and economic development. Therefore, it is necessary to adopt a new mode of economic development and environmental protection based on the existing scientific and technological means. The new mode is shown in Figure 1.

Figure 1 shows a new model of environmental and economic development. The difference between this model and the traditional economic development model is that environmental regulations and the environment are placed at the beginning of the model. This also determines that this development model is not based on the pursuit of economic benefits, but rather on the environment. In order to better correlate the protection of the environment with the economic development of the BRICS countries, the laws and regulations in Figure 1 only regulate environmental protection. However, it is also necessary to carry out corresponding regulations for the industry that has the greatest impact on the environment in the BRICS countries, namely, the industrial industry [12]. Since the secondary industry is very important to a country, a country's industrial strength can determine its competitiveness in the international community to a certain extent. Therefore, a country's heavy industry is very important for its environmental protection and international competition, and it is also very important for the evaluation of the secondary industry. The evaluation system for the secondary industry is shown in Figure 2:

In the evaluation system in Figure 2 above, the characteristics involved in the production process of the entire secondary industry have been described as indicators. It also performs corresponding calculations for the key parts of the figure. From the above figure, we can also know that if the secondary industry undergoes major changes, it may affect the overall competitiveness of the country in the international community. The above indicators can be used as a reference indicator for the BRICS countries before and after the implementation of environmental protection. However, more environmental-related indicators need to be collected for environmental protection. These indicators are serious pollutants for the environment, but are indeed essential for industrial development. The corresponding indicators of environmental pollutants are shown in Figure 3:

The indicators involved in various industries shown in Figure 3 are highly dangerous pollutants for the environment, and the environmental damage caused by them is also relatively serious. When a country's industry develops rapidly, the short-term economy will be greatly improved, but it will be accompanied by a large amount of emissions of these pollutants. In dealing with environmental issues, the BRICS countries are not only unified in the evaluation system of the abovementioned pollutant indicators, but also reflected in the development of the environment, environmental technology, environmentally friendly energy, and related political decisions. In addition, the global greenhouse effect is becoming more and more serious. And the BRICS countries, which are developing and emerging countries, are now the major countries in greenhouse gas emissions. Various countries have made corresponding policies and analyzed the emission of pollutants.

2.2. Relationship between Environmental Protection Laws and Environmental Sustainability. The environment in which the environmental protection laws of the five BRICS countries are promulgated is the growing concern of the international community for environmental governance. At the same time, the importance of the BRICS countries on their national economic development has also reached a new height. Since the concept of globalization was put forward, the vast majority of countries in the world have made their own connections in development. The linkages between countries make developing countries an opportunity to pass on energy consumption in developed countries. Although it can bring economic growth, modern industry and some manufacturing industries that have obvious harm to the environment have also brought serious environmental problems to the environment of developing countries [13]. As the representatives of developing countries, in order to achieve sustainable development in terms of the environment, the BRICS countries need to combine the sustainable development of the environment of the five countries on the basis of the environmental protection laws issued by the five BRICS countries. Its sustainable development model incorporating the concept of environmental protection is shown in Figure 4.

The environmentally sustainable development model in Figure 4 provides a complete display of the environmental use model. The sustainable development of the environment here is to rationally arrange the environmental resources of the entire Earth at the two levels of time and space. The purpose of this is not to make too much sacrifice of environmental resources for short-term development. The coordination in Figure 4 is to place environmental protection on a longer span and a larger space, not just between the BRICS countries. Moreover, in the above model, the usability of the environment and the normativeness in use are effective measures for environmental protection. Sustainable environmental protection brings not only environmental benefits, but also better maintenance of stable economic development.

2.3. Method of Environmental Sustainability Impact. The principle of the empirical analysis method is to use some specific analysis methods in the practical analysis to process the data to a certain extent. The usage scenarios of this method are mostly processing economic data, and the corresponding analysis methods are also diverse [14]. What this article studies is the impact of sustainability under environmental issues, and the influencing factors and indicators involved can be roughly specified in terms of nature and quantity. The first is the calculation of the attribute indicators in the influencing factors. Now it is assumed that the national competitiveness of the BRICS countries is denoted by K, and the five countries' corresponding efforts to implement environmental protection in their own countries are denoted by T. When K appears alone, its corresponding probability is expressed as P_{kk}. When environmental protection is simply analyzed from the perspective of protection, its corresponding probability

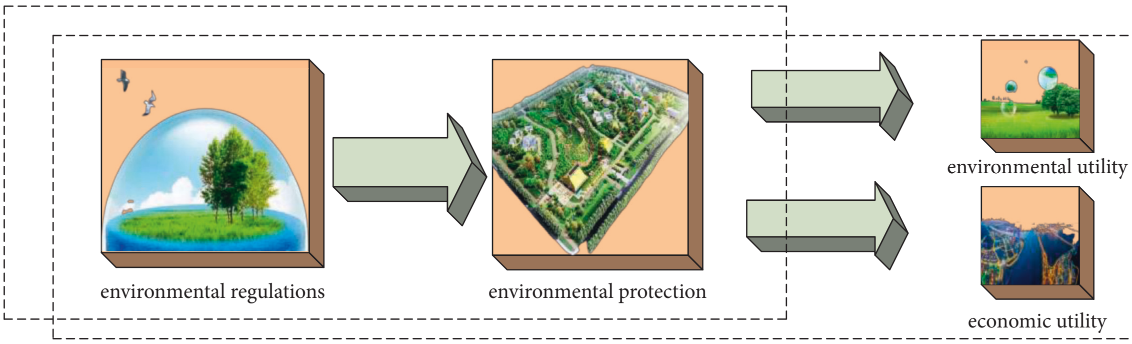


Figure 1: New model of environmental protection and economic development.

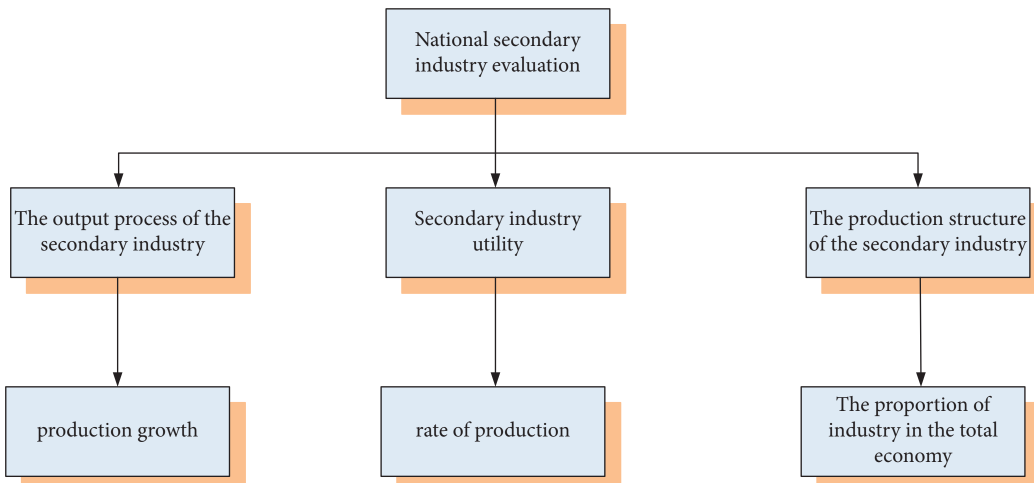


Figure 2: Evaluation system of the national secondary industry.

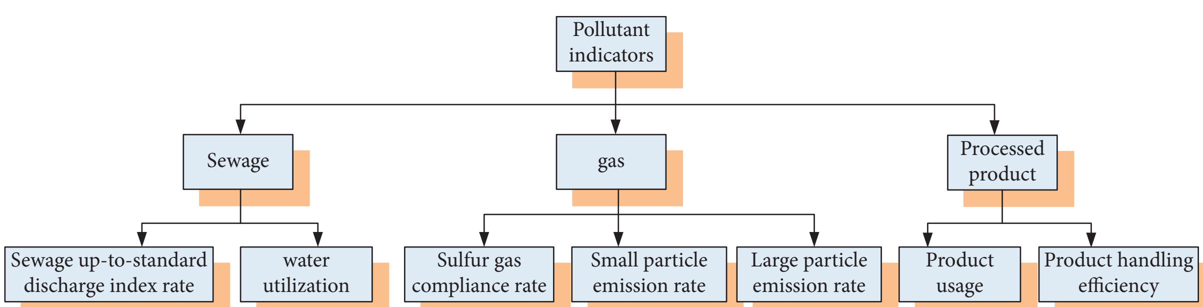


Figure 3: Secondary industry pollutant indicator system.

is P_{tt}. In the event of environmental protection, when neither the country's competitiveness nor the protection of the environment exist, the probability of occurrence is P_0, and when both attributes are present, the probability of occurrence of the corresponding event is P_{KT}. Because this article is about the impact on environmental sustainability, the abovementioned attribute indicators, that is, the relationship between the country's competitiveness and the strength of environmental protection, need to be related to a certain extent. First of all, it is necessary to determine the relationship between the competitiveness of the BRICS countries and environmental protection. The logarithmic analysis method is used here. The formula is as follows:

$$\ln P_{KT} = \ln P_{tt} + \ln P_{kk} + \ln \frac{P_{KT}}{P_{tt} P_{kk}}. \tag{1}$$

The above formula expresses the logarithmic form of the two influencing factors specified in nature. However, these two factors must be two without interference before they are

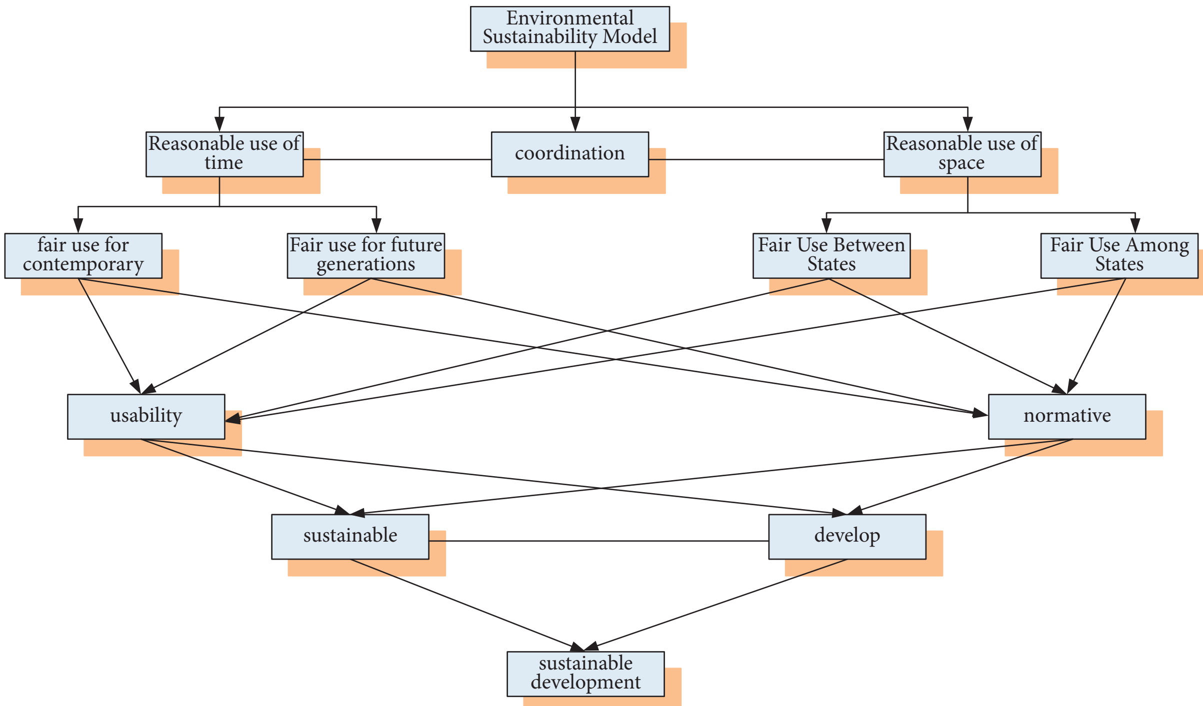


Figure 4: Sustainable development model under environmental protection.

correlated. The establishment of this requirement needs to be based on the following formula:

$$\frac{(P_{kk}P_{tt})}{(P_{KT}P_{TK})} = 1. \tag{2}$$

The above formula mathematically correlates the competitiveness K of the attribute country with the environmental protection intensity T corresponding to the country. The ratio of 1 in formula (2) represents only the independence between the above factors, and the regulation of the correlation strength can be expressed as

$$\eta = \frac{(P_{kk}P_{tt})}{(P_{KT}P_{TK})}. \tag{3}$$

The size of the η value in the above formula indicates whether there is a mathematically defined relationship between the country's competitiveness and the country's protection of the environment. It can be seen from the formula that when the value of η is more biased, it shows that there is a close relationship between the country's own competitiveness and the country's protection of the environment. The process of calculating the indicators of the nature category in the above content can also be extended to the influencing factors of other attribute categories, such as the relationship between the national environmental protection awareness of the BRICS and the strength of environmental protection. In addition to this, a mathematical definition of the influencing factors that can be monitored numerically is required. In Figures 2 and 3, an indicator system has been established for the pollution problems faced by the BRICS countries at the current stage of development [15]. As emerging economies of developing countries, the BRICS countries not only need to vigorously develop their own industries, but may also undertake the industrial production of some developed countries. The development of industries is very important for developing countries. There are three categories of indicators that are destructive to the environment, including sewage, gas, and solid pollutants. The indicators of the above three categories of pollutants are expressed as H_{ab}. It represents the pollution index of pollutant b in year a. The weight of one type of pollutants in the whole can be expressed as

$$L_{ab} = \frac{H_{ab}}{\sum_{a=1}^{i} H_{ab}}. \tag{4}$$

The above formula can calculate and express the respective weights of the three types of pollution. In order to better define the degree of confusion of a certain type of pollutant in the above pollution system, it can be expressed by the following formula:

$$\phi_i = \frac{1}{\ln 20} \sum_{a=1}^{20} L_{ab} * \ln L_{ab}. \tag{5}$$

The above calculation of the degree of confusion of pollutants in the pollutant system provides a good definition of the normative nature of pollutants. The above calculation process quantifies the pollutant indicators in industrial development in a very specific manner. Among them, formula (4) defines and calculates the weights of various pollutants in the industrial development of the BRICS countries. But in the end, the index of pollutants has to be calculated, and its formula is expressed as follows:

$$D_r = \sum_{b=1}^{p} k_b * L_{rb}. \quad (6)$$

The calculation formula of the above pollution index has carried out a specific calculation of the specific detection values of environmental pollutants. The calculation form of the above expression formula can summarize the detection values under the corresponding weights of all pollutant indicators in a class of pollutants. In order to better correlate the environmental protection laws promulgated by the BRICS countries with the lasting impacts on the environment occurring in the five countries, the calculation methods of formula (1) and formula (3) are also required. It can better present the results of the impact from the quantification of indicator attributes and indicators.

2.4. Environmental Sustainability Impact Experiments and Results. The experiment in this article compares the impact of BRICS environmental protection law enforcement and environmental sustainability between quantitative indicators of pollutant reduction over a longer period of time and the gross domestic product of the national economy. It also carries out certain statistical explanations. The five BRICS countries were established for their own economic construction to be more stable in the international community, focusing on economic development and taking into account other development contents. The problem of severe natural disasters in today's world is increasing in frequency in both developed and developing countries [16]. Environmental problems and the emerging climate change have threatened the survival of human beings to a certain extent, and the corresponding legal measures adopted by various countries have also been gradually implemented in the form of articles. Since the content of the BRICS economic development is industry and manufacturing, it is necessary to compare the differences in environmental protection among the five countries. The differences in the environmental protection scores of the BRICS countries in the 2018–2019 years are presented in Table 1.

The data in Table 1 are the scores of the BRICS countries on different indicators of environmental protection, and this scoring system is based on the scoring results of different indicators of environmental protection in the five countries. Taking into account the comprehensiveness of the evaluation of the BRICS countries, the evaluation indicators of this Office are the natural resources possessed by the country, the integrity of environmental resources, the maximum bearing capacity of the natural environment, the management ability of environmental resources, and the ability to coordinate and allocate resources. In 2018–2020, the ratings of all BRICS countries improved, except for Russia, which declined. Among them, the improvement of China's score is the most obvious, and the improvement of the ranking has reached 24. The second obvious improvement is India, followed by Brazil and South Africa. It can be seen from Table 1 that the measures for environmental protection in the BRICS countries have achieved a more obvious effect on the sustainable impact of the environment [17]. In addition to scoring the environmental protection of each of the five countries above, in order to realize the implementation of the environmental protection law while taking into account economic development, that is, the corresponding national income brought by environmental protection, it needs to count the country's gross national product and the income brought by environmental protection. The results are shown in Table 2.

Table 2 compares Russia as GDP and environmental protection income. As a result, it can be seen that with the gradual increase of Russia's GDP in successive years, the income brought by environmental protection has also gradually increased. It can be seen that although the investment in environmental protection is low in short-term income, the overall income in the future is still very promising, because the generation of environmental protection income also means the implementation of environmental protection laws, including related legal taxes [18]. It is selected according to the indicators in Figure 2, and also statistics on the pollutants of sewage, gas, and waste residues produced by Russia's industries in the BRICS countries in different years. The results are shown in Table 3.

In Table 3, the corresponding statistics of the three types of pollutants in Russia in the past 10 years are carried out. The statistical results of these pollutants can clearly see that the total amount is increasing year by year. However, in the past three years, that is, 2018–2020, the discharge of pollutants has shown a decreasing trend. This is closely related to the enhancement of environmental protection by the BRICS countries in recent years. The above statistical content adopts the empirical analysis method and uses the relevant formula to deal with it.

Impact of BRICS Environmental Protection Laws on Economic Development: The five BRICS countries all play an important role in the development of today's world. Although they are all developing countries, the development potential contained in these five countries is huge. When developed countries transfer their own industries to developing countries, it brings economic development to developing countries and also brings environmental damage to developing countries. Although the BRICS countries have promulgated relevant environmental laws many years ago, the effect of implementation is not significant. In recent years, both the international community and the BRICS countries have paid more and more attention to the frequent occurrence of natural disasters. The tax system related to environmental law has also been improved accordingly, and this system has a great effect on the implementation of laws related to environmental protection [19]. Now, the relevant taxes and their proportions of environmental protection in Brazil and Russia in the past 10 years are counted, and the results are shown in Figure 5.

As can be seen from Figure 5, Brazil and Russia in the BRICS countries are increasing their investment in the environment year by year. This reflects the determination of the BRICS countries for environmental protection, and at the same time, it also reflects the good state of their own economic development. The laws of Brazil and Russia's investment in the environment are consistent, and the

Table 1: Comparison of BRICS environmental protection scores in 2018–2020.

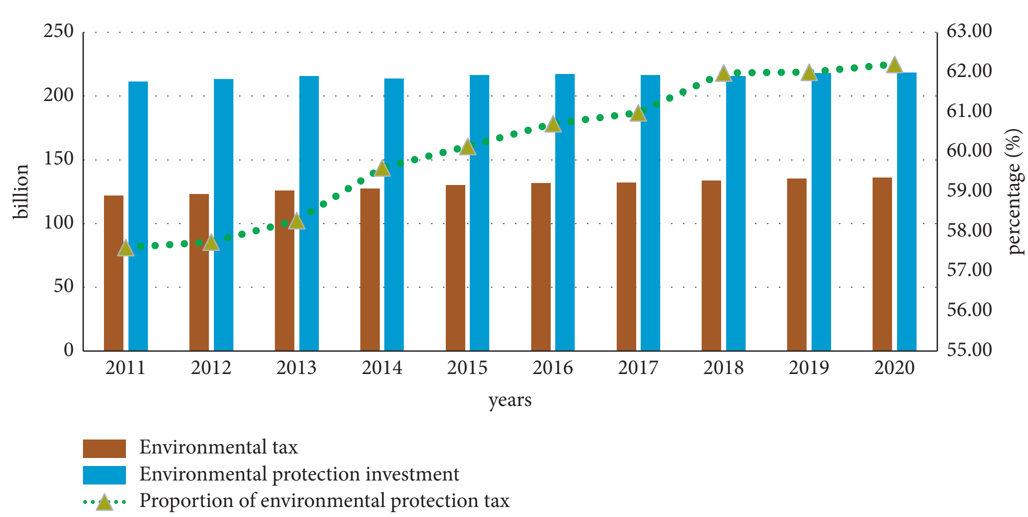
Nation	2018		2020		2018–2020 differences	
	Evaluation results	Score ranking	Evaluation results	Score ranking	Evaluation results	Score ranking
China	49.30	45	51.30	21	2.00	24
Russia	48.60	78	48.30	80	−0.03	−2
India	47.20	83	48.70	75	1.50	8
Brazil	52.10	21	52.70	17	0.60	4
South Africa	47.90	82	48.50	79	0.50	3

Table 2: Statistics of Russia's gross national product and environmental protection income.

years	Gross national product	Environmental protection income
2013	22940 billion	113.7 billion
2014	20820 billion	317.3 billion
2015	13700 billion	327.5 billion
2016	12800 billion	653.7 billion
2017	15740 billion	753.3 billion
2018	16610 billion	987.3 billion
2019	16880 billion	1013.7 billion
2020	14870 billion	1223.1 billion

Table 3: Generation of pollutants.

years	Sewage production	Harmful gas generation	Waste residue generation
2011	137.5 billion tons	127.3 billion tons	141.7 billion tons
2012	137.9 billion tons	138.7 billion tons	153.7 billion tons
2013	138.1 billion tons	152.6 billion tons	163.1 billion tons
2014	138.7 billion tons	153.8 billion tons	167.1 billion tons
2015	139.3 billion tons	154.6 billion tons	168.3 billion tons
2016	139.7 billion tons	157.5 billion tons	183.7 billion tons
2017	151.1 billion tons	158.9 billion tons	191.7 billion tons
2018	152.9 billion tons	161.7 billion tons	195.3 billion tons
2019	152.7 billion tons	160.7 billion tons	194.1 billion tons
2020	152.5 billion tons	159.3 billion tons	193.5 billion tons



(a)

Figure 5: Continued.

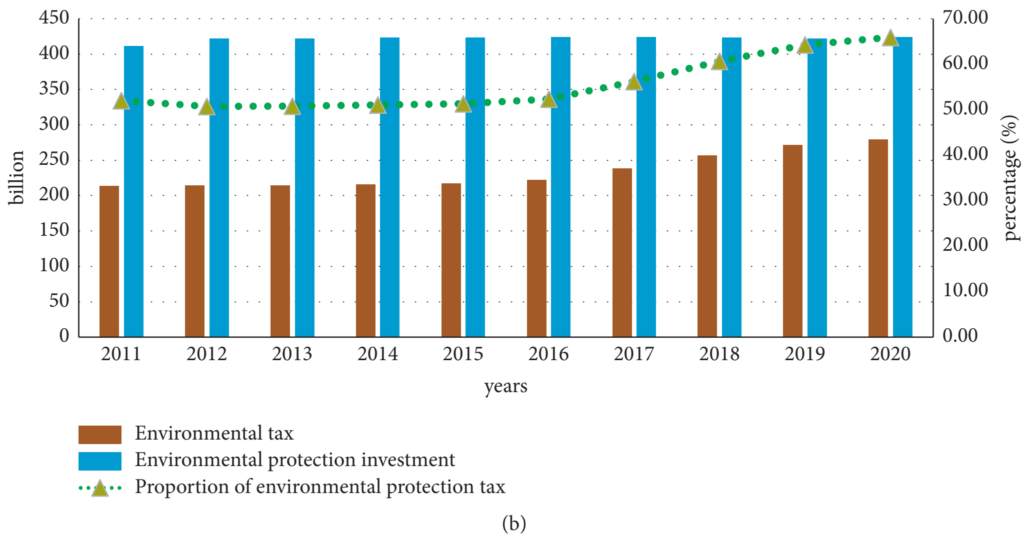


Figure 5: Comparison of results of environmental investment and environmental taxation in Brazil and Russia. (a) Statistical results of environmental taxation and environmental investment in Brazil. (b) Statistical results of Russian environmental taxation and environmental investment.

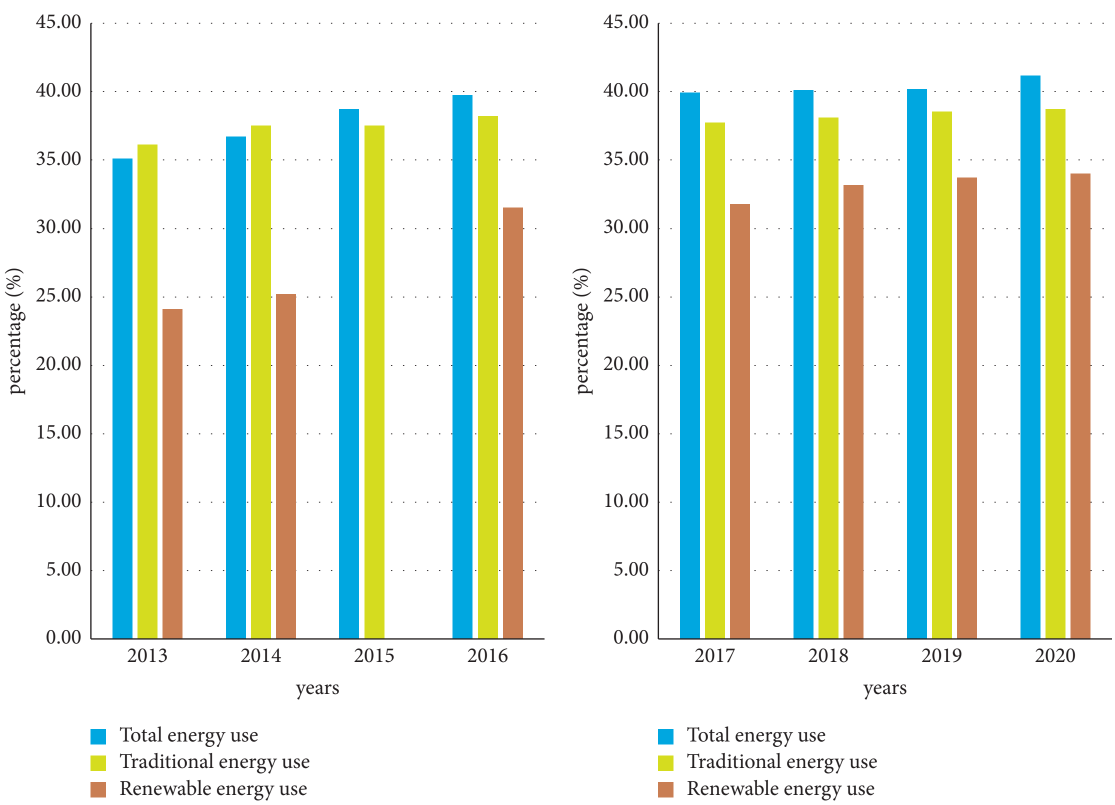


Figure 6: Share of BRICS countries in world energy over 8 years.

total investment in 2015 and before has gradually increased. Brazil's investment is 21.71 billion yuan, and Russia's investment is stable after 42.38 billion yuan. Correspondingly, the environmental protection tax has been increasing year by year, and the growth rate in Brazil and Russia from 2016 to 2020 reached 1.49% and 13.59%, respectively. Among them, Russia has the largest increase in returns on poster tax [20]. The above content calculates the attributes of economic development and environmental protection in the BRICS countries through formula (3).

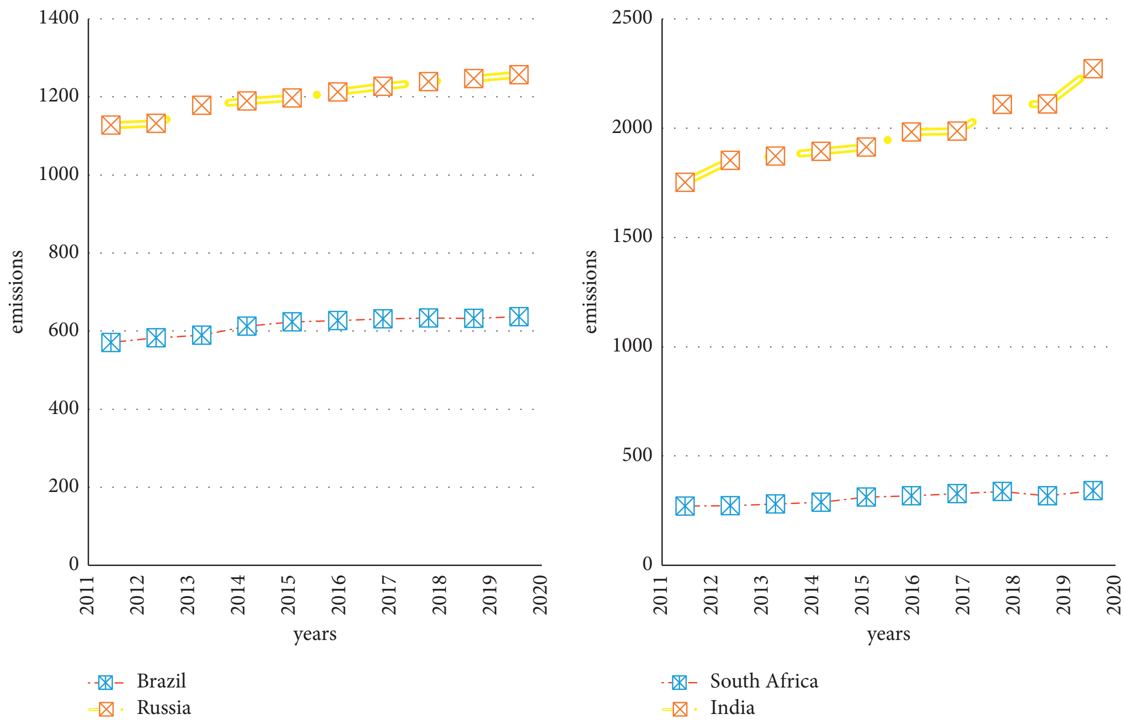


Figure 7: Pollutant gas emissions of the 4 BRICS countries.

Results of Environmental Sustainability Impacts: For environmental protection, developing countries will not take economic development as compensation. Although the development of industries has brought great damage to the environment, industry is very important to the economic development of a developing country. Since the industry needs to use a lot of energy in the process of development, in order to deal with the environmental pollution caused by traditional energy, this article will carry out quantitative empirical analysis of traditional energy and renewable energy. The result is shown in Figure 6.

The results in Figure 6 show the shift in energy usage. Traditional industrial energy is habitually used in most cases due to its high utility and adaptability, and the use of this energy is also increasing year by year [21]. It can be seen from the figure that due to the increase in the speed of development of the BRICS countries, the use of energy in the world's energy use continues to increase. By 2020, the BRICS countries will use 41.17% of industrial energy. But its use of renewable energy increased by 2.22% in 4 years 2017–2020, which reached 34.01%. Although it is not as good as the use of traditional energy, this result shows the efforts made by the BRICS countries for environmental protection. In order to better describe the attribute relationship between environmental protection and renewable energy, it needs to be calculated and defined using formula (1) and formula (3). In addition to the content discussed above, it also requires some specific and quantitative pollutant indicators for the BRICS countries in the implementation of environmental protection laws. It uses formula (6) to sum up the emissions of various pollutants, and the result is shown in Figure 7.

Figure 7 compares the emissions of pollutants in four BRICS countries. The results show that Russia and India are constantly increasing their pollutant emissions. By 2020, Russia's total emissions of polluting gases will reach 1,257 million tons, and India's total emissions of polluting gases will reach 2,271 million tons in the same year. This result shows that among the selected countries, countries with a faster development rate will produce more polluting gases. Together with the solution of the weight of formula (4), it can be known that the proportion of pollution caused by gas pollutants reaches 35.1%. After the environmental protection law was implemented in the form of taxation, the proportion of this pollutant dropped to 21.1%. It shows that the promulgation and implementation of environmental protection laws have a positive impact on the environment of the BRICS countries [22, 23].

3. Conclusion

This article is a discussion of environmental protection in the emerging economies of the BRICS in developing countries. This group of five developing countries has made its own contribution to global development in many ways. As typical representatives of developing countries, the BRICS countries have always been committed to the development of their own economic strength and comprehensive strength. Against the background of the common pursuit of environmental protection in today's international community, the BRICS countries are also carrying out environmental protection through some of their own actions. Compared with developed countries, the BRICS countries started a little late in protecting the environment due to their own development needs. In addition, the country's needs for industry and manufacturing make it difficult to coordinate the protection and destruction of the environment. At this stage, in order to implement the environmental law and better evaluate the effect of the environmental protection law, this article conducts an empirical analysis on environmental and economic development, as well as pollutants in the environment. It makes the article's elaboration on the sustainable impact of environmental protection law on the environment more complete.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Retraction

Retracted: Roles of International Environmental Law in China's Environmental Productivity: Challenges and Implications

Journal of Environmental and Public Health

Received 1 August 2023; Accepted 1 August 2023; Published 2 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] N. Tang, "Roles of International Environmental Law in China's Environmental Productivity: Challenges and Implications," *Journal of Environmental and Public Health*, vol. 2022, Article ID 8980234, 9 pages, 2022.

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Research Article

Roles of International Environmental Law in China's Environmental Productivity: Challenges and Implications

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International environmental law is the basic charter for dealing with international environmental issues, and it plays an important role in international environmental governance. In recent years, China's economy has achieved great development, but environmental problems are also very prominent. International environmental law provides a basic reference for China's environmental governance, but it also brings challenges to the development of China's environmental productivity to a certain extent. At the same time, due to the unique dominant position of international environmental law, it has played a certain restrictive role in the development of China's environmental productivity. Based on this, in order to promote the sustainable development of China's economy, this paper took China's industrial and agricultural development as the research object. This paper has conducted research on China's industrial and agricultural environmental productivity, aiming to explore the role of international environmental law in China's environmental productivity. The article first analyzed the limitation of international environmental law on China's environmental productivity, and then on this basis, the article conducted a numerical simulation of China's industrial and agricultural environmental productivity. Finally, starting from the actual development situation, the paper aimed to find out the numerical deviation of China's environmental productivity changes through quantitative analysis. In the course of the research on environmental productivity development, the article found a strong correlation between environmental productivity and international environmental law in China. The correlation between environmental productivity and international environmental law reaches 59.93% in South China and 61.02% in North China. Also, after a series of comparative analyses, the article finds that changes in climate characteristics can exacerbate the regulation of China by international environmental law and seriously affect China's economic development. In this case, China's economy declined by 2.6% year-on-year, which further pushed China to practice sustainable development strategies. This shows that it is essential to study the relationship between international environmental law and China's environmental productivity.

1. Introduction

International environmental law is the overarching charter for all international environmental relations and is a unified constraint on global environmental protection issues. China is a staunch defender of international environmental law. In the process of environmental governance and economic development, China has always implemented and enforced the relevant provisions of international environmental law. As global environmental problems become more severe, the role of international environmental law as hard law is being strengthened. In the process, international environmental law has become stricter in its restrictions on pollution emissions, but this has created a serious conflict with domestic pollution emission regulations. The sustainable development principles of international environmental law have severely restricted China's economic development and undermined its economic development strategy. China's environmental productivity has been slow to develop and faces economic, technological, and energy challenges. Moreover, environmental productivity reflects not only local economic conditions, but also China's overall competitiveness. But opportunities and challenges always go hand in hand. With the combined efforts of international environmental law and Chinese environmental law and regulations, China's environmental problems will be further improved.

At the same time, the improvement of the ecological environment will, to a certain extent, promote the progress of China's environmental productivity and bring a broader platform and space for China's economic development. On this basis, the economic value of China's industrial and agricultural products will also increase, thus providing a further incentive for the government and practitioners to vigorously develop environmental productivity and promote circular economic development. In other words, international environmental law not only poses a challenge to China's economic development, but can also promote the progress of China's environmental productivity and will further facilitate China's economic development.

Environmental productivity is the latest product of the sinicization of Marxism, which has attracted many scholars to study in recent years. Among them, Abad A established a multistage exponential model by considering the joint production of ideal and nonideal outputs in multiple production processes. The method he proposes not only evaluates the environmental productivity of the entire steel industry but also examines each of its subprocesses. Then, he proved the validity of the proposed model through the application of 48 steel enterprises in China during 2009–2013 [1]. Volis et al. aimed to investigate and study the relationship between environmental innovation, environmental performance, and environmental productivity. Using a regional accounting matrix that includes environmental accounts, he focused on sectoral environmental productivity in Italian regions. In the process, he classified them into the environmental field and the previously established WIPO Green List by adopting different international green technologies. Econometric results show that regions and sectors characterized by higher levels of green technology face better environmental performance [2]. Ahmed et al. pointed out that China has made great economic achievements in the past few decades due to the booming industry. In order to find a sustainable development path, they suggested that it is necessary to evaluate China's industrial energy and environmental productivity and to explore its reasons. Based on this, they proposed a global productivity index to evaluate China's industrial energy and environmental productivity and then found the deviation of China's industrial technological change by relaxing Hicks' neutral assumption and decomposing industrial technological change [3]. In order to study the environmental productivity of different enterprises, Wei took the amount of enterprise emissions trading as the research object. During the research process, he fully investigated China's corporate emissions trading data in the past ten years, and based on this, he made predictions on the trading data in the next ten years. Finally, he found that companies with higher environmental productivity also had lower emissions trading amounts [4]. Wang et al. pointed out that, through the formulation of environmental regulation policies, the transformation and optimization of the industrial structure can be promoted, thereby promoting the improvement of its green total factor productivity. In order to verify the relationship between green productivity and industrial structure, they used a data simulation model to analyze the green productivity of different provinces in China [5]. The above scholars have analyzed China's environmental productivity from different levels, but they have not considered the challenges brought by international environmental law to the development of China's environmental productivity.

International environmental law is closely related to the development of China's environmental productivity. Among them, Zimmermann pointed out that the adjustment and change of international environmental law will directly affect local environmental policies and regulations. In addition to this, he found that many conventions are concerned with environmental protection issues and mentioned that all countries have obligations and responsibilities for environmental damage and pollution caused by their development activities. Most of the Persian Gulf littoral countries are members of these conventions, and they are obliged to comply with environmental obligations and regulations related to their extensive activities along the Persian Gulf coast, which often lead to sea drying and land reclamation [6]. Laina pointed out that the adjustment of international environmental law has brought serious challenges to countries. In order to jointly cope with the challenges, he proposed that, from the perspective of international productivity, efforts should be made to promote the joint response of countries to environmental challenges [7]. Discussing approaches to global governance, Kotzé and French pointed out that international environmental law has been confronting emerging global environmental issues in an innovative way. At the same time, they also pointed out that international environmental law not only regulates global environmental protection issues, but also puts forward new requirements for industries related to environmental protection [8]. Humby believed that treaties or specialized judicial bodies have the advantage of addressing fragmentation and inconsistency in international environmental law, which can fill gaps in international environmental law. At the same time he proposed a centrifugal paradigm that highlights how specialized international judicial institutions can help strengthen the fragmented and inconsistent management functions of the International Court of Justice [9]. Ukovi pointed out that China's environmental regulations and policies have always followed the pace of international environmental law, but China's economic environment has also been greatly affected in the process. At the same time, he also pointed out that although the international environmental law has brought challenges to China's economy, China will surely rise to the challenge [10]. The above scholars have analyzed the rules and systems of international environmental law from different angles, but they have not combined international environmental law with environmental productivity.

Based on China's environmental productivity, this paper focuses on the challenges and significance of international environmental law to China's environmental productivity. Based on this, studying the relationship between international environmental law and China's environmental productivity is conducive to helping China break through the situation quickly and achieve sustainable economic development. Energy price and energy consumption structure have a negative impact on environmental productivity bias, but the cost of suppressing air and water pollutants has a positive impact on environmental productivity and energy bias. Among them, the deviation between labor and environmental productivity is between 0.55 and 0.57, which indicates that the price of labor will directly affect the local environmental productivity. The reason is that, in the context of international environmental law, rising prices of other energy sources will directly affect the development of local industries and damage the local natural environment. If energy prices are low, it will stimulate the local economy to vigorously develop and reduce the plunder of the natural environment.

2. Restrictions of International Environmental Law on the Development of China's Environmental Productivity

2.1. Development of China's Environmental Productivity. Environmental productivity refers to the nature of the productivity of the natural environment and its elements, as well as a green productivity produced by the integration and optimization of the natural environment and social productivity [11]. If the reproduction of water, forests, rivers, coal, and other elements in the environment is destroyed, the environmental productivity will be destroyed, and its supporting role for social development will be weakened.

Since the reform and opening up, China has continuously attached importance to and developed environmental productivity [12]. In terms of environmental legislation, China has made great achievements in accordance with the guidance of international environmental laws. A multilevel environmental legislation system has been initially formed, and environmental productivity has continued to develop. With the advancement of science and technology and the times, although China's environmental productivity has achieved certain development, its development stamina is insufficient, and the relevant legal protection is lacking [13]. Due to the large gap between the actual conditions in different parts of China, it is difficult for China to formulate uniform rigid regulations in the actual legislative process, which provides regions with a lot of autonomy. In this reality, Guangxi's environmental productivity has developed rapidly, and many regulations and management methods related to the environment have been proposed [14–16]. For example, Guangxi promulgated the "Guangxi Zhuang Autonomous Region Nanning Qingxiu Mountain Protection Regulations" to escort the development of environmental productivity. However, Guangxi is only a minority that has achieved development and progress. In most areas of China, the development of environmental productivity is extremely unbalanced, which has brought serious challenges to the overall development of China's environmental productivity.

In this case, the distribution of China's environmental productivity is both scattered and concentrated. Decentralization means that the development of China's environmental productivity is relatively scattered, and many areas where environmental productivity has achieved good development are scattered [17]. Concentration means that the overall development of China's environmental productivity is relatively concentrated; that is, the development of environmental productivity is generally slow.

2.2. Numerical Simulation of Environmental Productivity. In order to further develop China's environmental productivity and study the impact of international environmental law on China's environmental productivity, the environmental productivity of China's industry and agriculture was taken as an example to simulate its environmental productivity. On this basis, in order to assess the bias in the simulation, we further propose a related bias model.

The environment has a profound impact on the development of industry and agriculture and determines the actual local environmental productivity. In order to fully study the impact of international environmental law on China's environmental productivity, it is necessary to accurately express the environmental productivity. Among them, the simulation model of China's environmental productivity is expressed as follows:

$$\begin{aligned} \frac{d\mathcal{P}}{dt} &= r_1 + r_2 \cdot \exp\left(\mathcal{Q}_e + \sqrt{\mathcal{K}_u}\right), \\ \mathcal{Q}_e &= -\mathcal{G}\left[r_3 \cdot \left(\frac{\mathcal{T}_{\max} - \mathcal{T}_0}{\mathcal{T}_0 - \mathcal{T}_{\min}}\right)\right]^r. \end{aligned} \tag{1}$$

Among them, $\mathcal{Q}_e$ represents the environmental development conditions, $\mathcal{K}_u$ represents the economic development coefficient, and $\mathcal{G}$ represents the policy support in different regions. In this process, regional environmental factors are the main factors affecting the regional environmental productivity.

Since the commodity rate of China's agriculture is relatively low, its economic coefficient is analyzed from the perspective of environmental development. In the process of characterization, the economic coefficient is naturally divided into two parts:

$$\begin{aligned} \mathcal{W} &= \frac{\mathcal{P}}{\mathcal{Q}} = \frac{\mathcal{Q}_i}{\mathcal{Q}} + \frac{\mathcal{Q}_j}{\mathcal{Q}}, \\ 10^3 \mathcal{Q}_i &= 354.11\overline{\mathcal{T}} - 12.223\overline{\mathcal{T}}_i^2 + 1.231\mathcal{Q}. \end{aligned} \tag{2}$$

In the above formula, the economic coefficient $\mathcal{W}$ consists of two parts, the economic quantity $\mathcal{Q}$ and the output $\overline{\mathcal{T}}$. Among them, $\mathcal{Q}_i$ represents the conversion coefficient, which describes the maximum output under certain productivity conditions. $\mathcal{Q}_j$ represents the accumulation factor, which describes the minimum energy consumption required to produce a quantitative product.

On the basis of the above analysis, the environmental productivity simulation model can preliminarily simulate the development and change of the minimum environmental conditions of China's environmental productivity. Then, the most basic environmental productivity can be obtained by using the economic coefficient. The calculation process is as follows:

$$10^3 \mathcal{Q}_i \times 0.18152 \overline{\mathcal{T}}_i^2 + 10^3 \mathcal{Q}_j \times 1.2387 \overline{\mathcal{T}},$$
$$\mathcal{Y}(f) = \beta \cdot \mathcal{R}_{ij}. \tag{3}$$

In the above formula, $\mathcal{Y}(f)$ represents the final yield. The degree of deviation between economic output and the environment can be expressed as

$$\mathcal{R} = \frac{\mathcal{S} \cdot c}{1 + \mathcal{A}c}. \tag{4}$$

Among them, $\mathcal{R}$ describes the degree of deviation between environmental productivity and environmental change, $\mathcal{S}$ represents economic output, and $\mathcal{A}$ represents the magnitude of environmental change.

Based on the above calculations, the most basic Chinese environmental productivity is basically simulated, and it can be seen that the environmental productivity is greatly affected by the surrounding environment. And in order to analyze the environmental impact, a deviation model is designed on the basis of simulating the environmental productivity, which will provide support for the development of the environmental productivity which is further studied in this paper. At the same time, from the characteristics of the model, we can preliminarily see that there are many factors that affect the changes in China's environmental productivity, so this essentially determines that it will be affected by changes in related environmental factors.

2.3. Impact of International Environmental Law on China's Environmental Productivity. International environmental law is one of the important components of international law [18–20]. In the development and change of international environmental law, Chinese environmental law also changes and develops accordingly. Regarding the basic principles of international environmental law, China has always adhered to and basically followed and constantly balanced the balance between international environmental law and Chinese environmental regulations [21]. However, with the acceleration of China's development, the pressure on China's internal environment has also increased, which will inevitably lead to a collision between China's economic development and environmental development and an imbalance between international environmental laws and Chinese environmental regulations. In other words, during the development of China's environmental productivity, the changes and development of international environmental laws have brought great restrictions on China's environmental productivity.

2.3.1. Restrictions on Production Methods under International Environmental Law. With the continuous development of the economy and society, energy-saving and efficient production methods are increasingly recognized by international environmental laws [22, 23]. The development momentum of China's industrial and agricultural production has always been insufficient, and its development concept is very different from that advocated by international environmental law [24]. On the one hand, the degree of mechanization in China is not high, and agricultural planting and harvesting rely on artificial cultivation, which not only increases the consumption of resources and waste of energy, but also causes certain damage to the natural environment. On the other hand, industrial production will inevitably bring about environmental pollution, destroy the local ecology, and hinder the sustainable development of environmental productivity [25].

2.3.2. Limitations of International Environmental Law in Sustainable Development. At the same time, as energy depletion and excessive waste of resources have become global issues, international environmental law has paid more and more attention to the concept of sustainable development. China's industry and agriculture cannot form intensive production in the process of development, which cannot meet the needs of sustainable development, thus seriously hindering the development of China's environmental productivity. Under this circumstance, the mechanization and intensive development of China's industry and agriculture can continuously form sustainable development in terms of economy and resources and at the same time promote the development of China's environmental productivity [26]. However, in most areas of China, due to environmental damage and economic decline, the development of environmental productivity in these areas still has a long way to go to meet the requirements of sustainable development. Therefore, international environmental law has brought serious constraints to China's environmental productivity in terms of economic and environmental sustainable development.

3. Challenges Brought by Changes in International Environmental Law to China's Environmental Productivity

From the above analysis, we can know that the development of China's environmental productivity is directly affected by factors such as environment and energy. As we all know, China is a country rich in energy, which contains very rich natural resources. However, with the development of economy, China's energy reserves cannot meet its increasing energy demand, which forces it to import energy. And since joining the WTO, China has become the world's factory, so its demand for energy is increasing day by day. International environmental law is an international general law for coordinating environmental protection and strengthening international environmental protection and cooperation. With the aggravation of global climate problems, international environmental law is increasingly showing mandatory features, and the situation of hard legalization of international environmental law has become clear.

In this context, in order to protect their own interests, countries around the world have taken some actions aimed at maintaining their privileges and unique interests under international environmental law. Due to their relatively advanced technology and high level of economic development, developed countries are basically in a dominant position in the formulation of international environmental laws. However, developing countries have gradually become victims of changes in international environmental law due to technological and economic backwardness. China is the largest developing country in the world, so under the change and adjustment of international environmental law, China is in a very disadvantageous position.

Under the control of public opinion and technology in developed countries, the change and development of international environmental law is imminent. Although today's climate issues have delayed the mandatory measures of international environmental law, as time goes on, international environmental law will become more and more restrictive to developing countries such as China. First, it will seriously affect China's energy strategic security. At present, China's energy needs are basically maintained by imports, but with the stricter international environmental laws, China's energy reserve plan will definitely be disrupted. Second, it affects China's carbon emissions trading rights. With the accelerating process of hard legalization of international environmental law, it is an inevitable trend for China to be included in the list of regulated carbon emissions. Therefore, this will seriously further hinder the development of China's environmental productivity and bring heavy damage to China's economy. Finally, with the intensification of climate problems, many substandard industries and services in China will be suspended or regulated by international environmental laws, which makes the development of China's environmental productivity without guarantee.

4. Development of China's Environmental Productivity under the Background of International Environmental Law

According to the environmental productivity simulation model and related algorithms proposed in this paper, it combines some of the production materials of the China Industrial and Agricultural Cooperation Group in 2016 and 2017. On this basis, the article uses real data to test the model and reduces the error in the design and practice process. At the same time, in order to study the relationship between environmental productivity and changes in international environmental law, the article uses correlation analysis to analyze the degree of correlation between China's environmental productivity and international environmental law. The results are shown in Table 1.

Table 1 shows that there is a strong correlation between environmental productivity and international environmental law. Among them, the degree of correlation between environmental productivity and international environmental law in South China reached 59.93%, and the degree of correlation between environmental productivity and international environmental law in North China reached 61.02%, which shows that there is a close connection between China's environmental productivity and international environmental law.

The reason for this is that most of China's plains and hills are concentrated in South China, which conforms to the topographical factors of agricultural and industrial layout. Moreover, because these regions have relatively developed economies and relatively strong awareness of environmental protection, the frequency of communication with the outside world is relatively high, and they are easily affected by changes in international environmental laws. At the same time, North China is relatively close to the Chinese capital, and relevant policies can be implemented there soon, so it determines that the environmental productivity of the region is basically guaranteed.

In order to analyze the exact relationship between environmental productivity and international environmental law, the article then analyzes the specific impact of international environmental law on China's environmental productivity from different perspectives. Among them, the percentage distribution of agricultural environmental productivity anomaly under different economic development conditions is shown in Table 2.

Table 2 shows that there is a high link between environmental productivity and economic disparity, with the highest economic coefficient reaching 9.6%. In terms of distribution, we can see that the overall environmental productivity of China's agriculture presents a medium-high-high trend. Among them, the Yunnan-Guizhou Plateau and other places have higher economic coefficients, mainly because the natural conditions of the Yunnan-Guizhou Plateau and other places are relatively good, the ecological environment is well maintained, and it is suitable for agricultural production, so its environmental productivity is also maintained at a high level.

Due to the wide distribution of China's industries, this article only analyzes the impact of international environmental law on China's environmental productivity from several perspectives. Among them, the percentage distribution of industrial environmental productivity anomaly under different economic development conditions is shown in Table 3.

Table 3 shows that the anomalous percentage distribution of environmental productivity of China's industry basically shows a high-high-medium trend. Among them, due to the developed economy in the middle and lower reaches of the Yangtze River, it maintains a relatively high economic coefficient and output. In this case, the local area has enough energy and technology to protect the environment, so its environmental productivity remains at a high level, but as a port city, it is extremely vulnerable to changes in international environmental laws. At the same time, under its influence, changes in local environmental policies will also bring heavy losses to the development of industrial environmental productivity. In this case, the local economic coefficient tends to be zero at the lowest.

The reason is that the middle and lower reaches of the Yangtze River are the window for China to communicate with the world, so it is most vulnerable to the influence of international environmental laws. In this case, local environmental regulations are largely aligned with policies and international ideas.

Table 1: Environmental productivity and international environmental law in different geographical dimensions.

Types	Economic factor	Economic base	Energy prices	Climate features
South China	22.5	16.9	45.6	59.93
North China	23.1	18.5	49.5	61.02
Northwest	35.6	20.54	55.2	56.2

Table 2: Distribution of agroenvironmental productivity under different economic development scenarios.

Environmental productivity	Coefficient ($\mathscr{W}$)	Percentage ($\mathscr{Q}$)	Percentage ($\overline{\mathscr{T}}$)
$\mathscr{Y}(f1)$	9.6	14.4	10.7
$\mathscr{Y}(f2)$	2.0	11.2	11.9
$\mathscr{Y}(f3)$	9.2	12.2	16.4

Table 3: Percentage distribution of industrial environmental productivity anomaly under different economic development conditions.

Environmental productivity	Coefficient ($\mathscr{W}$)	Percentage ($\mathscr{Q}$)	Percentage ($\overline{\mathscr{T}}$)
$\mathscr{Y}(f1)$	24.9	15.8	2.5
$\mathscr{Y}(f2)$	21.0	14.1	3.7
$\mathscr{Y}(f3)$	25.8	0	1.8

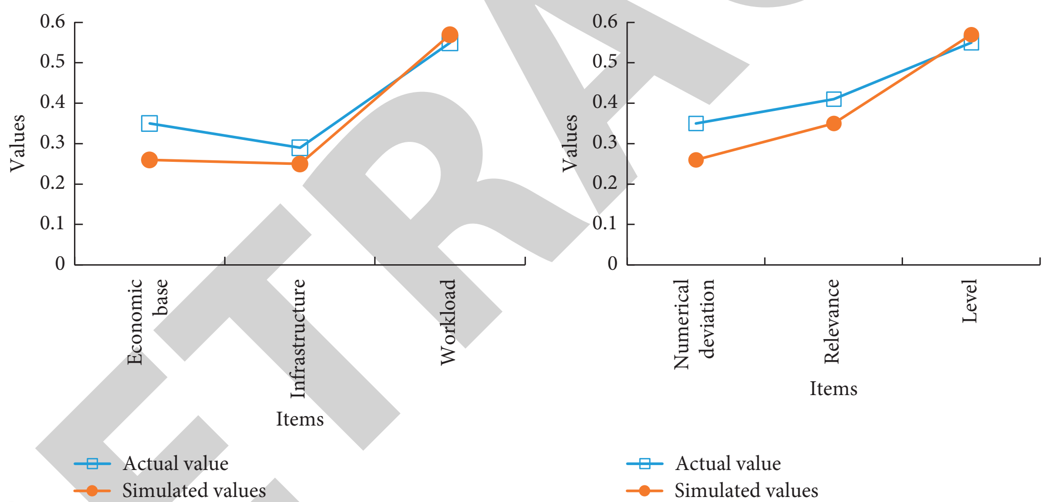

Figure 1: Economic base and environmental productivity bias.

5. China's Environmental Productivity Results under International Environmental Law

At the same time, under the influence of local environment and policies, the distribution of environmental productivity in China also presents many characteristics. In this process, international environmental law has played a leading role in China's environmental policy formulation, so it also promotes changes in environmental productivity to a certain extent. Next, this paper will focus on analyzing the deviation of environmental productivity under the background of international environmental law from the aspects of economic foundation, energy price, industrial scale, and climate characteristics.

5.1. Deviation between Economic Base and Environmental Productivity. The local economic environment directly reflects the local natural environment, which will also have a great impact on the environmental productivity of the country. According to the environmental productivity simulation model, China's environmental productivity is preliminarily estimated, and the deviation between the estimated value and the actual value is shown in Figure 1.

Figure 1 shows that the economic base has a clear positive effect on the environmental productivity bias, while the infrastructure has a direct negative effect on the environmental productivity bias. Among them, the deviation coefficient between the economic base and environmental productivity is 0.35. This is because, in most parts of China, economic development is showing an abnormal

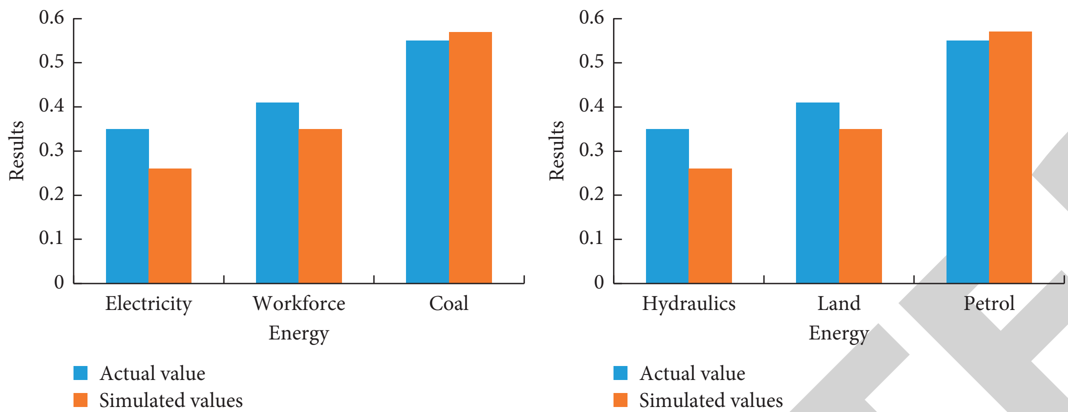

Figure 2: Energy prices and environmental productivity deviations.

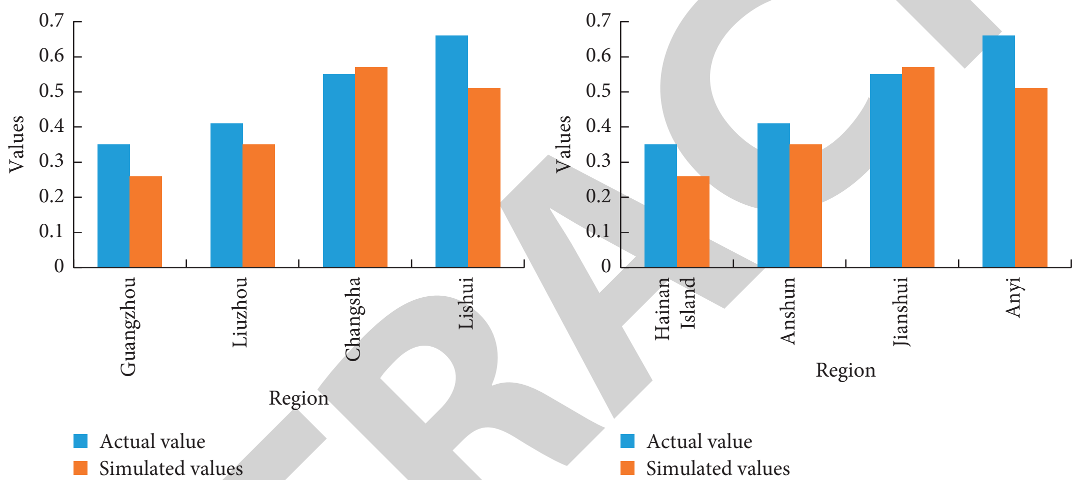

Figure 3: Industrial scale and environmental productivity bias.

development pattern. In this model, people often choose to sacrifice the environment to develop the economy, so the areas with higher economic foundations tend to have lower environmental productivity.

5.2. Deviation between Energy Prices and Environmental Productivity. The price of energy directly affects local environmental productivity. At the same time, energy prices are also an intuitive reflection of international environmental law, which to a certain extent reflects environmental policies and local environmental protection efforts. Among them, the deviation distribution between energy prices and environmental productivity is shown in Figure 2.

Figure 2 shows that energy prices and energy consumption structure have a negative impact on environmental productivity bias, but the cost of suppressing air and water pollutants has a positive impact on environmental productivity and energy bias. Among them, the deviation between labor and environmental productivity is between 0.55 and 0.57, which indicates that the price of labor will directly affect the local environmental productivity. The reason is that, in the context of international environmental law, rising prices of other energy sources will directly affect the development of local industries and damage the local natural environment. If energy prices are low, it will stimulate the local economy to vigorously develop and reduce the plunder of the natural environment.

5.3. Industrial Scale and Environmental Productivity Deviation. Since industry is the foundation of China's economy, it is necessary to expand the scale of industry in order to improve China's economic coefficient. However, vigorously developing industry may damage the environment and affect environmental productivity, which is very different from the principles of international environmental law. Therefore, international environmental law will play a certain regulatory role in the development of China's environmental productivity. Among them, the deviation between industrial scale and environmental productivity is shown in Figure 3.

Figure 3 shows that, in most regions of China, the industrial scale is large, but the level of environmental protection is not high. Among them, in Guangzhou and other places, the predicted environmental force is 9% lower than the actual value, which shows that, in relatively economically developed regions, due to technological progress and

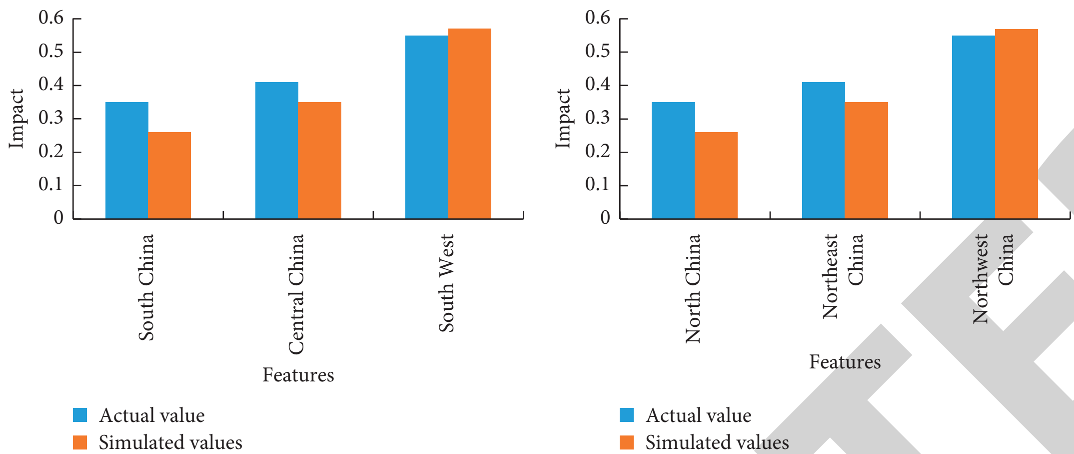

Figure 4: Climate characteristics and environmental productivity deviations.

development of concepts, local environmental productivity is relatively greatly affected by international environmental laws. In this case, the industrial scale directly reflects the local level of environmental productivity.

5.4. Bias between Climate Characteristics and Environmental Productivity. Climate is often an important factor affecting environmental productivity. Because climate and environmental characteristics are often closely related to local environmental and environmental protection policies, climate characteristics are often the best indicator of environmental productivity. Among them, the deviation distribution of climate characteristics and environmental productivity is shown in Figure 4.

Figure 4 shows that, in most of China, there is often a link between climatic characteristics and environmental conditions. Among them, especially in South China and other places, due to the relatively developed economy, this destroys the local climate characteristics to a certain extent, so the environmental productivity of the place is also affected. In South China and Central China, China's environmental productivity has also been affected, down 26% year-on-year due to changing climatic characteristics and regulation by international environmental laws. The reason is that, in most parts of China, due to the reform and regulation of international environmental laws, China's environmental productivity has also been greatly affected, which has led to a decline in the level of environmental productivity.

Undoubtedly, international environmental law has brought serious obstacles to the development of China's environmental productivity, but it has also helped China to improve the ecological environment to a certain extent. On the one hand, the policy of international environmental law on the environment is directly reflected in the import and export trade, so this also forces China to continuously improve the environment, give full play to its own advantages, and enhance environmental productivity. On the other hand, the relevant concepts advocated by international environmental law have also assimilated China's industrial and agricultural industries to a certain extent, which further promotes the sustainable development of China's economy and continuously improves environmental productivity. In this context, the relevant concepts of international environmental law continue to promote the development of China's environmental productivity, and it also points out the direction for China's economic development.

6. Conclusion

With the acceleration of globalization, the influence of international environmental law has gradually spread throughout the world. Environmental productivity concentrates on the natural productivity of a country and represents the local level of ecological development. China, as the world's largest developing country, is increasingly playing a pivotal role in environmental governance and other areas. Against the backdrop of the reformulation of international environmental law, China's traditional economic development model and economic development strategy are seriously at odds with the concept of sustainable development advocated by international environmental law. In this process, how to balance economic development and environmental protection at the same time has become a major challenge that China needs to face. Therefore, it is of great significance to study the impact of international environmental law on China's economic development and environmental productivity.

Although international environmental law has brought challenges to the development of China's environmental productivity, it has also promoted China's economic development to a certain extent. The article constructs an environmental productivity simulation model and analyzes the relationship between international environmental law and China's environmental productivity at a mathematical and theoretical level. In addition, the article also analyzes the deviations between China's environmental productivity and the impact of international environmental law in terms of economic fundamentals and energy prices. However, due to time and the limitations of the research field, the article does not go into the study of international environmental law. It

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Research Article

Analysis of the Role of Promoting Sustainable Green Growth through Government Agencies in a Legal Context

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The rapid development of the global economy has also caused the deterioration of the natural environment. The traditional economic growth method can no longer meet the development requirements of the times for the environment. The realization of sustainable and green development of human society has become the consensus of the whole society. To improve the degree of the greening of the economy, it is necessary to coordinate the management of various departments and to integrate the concept of environment and resources into economic growth. It is an important way for government departments to formulate corresponding sustainable green growth policies by relying on laws to achieve the strategic goals of sustainable green growth. In order to explore the role of government agencies in sustainable green growth through the enactment of relevant laws, this article takes China as the study of the environment. From the perspective of environmental protection tax law, through the establishment of the relationship model between ET and economic variables and ET and environmental indicators, using vector autoregression and system dynamics simulation analysis methods, the effect of ET on the environment and economy is studied. In the analysis of the impact on the environment, the impact of the auxiliary policy of ET on sustainable green growth is discussed. The experimental results show that the impact of environmental tax (ET) on GDP is more obvious. The simulation results show that when the proportion of technology investment is 35%, the promotion effect of sustainable green growth is the best. That is to say, the formulation of relevant laws and policies by government agencies has a certain role in promoting sustainable green growth.

1. Introduction

In recent years, with the rapid growth of the global economy, the excessive use of some nonrenewable resources has led to problems such as resource crisis and environmental degradation worldwide. Environmental and resource issues have become challenges that all countries in the world need to face together. The stock of resources on earth is limited. In order to promote economic growth, environmental pollution and ecological damage have been seriously neglected, resulting in massive consumption of energy and resources, and a sharp reduction in nonrenewable resources. Economic losses will be difficult to measure in the future. People are also gradually realizing that if environmental and resource issues are allowed to continue to develop, human beings will pay a high price in terms of economy, personal health, and welfare. All kinds of phenomena show that the traditional growth mode can no longer meet the needs of economic and environmental development in today's society. In this context, human beings need to consider that while maintaining economic growth, resources can continue to provide resources and environmental services to human beings. As a result, a new concept of economic development that can not only meet the needs of economic development but also conform to the concept of environmental protection emerges as the times require, namely, sustainable development strategy and green growth. In order to achieve the strategic goal of sustainable green growth, government agencies need to take effective economic measures. The research on the role and impact of sustainable green growth through a legal perspective can provide theoretical reference for government agencies to establish a sound economic policy for the common development of the environment and economy. It is of great significance to realize the new economic model of sustainable green development.

Starting from the challenges brought about by the environmental and economic problems faced by today's society, this article expresses the necessity of changing the traditional economic growth mode. This leads to the new economic concept of sustainable development strategy and green growth mode. Moreover, from the ET system in the environmental protection tax law implemented by government agencies, the relevant experimental research is carried out on the environment and the economy. According to the search of many literature studies, the research data were obtained from The National Statistical Yearbook of China, and the vector autoregression and system dynamics simulation were used for the study. The results show that the implementation of the environmental tax system has a certain impact on economic growth. Under this premise, legal policies play a supporting role. For example, increasing the proportion of investment in pollution control and technological innovation can effectively achieve the two-way development of economic growth and environmental protection concepts. In short, government agencies have a certain role in promoting the economic development model of sustainable green growth by formulating relevant tax laws. To some extent, this article studies the legal perspective on the research of sustainable green growth, but at the same time, because in the process of data analysis, the environment tax-related data are less, and the concept of environmental taxes is sorted by the literature, there are no official data, it is the limitations of this article, and it is also the direction of further improvement is needed in the future research. The innovation of this article lies in content innovation. At present, there are few studies that integrate the concept of sustainable development and green growth and establish a data analysis model from the perspective of law. Second, the system dynamics simulation is used to analyze the data, the model is tested, and the results are more convincing.

2. Literature Review

Protecting the ecological environment while maintaining the economic growth rate is the policy focus of all countries in the world, and many scholars have conducted research on this topic. Podder Bhadra studied the correlation between India's economic growth and the concept of sustainable green development and believed that such a fast-growing economy should pay more attention to the concept of sustainable green development in the process of promoting development [1]. Ali applied the concept of sustainable green development to the green business behavior of banks and analyzed the promotion effect of the sustainable green concept on green banking business through questionnaires [2]. Ge analyzed the sustainable ways to achieve green growth in regions relying on oil economic development by building a system model [3]. Vargas-Hernandez studied the influence factors and contributions of the strategic goals of green economic growth and sustainable development in actual economic transformation through a literature survey [4]. Panzer-Krause analyzed the impact of sustainable green development concepts on the development of rural areas based on a survey of the development concepts of tourism entrepreneurs in rural Ireland [5]. It can be seen that most of these studies on sustainable green growth are aimed at its effects in other aspects, while few of them involve policy research on sustainable green development. An important tool for government agencies to intervene in the market economy is policy, of which taxation is an important part. Therefore, it is necessary to study the ET system constituted by the implementation of economic means.

The ET system is based on the environmental protection tax law. Environmental protection has long been an important issue under the economic development goals of various countries. Sadeleer believed that environmental protection measures should include the formulation of relevant environmental protection tax laws, and analyzed the key issues of levying ET on some large retail enterprises [6]. From the perspective of environmental protection, Yang analyzed the state and pattern of formulating energy use intensity in commercial buildings and investigated the relationship between ET and energy intensity [7]. Zhang carried out a two-layer multiobjective optimization of waste distribution management under the premise of considering ET [8]. Xue Xu analyzed the improvement effect of ET law on urban air pollution through the study of urban air quality [9]. Bassani studied the challenges faced by the ET system between environmental protection and economic compensation [10]. In contrast to existing global-scale studies focusing on semifinished HWP, Zhang has developed a methodology to link global HWP production and end-use by using the Eora multiregional input-output table [11]. Most of these studies are based on the premise of known ET, and research on a single issue of the environment and the economy. Although some of them considered economic issues from the perspective of environmental protection, relatively few of them considered sustainable green development of both environment and economy. However, the environment and the economy are inseparable, and there is a need for coordinated development between economic development and environmental protection. Therefore, it is in line with the needs of the times to explore the influence of relying on the legal system for the coordinated development of economic growth and environmental protection.

2.1. Theoretical Deconstruction of Promoting Sustainable Green Growth from the Perspective of Law

2.1.1. Deconstruction of Sustainable Green Growth Theory. Green growth is a circular economy development mode with resource conservation and environmental protection as constraints. Green represents the environment and growth represents the economy, so green growth emphasizes the positive relationship between the environment and the economy [12]. Sustainable development is broadly defined as follows: under the premise of ensuring that natural resources can continue to provide resources and environmental services for the development of human society, it can produce the best results in terms of the economy [13]. It requires people to take into account the resource and environmental needs of future generations while using the natural environment to develop the economy. Green growth is an extended concept of sustainable development theory. At the same time, the strategic goal of sustainable development also provides a leading direction for green growth [14] as shown in Figure 1.

As shown in Figure 1, the basic content of sustainable green growth includes the sustainable development of economy, ecology, and society [15]. Environmental resources on earth are scarce. While pursuing economic development, human beings should also take into account the interests of the next generation and should not blindly pursue economic development. For countries whose industrialization development process is gradually accelerating, the problem of environmental pollution is inevitable. The difficulty is to minimize the problem of environmental pollution. If environmental problems cannot be properly solved, it will also restrict economic growth. Therefore, both developing countries and developed countries need to pay attention to economic development while taking into account the protection of environmental resources, so as to fully realize the goal of green growth [16]. In China, green development mainly includes the content and methods of ecological governance at the micro and macro levels, for example, the integration of green concepts into industrial development to promote industrial upgrading; environmental protection as a part of the green industry has become a new driving force for economic growth and other social phenomena can be called the content of green development. In this process, government agencies need to break through the laws and regulations of ecological governance, integrate the idea of ecological governance into the law, formulate corresponding laws to support ecological governance work, and realize the institutionalization of sustainable green development and the standardization of sustainable green growth [17].

In general, to achieve sustainable green growth, the government, enterprises, and the public need to be united. While achieving economic development and completing the protection of the environment, the state and society should encourage innovation and encourage enterprises and government departments to learn advanced management experience and develop advanced technologies. It is used to seek sustainable green and healthy economic development methods and more efficient organizational models [18], incorporate the concept of sustainable development into the formulation of laws and regulations, and integrate the concept of sustainable green growth into the daily life of the people, so as to better promote its development.

2.1.2. ET System and Its Theoretical Relationship with Sustainable Green Growth. With the increasing problem of environmental pollution, the state has promulgated relevant environmental protection laws and regulations. Among them, the introduction of the Environmental Protection Tax Law is an economic means to reduce environmental pollution while maintaining economic growth under the market economy. The ET under the Environmental Protection Tax Law mainly refers to some taxes with green properties. The theoretical relationship between ET and sustainable green growth is shown in Figure 2.

As shown in Figure 2, the content of sustainable green growth includes three aspects: economy, environment, and society. A complete sustainable green growth system is the balanced development of these three aspects. Energy resources in the environment can bring value to the economy, and while realizing economic value, attention should be paid to maintaining environmental quality and having a good natural environment and economic level. Humans will have more social welfare, which is an interlocking cyclic process. In order to realize this whole process perfectly, enterprises, institutions, and individuals need to have good environmental awareness. Government agencies should encourage society to realize technological innovation and formulate relevant laws and policies for pollution control [19]. Appropriate subsidies should be given to encourage enterprises to move closer to the concept of sustainable green growth while collecting environmental taxes.

From the relationship between the two, the ET system can promote sustainable green development. This is because the effective implementation of the ET system can solve the problems of unreasonable resource allocation and environmental pollution control to a certain extent. A good and harmonious resource and environment is an important prerequisite for achieving sustainable green growth. From another perspective, the implementation of the ET system and the legalization of the concept of protecting the ecological environment for people from all walks of life are conducive to promoting the process of sustainable green development in the whole society. Therefore, it can be said that ET can actually provide the necessary guarantee for sustainable green growth. These tax revenues can provide corresponding financial support for environmental pollution control [20]. In this process, the environmental cost of enterprises has increased, which can effectively restrain the current situation of excessive environmental development and pollution and effectively achieve the purpose of environmental protection. In recent years, the government has reduced the frequency of consumers' use of products that can cause environmental damage through price regulation, which is also a manifestation of sustainable green growth. For example, the rise in gasoline prices has promoted the increase in sales of new energy-saving vehicles, indicating that the implementation of the ET system can promote the sustainable development of people's consumption behavior [21, 22]. All in all, from a theoretical analysis point of view, the environmental tax system can effectively promote sustainable green growth.

2.1.3. Sustainable Green Growth Evaluation. In recent years, the theory of sustainable green growth is developing constantly. The concept of green growth is not only limited to

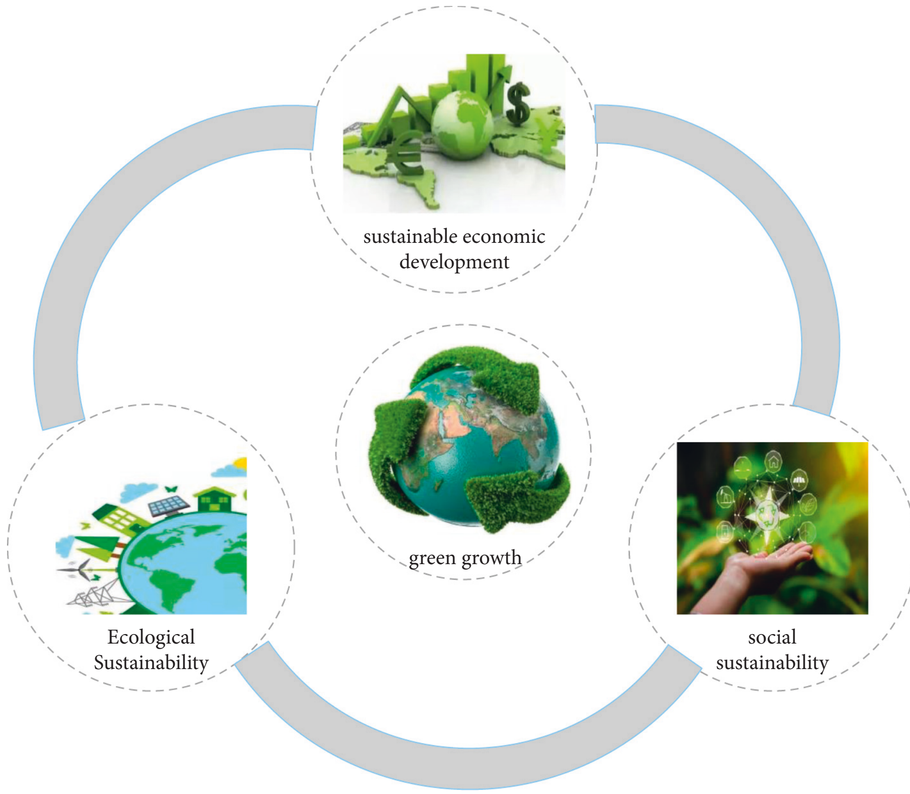


Figure 1: Basic elements of sustainable green growth.

theory, but also gradually begins to develop into practice. Therefore, how to judge the fit degree of green growth theory and practice, that is, how to evaluate the actual results of green growth in practice, is an important step for green growth to be successfully practiced from theory. Therefore, it is necessary to objectively evaluate the contribution of green growth to reality. At present, the evaluation index system mainly focuses on the evaluation system established by international authoritative institutions, experts, and scholars around the world. Among them, international authorities include OECD, UNEP, WB, and GGGI. The rating indicators established by OECD are evaluated from these aspects: economic background and growth characteristics, environmental resource productivity, natural resource base, environmental quality, economic development opportunities and policy support, and correlation with green growth, rationality analysis, and data scalability. UNEP constructs evaluation indicators from three aspects: environmental problems and development goals, green economic measures intervention, and the relationship between green economic measures and society. WB takes society, economy, and environment as the overall framework and constructs from the aspects of environmental quality improvement, consumption of human material resources and natural resources, employment, and so on. GGGI takes the country as the basic consideration unit and designs the evaluation index comprehensively from the perspective of the country's general situation, development, and support. The evaluation indicators established by experts and scholars around the world are basically based on international authoritative institutions and modified according to the characteristics of the study area. This article will integrate the evaluation indicators of international authoritative institutions and study sustainable green growth from the aspects of environment and economy.

2.2. Deconstruction of the Role of Promoting Sustainable Green Growth from a Legal Perspective

2.2.1. Data and Variables. This article conducts relevant research on the cycle system of sustainable green growth, and defines variables from the aspects of economy, environment, society, and ET. First, economic variables include GDP, urban unemployment rate, and consumer price index (CPI); environmental variables include wastewater, waste and solid waste (three wastes) emissions, energy consumption, and pollution index [23]. Social variables include the Human Sustainability Index (HSDI) adjusted for unevenness. ET supporting policies are reflected in pollution control, technology investment, and general user subsidies. This article will study the impact of these supporting policies on the environment.

The pollution index mainly measures the impact of the "three wastes" on the environment, and its calculation formula is as follows:

$$\lambda_a = \sum_{b=1} \omega_b \delta_{ab}. \tag{1}$$

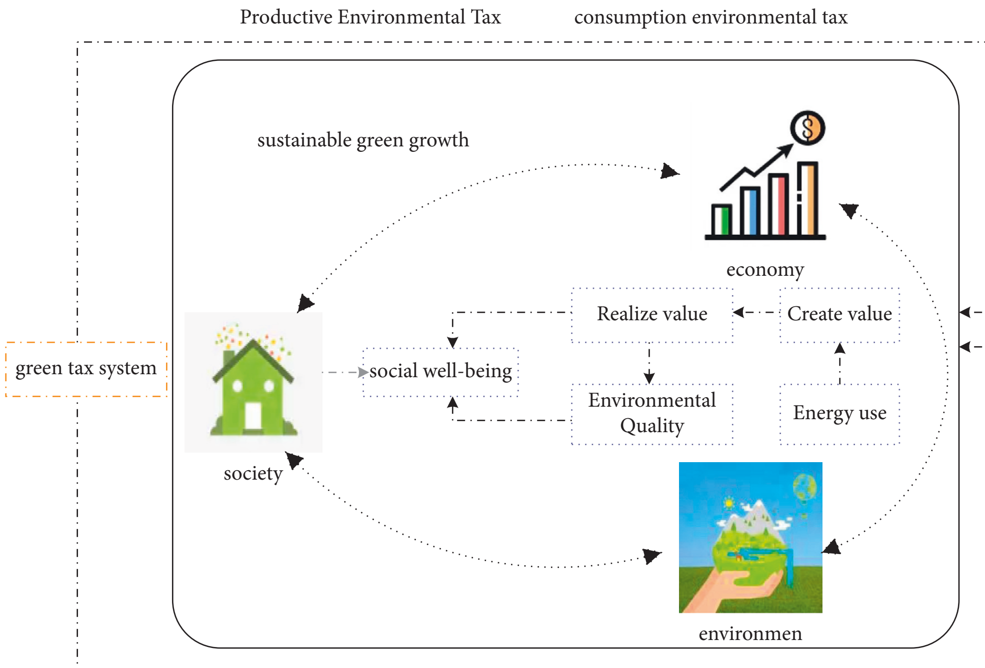


Figure 2: Theoretical relationship between ET and sustainable green growth.

Among them, a represents the year, b represents the number of pollution indicators, δ represents the proportion, and ω represents the weight.

The HSDI is composed of health, education, income, and pollution index, and its calculation formula is as follows:

$$HSDI = \sum_{T=1}^{R} \frac{(M_T - N_T)^{Ginl}}{(K_T - M_T)R}. \quad (2)$$

According to the data from China's National Statistical Yearbook, the environmental protection tax revenue has had specific values since 2018. The data for the past three years are shown in Table 1.

As shown in Table 1, the environmental protection tax in the past three years has not accounted for a small proportion of the total tax revenue, and the data are relatively small. Therefore, this article will select other tax revenue related to environmental protection for relevant analysis, which can explore the impact of environment-related tax regimes on the economy and the environment. All these environment-related taxes are collectively referred to as ET, and the details are as follows. For example, value-added tax, consumption tax, and enterprise income tax reflect economic aspects; in terms of land, urban land use tax and farmland occupation tax; it also includes resource tax and vehicle purchase tax. According to the data from China's National Statistical Yearbook, the ET revenue data from 2011 to 2020 are shown in Table 2.

As shown in Table 2, in general, the ET revenue generally increases year by year, with a few taxes increasing and decreasing. In order to better reflect the greening degree of taxation, the total ET revenue and total tax revenue and their ratios are drawn into a statistical figure, as shown in Figure 3.

As shown in Figure 3, during the period from 2011 to 2020, ET revenue increased almost year by year. In 2020, affected by the pandemic, various tax revenues decreased. The proportion of ET revenue grew the fastest between 2015 and 2017 and was relatively stable after that, which also shows that the implementation of ET needs to be improved.

The data of GDP, urban unemployment rate, and consumer price index from 2011 to 2020 are shown in Table 3.

The emissions and total energy consumption of the "three wastes" from 2011 to 2017 are shown in Table 4.

The data in Tables 3 and 4 are all from the National Statistical Yearbook of China. This article will use these data to explore the impact of environmental taxes on the economy and the environment.

2.3. *Deconstructing the Role of ET on the Economy.*

First, according to the data contained in Figure 3 and Table 3, it is assumed that ET is conducive to sustainable economic growth. Next, the vector autoregressive model will be used to test the hypothesis, and the impulse function will be used to analyze the vector autoregressive model. The obtained experimental results are shown in Figure 4.

As shown in Figure 4, when the ET is given a positive shock, the responses of GDP, urban unemployment rate, and CPI are observed, respectively. From the perspective of GDP indicators, GDP rose gradually in the early stage, but the increase was not large. Then, there was a negative growth in GDP, indicating that the ET had an inhibitory effect on GDP. However followed by growth again and again, the magnitude of the role was getting bigger and bigger, indicating that the impact of ET on GDP is more notable. Judging from the urban unemployment rate indicator, in the

Table 1: 2018–2020 environmental protection tax data.

Year	Environmental protection tax revenue (100 million yuan)	Total tax revenue (100 million yuan)	Proportion (%)
2018	151.38	156402.86	0.097
2019	221.16	158000.46	0.140
2020	207.06	154312.29	0.134

Table 2: ET revenue data from 2011 to 2020 (100 million yuan).

Year	Added value tax	Consumption tax	Corporate income tax	Resource tax	Urban maintenance and construction tax	Urban land use tax	Vehicle purchase tax	Farmland occupation tax
2011	24266.63	6936.21	16769.64	595.87	2779.29	1222.26	2044.89	1075.46
2012	26415.51	7875.58	19654.53	904.37	3125.63	1541.72	2228.91	1620.71
2013	28810.13	8231.32	22427.2	1005.65	3419.90	1718.77	2596.34	1808.23
2014	30855.36	8907.12	24642.19	1083.82	3644.64	1992.62	2885.11	2059.05
2015	31109.47	10542.16	27133.87	1034.94	3886.32	2142.04	2792.5916	2097.21
2016	40712.08	10217.23	28851.36	950.83	4033.60	2255.74	2674.16	2028.89
2017	56378.18	10225.09	32117.29	1353.32	4362.15	2360.55	3280.67	1651.89
2018	61530.77	10631.75	35323.71	1629.90	4839.98	2387.60	3452.53	1318.85
2019	62347.36	12564.44	37303.77	1821.64	4820.57	2195.41	3498.26	1389.84
2020	56791.24	12028.10	36425.81	1754.76	4607.58	2058.22	3530.88	1257.57

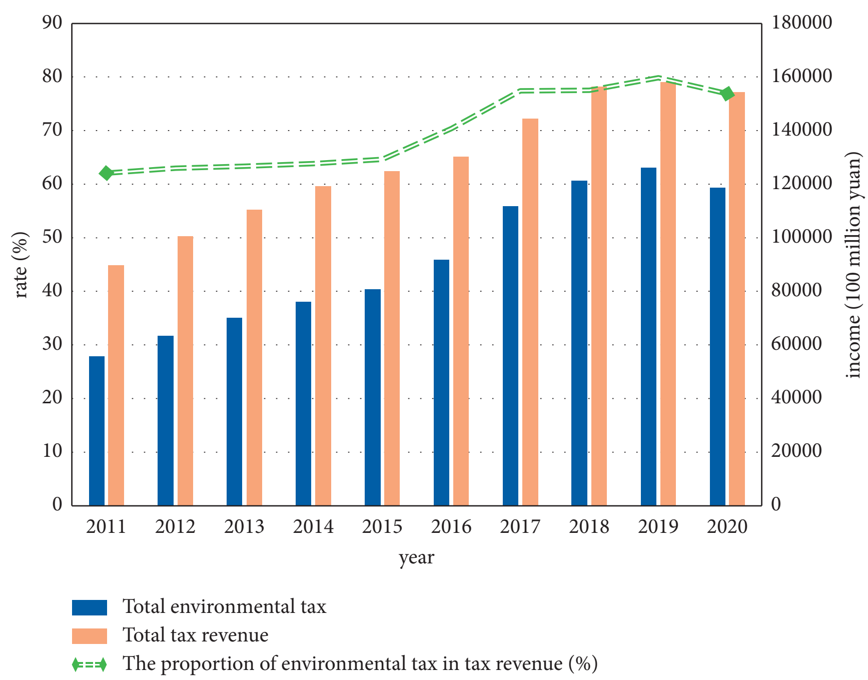


Figure 3: ET and their proportions.

Table 3: Data on some economic variables from 2015 to 2017.

Year	GDP (100 million yuan)	Urban unemployment rate	Consumer price index (CPI)
2011	487940.2	4.1	109.8
2012	538580.0	4.1	109.1
2013	592963.2	4.05	107.9
2014	643563.1	4.09	108.4
2015	688858.2	4.05	109.5
2016	746395.1	4.02	108.2
2017	832035.9	3.9	106.6
2018	919281.1	4.9	107.4
2019	986515.2	5.2	106.1
2020	1015986.2	5.2	97.8

Table 4: Emissions and total energy consumption of "three wastes" from 2011 to 2017.

Year	Wastewater discharge/ten thousand tons	Exhaust emissions/ten thousand tons	Solid waste output/ten thousand tons	Total energy consumption (tons of standard coal)
2011	6591922	5901.01	322772.34	387043
2012	6847612	5691.16	329044.26	401238
2013	6954433	5549.42	327701.94	416913
2014	7161751	5793.17	325620.02	428334
2015	7353227	5248.15	327079	434113
2016	7110954	3507.83	309210	441492
2017	6996610	2930.49	331592	455827

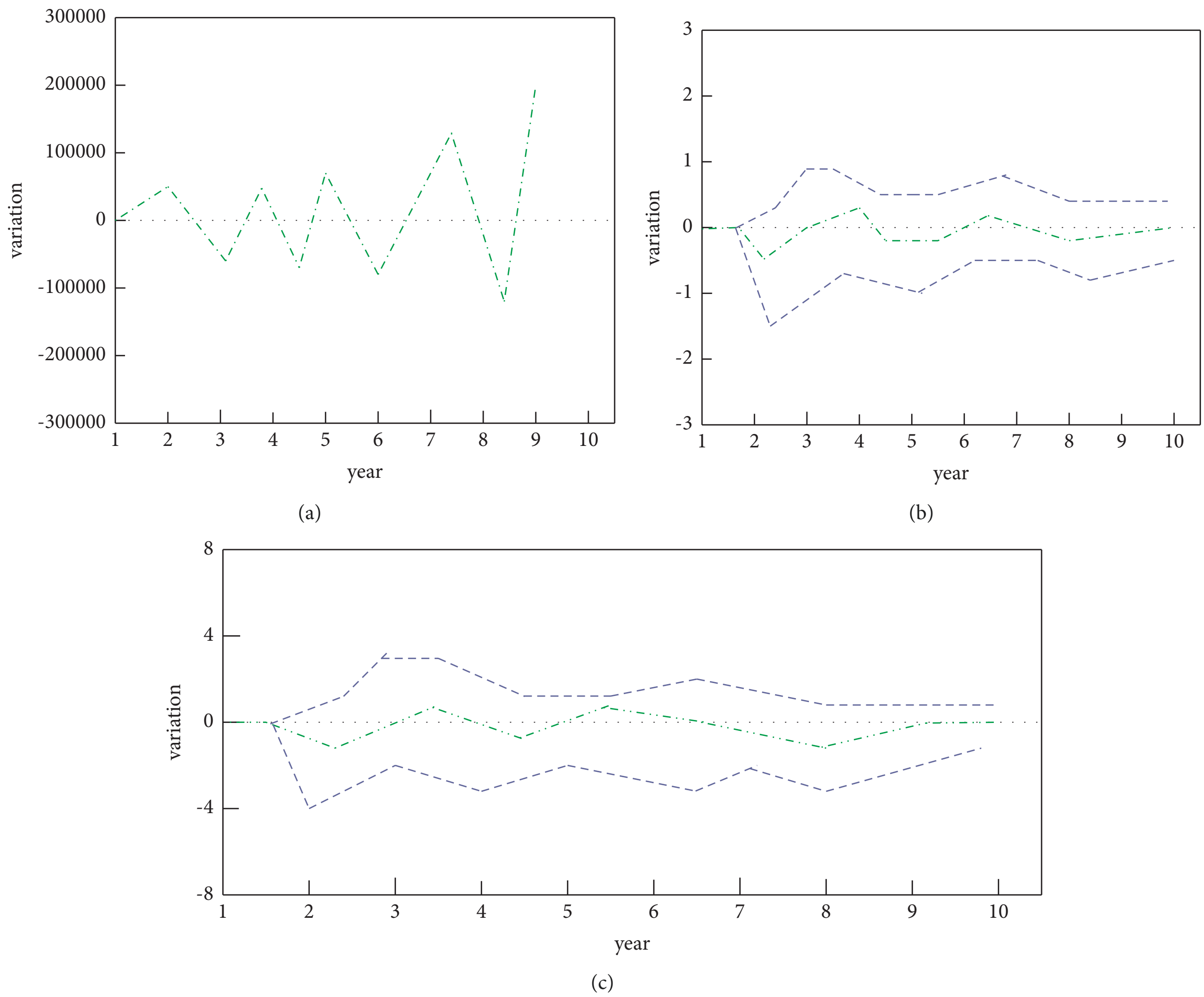
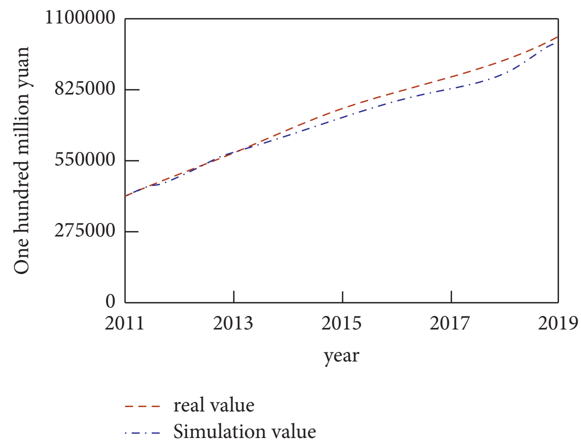


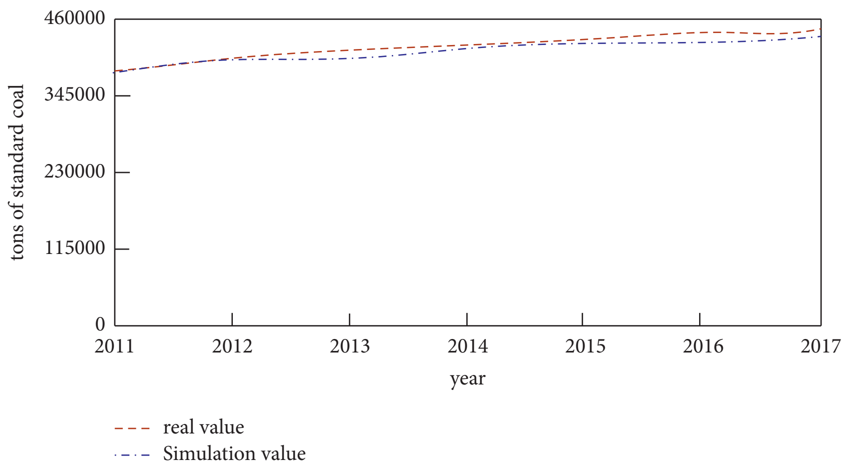
Figure 4: Response functions between ET and several economic variables. (a) Response curve of GDP to ET. (b) Response curve of urban unemployment rate to ET. (c) Response curve of consumer price index to ET.

initial stage, the curve is downward; it can be seen that the ET has a restraining effect on the unemployment rate, but there is almost no change after that. It shows that the ET has an impact on employment promotion only at the beginning, but in the long run, this impact is negligible. The same is true for CPI. The trend of change is similar to that of the unemployment rate, and there is almost no change in the later period. It shows that the impact of ET on CPI is very weak, that is to say, prices will not fluctuate greatly because of ET.

According to the analysis of the above three functions, it can be concluded that the impact of the ET system on GDP is relatively obvious. This effect circulates between inhibition and promotion, and the force gradually increases. This shows that government agencies implement an effective ET system, which has a greater impact on the economic aggregate. Overall, the ET system can effectively promote the realization of sustainable green growth. However, in terms of employment and prices, the impact of ET is minimal, indicating that the implementation of the ET system does not



(a)



(b)

Figure 5: Fitting diagram of simulated value and real value. (a) Fitting graph of simulated GDP and real GDP. (b) Fitting diagram of simulated value and real value of total energy consumption.

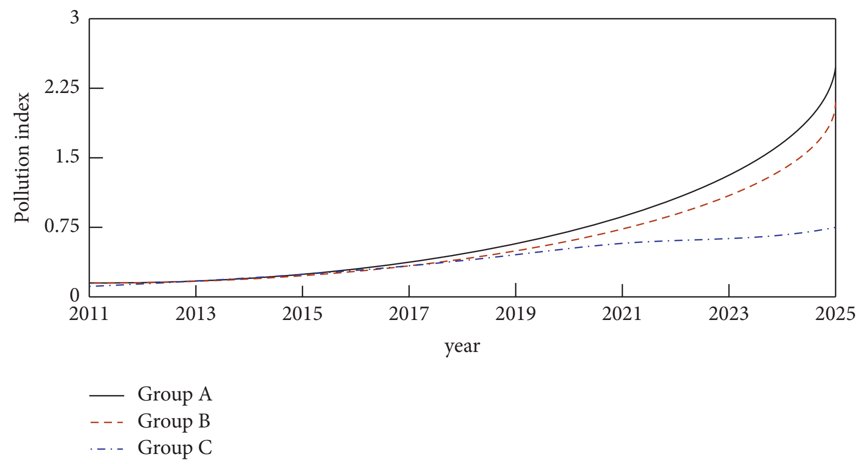
affect people's employment and consumption levels. From this, it can be shown that environmental taxes mainly have an impact on GDP in economic variables.

2.4. Deconstruction of the Effect of ET on the Environment. The analysis of the environment will be carried out with two variables, pollution index and HSDI. Predictive analysis of these two indicators is carried out through system dynamics simulation. First, the validity of the model is verified. This article will test the consistency between the retrograde simulated value and the real value, and the test results are shown in Figure 5.

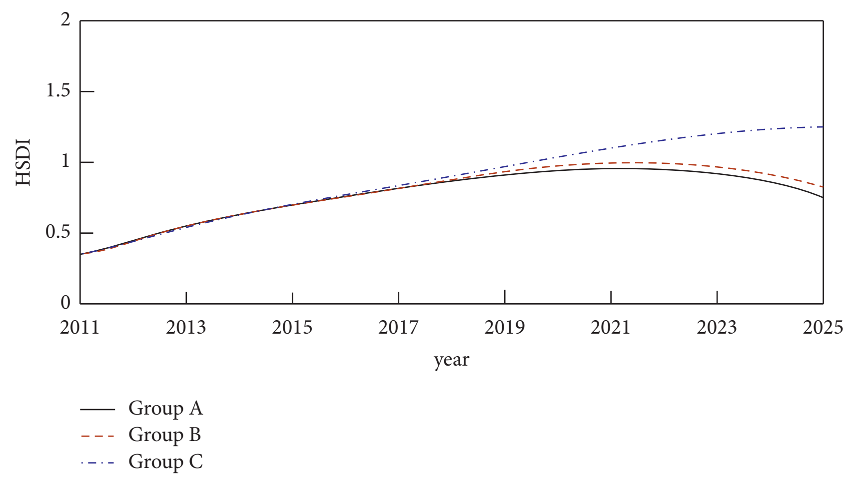
It can be seen from the data in Figure 5 that the average absolute error between the simulated value and real value of GDP and the total energy consumption is 4.85% and 4.98%, respectively, and the simulated value is basically consistent with the real value, indicating that the variable selection and parameter setting of the model and the functional relationship between variables are reasonable.

During the experiment, in order to better observe the impact of ET and its supporting policies on the environment, three groups of schemes were designed for comparison. Among them, group A represents the situation where there is no investment in ET and its related content, as a control group, group B represents the participation in ET but no investment in other related policies, group C is in the case of adding ET, and the investment in other related policies is the same. The proportion of investment is 20%. The obtained simulation results are shown in Figure 6.

As shown in Figure 6, when the ET is added and there is no support for other related policies, the pollution index decreases. It shows that the emission of pollutants has been alleviated, but the mitigation extent is not large. When the ET was added and the relevant policies were invested, the pollution index decreased significantly. It shows that while levying ET, encouraging enterprises to carry out technological innovation and providing subsidy support has a certain effect on curbing environmental pollution. The simulation results of HSDI also show that when the ET is levied alone and supplementary support is added, the HSDI has a certain increase, but the increase is small. After adding auxiliary support, the increase is larger. However, in the long run, the change in HSDI shows a downward trend. It shows



(a)



(b)

Figure 6: Pollution index and HSDI simulation results under different scenarios. (a) Simulation results of a pollution index. (b) HSDI simulation results.

Table 5: Group ratio settings.

Group	Proportion of investment in pollution control (%)	Proportion of technology investment (%)	Proportion of subsidy input for general users (%)
Control group	20	20	20
D	35	20	20
E	20	35	20
F	20	20	35

that after adding ET and its auxiliary policies, the environment can be improved within a certain period of time, but the environmental cost will also increase, which will bring pressure on the economy and society. In general, the collection of ET and supplementary policy support can achieve a better effect on sustainable green growth.

From the simulation results, the simultaneous implementation of ET and related policies is more conducive to the sustainable development of the environment and economy. Next, it will be discussed how to adjust the investment ratio of auxiliary policies under the premise of adding ET. That is, pollution control, technology investment, and general user subsidy investment are simulated and analyzed according to different investment ratios. Under the premise that the environmental tax conditions remain unchanged, the input ratios of the three control groups are set to be 20%, and the experimental groups are groups D, E, and F. Based on the control group, the investment ratios for the three policies were increased by 15%. The proportion setting of each group is shown in Table 5.

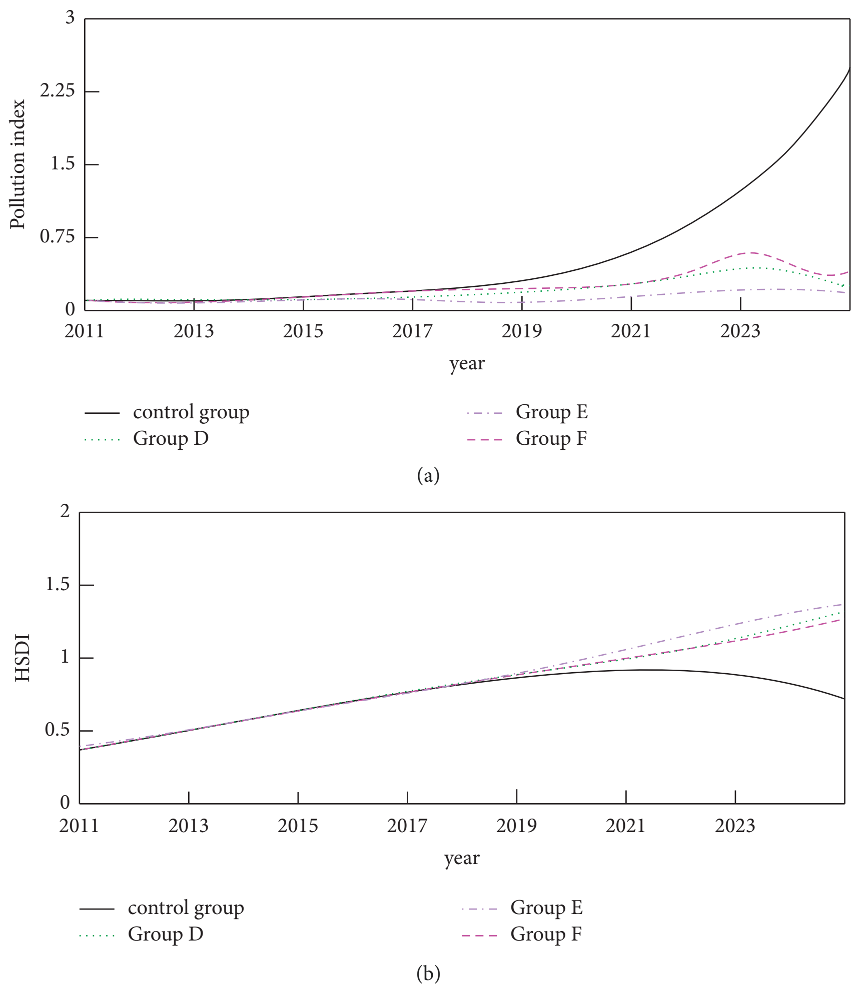


Figure 7: Pollution index and HSDI simulation results under the adjustment scheme. (a) Simulation results of the pollution index. (b) HSDI simulation results.

As shown in Table 5, the setting ratio of the simulation was carried out according to the content of Table 5, and the obtained simulation results are shown in Figure 7.

As shown in Figure 7, when the input ratios of the three auxiliary policies are inconsistent, the effects on the pollution index and HSDI are also inconsistent. It can be seen that when the technology investment ratio is the highest, the environmental pollution index is the lowest, and the HSDI value is the highest. It shows that increasing the support for technology has a greater effect on promoting sustainable green growth, and the proportion of investment in increasing pollution control is slightly better than that in user subsidies. On the whole, under the conditions of the implementation of ET, appropriate investment in technology should be given, and the proportion of funds for pollution control should be increased accordingly, which will play a better role in the development of the green economy.

From the above two sections, it can be seen that environmental tax has a certain impact on environmental protection and economic growth. Moreover, its effect on GDP is more obvious, its effect is cyclical, and its effect on GDP increases year by year. In terms of employment and prices, environmental tax has little impact on these two aspects, indicating that the economic and employment dividend brought by the environmental tax is not significant at present. From an environmental point of view, increasing investment in technology is more conducive to sustainable green growth.

3. Conclusion

This article explores the relationship and retrograde between ET and sustainable green growth by constructing an analytical model. Comprehensive economic and environmental analysis shows that ET has a more obvious role in promoting sustainable green growth. In terms of the economy, adding ET has an obvious effect on economic growth, but has little effect on the unemployment rate and consumption level. In terms of the environment, adding an ET can effectively reduce the emission of pollutants and increase the level of HSDI. Under the condition of ET, supplemented by supporting policies, such as technology investment and pollution control investment, the improvement effect on the environment is the best. In general, it can be concluded from the related research in this article: first, the ET can be increased in the initial stage, but it should be appropriately reduced in the long run. This is due to the large amount of pollutants discharged in the initial stage. At this time, increasing the ET can achieve a good restraint on such behaviors of enterprises. With the passage of time, the emission of pollutants is less, and the improvement effect will be significantly weakened by continuing to implement the original policy at this time. Second, auxiliary policies should be properly equipped with the collection of environmental theory, especially the technical innovation of enterprises can be given corresponding support. To a certain extent, this can better achieve the goal of sustainable green growth. In general, government agencies have a good role in promoting sustainable green growth by formulating relevant laws and policies and supplemented by supporting policies. The concept of sustainable green growth has been put forward so far. Relevant research on action path, evaluation index, and other aspects is mainly based on the macro level, but the research on the micro level of a certain industry or enterprise needs to be further pursued. At the same time, according to China's official data, from the legal angle, using the authority of a government that has set up the environment tax that is collected and measures that are still in their infancy, it is only appropriate to change, on the basis of blowdown cost in the future, how legal means are used to promote sustainable green growth, which is the focus of subsequent research.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

Environmental Emission Validation Analysis Using a Dual-Fuel Engine

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The research work presents the results of testing using an internal combustion engine ignition/compression using diesel and LPG mixtures without preheating. The energy performance of regulated brake emissions and changes in fuel consumption for a compression ignition engine is investigated in this study. It is assured that the engine's operation is not harmed as a result of the installation of this mix. The engine produces torque and power when it is working according to the design parameters. In tests with these combinations, results with a thermal efficiency of 10% were obtained, which was higher than the 5% obtained in diesel tests. It is used in compression ignition engines to offer a fuel source for the generation of electrical energy.

1. Introduction

Currently, about 60% of the oil produced in the world is used to produce fuel for fuel system transportation. The greatest challenges that the world has are access to energy, environmental sustainability, security, and development for economic growth [1]. Therefore, it is given as a solution to liquefied petroleum gas (LPG). LPG is a fuel derived from the mixture of propane and butane. The first is present in large quantities, and the second may be in low percentages; these are obtained from natural gas deposits or distillation petroleum [2]. This project aims to check whether the diesel-LPG mixture without preheating and without substantial modifications to the internal combustion engine of compression ignition can operate adequately, and to further study whether the engine is properly operated, then the behavior of emissions such as carbon dioxide (CO_2), carbon monoxide (CO), and unburned hydrocarbons (HC). On the contrary, the economic benefits are due to the difference in fuel prices, especially when assessing diesel fuel with different volumetric flow rates compared with when assessing LPG. Internal combustion engines are part of the most energy generators currently used, and their main function is to change the chemical energy produced by mechanical energy fuel [3]. Due to their great versatility, they are used in various applications such as land and sea transportation, plant power generators, and non-interconnected areas, that is, places where the possibility of having energy is minimal. The generation of electricity using an internal combustion engine is a solution to the lack of energy. This is one of the most used motors in the industry, such as compression/ignition. One of the disadvantages of compression/ignition engines is the emissions generated when operating [4].

For this reason, it is desired to make a mixture of diesel and LPG to study the effects that combustion of these can have on emissions and therefore know whether there is a reduction in consumption of the fuel by the addition of LPG. On the contrary, it is important to expand knowledge about diesel-LPG (dual-fuel) engines to contribute to an energy solution at the national level [5]. With the implementation of diesel-LPG mixture as a fuel in a combustion engine internally, a considerable decrease is expected in the particles expelled in the exhaust gases, promoting care for the environment, in addition to benefiting sectors that lack electricity service [6]. LPG is a natural hydrocarbon fuel consisting of propane and butane in any percentage. When pressure is applied, it liquefies, allowing storage of a large quantity versus a small volume. Many cars worldwide use this gas since it has low cost, is environmentally friendly, generates better performance, and is safe to use [7]. A better combustion rate of LPG than that of diesel helps extend the engine's life; it is also a noncorrosive, additive-free gas with an octane good rating. The addition of LPG before the turbocharger reduces the air temperature, thus favoring the air-gas mixture that later burns with diesel, which is used as an additional fuel instead of a substitute fuel. A study of liquefied petroleum gas as an alternative motor fuel shows how to combine diesel with LPG to reduce polluting gas emissions [8]. They created an injection system for the gas, which is remotely controlled using a computer injected according to the engine requirement; it was concluded that when revolutions increase by a minute of the engine, the CO decreases and NOX increases. In another instance, the use of liquefied petroleum gas has more advantages than disadvantages [9]. However, its most notable flaw is the stored way it is made in pressure tanks and is later distributed. Safety is an important factor, and the transport of LPG can threaten it. For example, there have been several accidents where LPG explodes; however, they have been minimized with the rules that have been stipulated [10]. Another interesting aspect is the great expectation of implementing the LPG as an alternative fuel within the automotive industry and even transitioning to other more environmentally friendly energy sources. Regarding the design and regulations for converting motor vehicles with gasoline to those with LPG, many books and other literature discuss the performance and LPG engine efficiency through experiments, models, and simulations [11]. Finally, the following work combines two fuels, diesel and liquefied petroleum gas, which is developed to guarantee that a combination of fuels can reduce the polluting gases generated by diesel and observe their behavior in terms of efficiency, and delivered torque and power.

The main contribution of a dual-fuel engine application is to provide a lower compression pressure and a longer ignition delay than a diesel engine in the normal mode. A dual-fuel engine has a higher output power than a single-fuel engine. Although dual-fuel engines emit significantly less carbon monoxide (CO), carbon dioxide (CO2), and hydrocarbons (HC) than single-fuel engines, the exhaust gases emitted by dual-fuel engines are significantly cleaner.

Dual-fuel engines have specific gaps in specific areas in order to achieve the highest substitution ratio or the highest percentage of natural gas replaced by diesel fuel. A small amount of diesel can be accurately and consistently injected into an engine, which currently limits this ratio.

2. Experimental Setup

Modifications were made before starting the experimental tests, such as assembling a flow valve at the diesel inlet to the engine to have greater control of the fuel flow, as shown in Figure 1. Moreover, to measure the temperature in the oil, the exhaust pipe, and the pipe air intake, three thermocouples were introduced. During the first tests, while evaluating the correct operation of the test bench, the universal coupling showed stud/thread faults that hold the wedge, increasing the play of the part and affecting the measurements of the torque sensor consequently [12]. The thread diameter was changed with the help of a male and fitted with a prisoner. The installation of the independent fuel tank is carried out for the intake of the fuel at the same time since the last tank located at a side of the engine made it difficult to take data with the digital camera. Table 1 shows the uncertainty error using the test engine.

3. Experimental Procedure

Then, the start button is pressed, and automatically, the program says calibration in progress. When the calibration screen disappears, the program begins to collect data [13]. The probe should therefore be placed on the exhaust pipe and monitored until the values of the exhaust gas leakage stabilize [14]. It is recommended to clean the probe or cable of the gas analyzer with the help of a compressor after each intake so that the next data can be taken. In another instance, with the help of a digital hygrometer thermometer, the ambient temperature and relative humidity data values are taken last after having the data of the gases of the exhaust gas analyzer. At the end of the data records for the loads mentioned above, it is necessary to remove the load and turn off the engine to let it cool down and thus start the procedure again. After about 5 minutes, the above procedure mentioned for each diesel-LPG mixture is repeated. However, this time the flow of the LPG supplied has to be taken into account [15]. This flow is controlled by a flow meter, which measures the volumetric flow rate in standard cubic feet per hour (SCFH). Before braking the engine with various loads, the liquid petroleum gas shut-off valve is opened, and the corresponding data are collected for each load. Table 2 shows the three flows used in practice and their real values. Corresponding to the volumetric flow (gr/s), Table 2 also shows the uncertainty error using the test engine.

4. Results and Discussion

Next, the results were obtained with the four types of fuels in their mixture, evidencing the behavior of each of these to the same loads, following the same procedure and trying that this is a cause of change in the conditions of the tests.

4.1. Specific Fuel Consumption. The specific brake fuel consumption results for each test are shown in Figure 2. The diesel-LPG 1 mixture has 12% more consumption at low loads than diesel, but when working with loads, it is better to use the diesel-LPG 1 mixture with a saving of 63% of fuel. The specific fuel consumption fuel in the diesel-LPG 2 mixtures saves 30% and in the diesel-LPG mixtures saves 3.45% of fuel, being a favorable option to reduce consumption in loads whether it can be low or high [16].

4.2. Thermal Efficiency. Consequently, in Figure 3, it can be seen that the thermal efficiency depends on the amount of fuel that enters the cylinder [17]. The less the diesel is

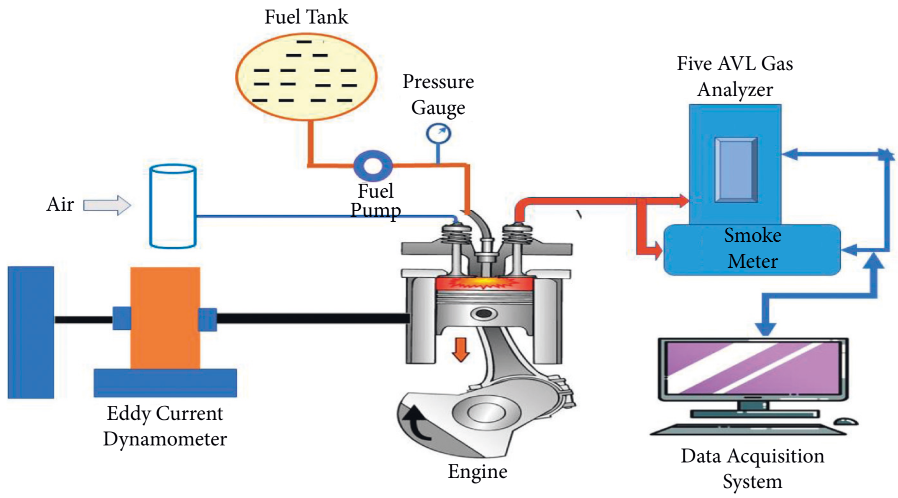

Figure 1: Schematic diagram of the proposed diesel-LPG (dual-fuel) system.

Table 1: Uncertainty error using the test engine.

Parameter	Resolution	Accuracy	Range
CO	1 ppm	±20 ppm (for <400 ppm CO)	0–10000 ppm
HC	0.3%	±10 ppm (for <100 ppm HC)	0–5000 ppm
Oxygen (O_2)	0.1%	−0.1% + 0.2%	0–25%
Carbon dioxide (CO_2)	0.1%	±0.3%	0–fuel value
Pressure	0.01 mbar	±0.5% full scale	0–150 mbar
Operating temperature, −10 to 45°C			
Warm-up time, 3 min			
Response time T90, 30 sec			
Operating humidity, 5–95% noncondensing			

Table 2: LPG flow for the three different tests.

Designation	Flow (SCFH)	$\dot{m}$ LPG (gr/s)
Diesel-LPG 1	5	4.80 E-08
Diesel-LPG 2	10	9.70 E-08
Diesel-LPG 3	15	1.40 E-07

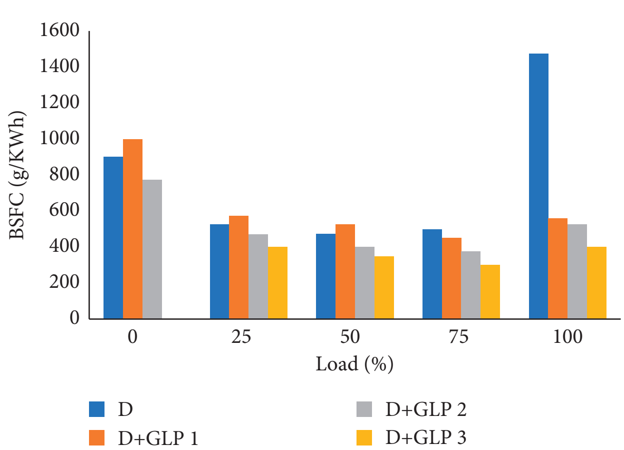

Figure 2: Brake-specific fuel consumption vs load.

incorporated into the cylinder, the engine will take better advantage of the heat produced by the combustion of the mixtures. This is evidenced by the specific fuel consumption in Figure 2, knowing that the volume of air inside the cylinder can only be affected by the ambient temperature when the tests were done, and that the amount of fuel makes the difference that the mixture can be rich or poor in the air since the air inside the motor is constant [18]. This means that the less the fuel entered into the cylinder, the air-fuel ratio will be better regarding diesel. On the one hand, for the higher load applied to diesel, there is a decrease in the thermal efficiency of 64%; on the other hand, the mixtures of diesel-LPG 1, diesel-LPG 2, and diesel-LPG 3 presented a reduction in the thermal efficiency of 47%, 74%, and 76%, respectively.

4.3. Volumetric Efficiency. The average values of the ambient temperature and the relative humidity with which each test was carried out were recorded [19]. The temperature directly influences the volumetric efficiency of the engine; it decreases the density of air. From Figure 4, it can be inferred that the lower the temperature, the higher the humidity and therefore the higher the volumetric efficiency for the mixtures than for diesel as there is an increase in air volume.

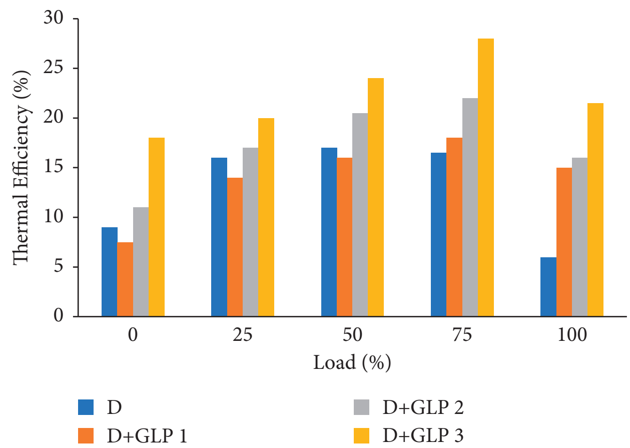

Figure 3: Thermal efficiency vs load.

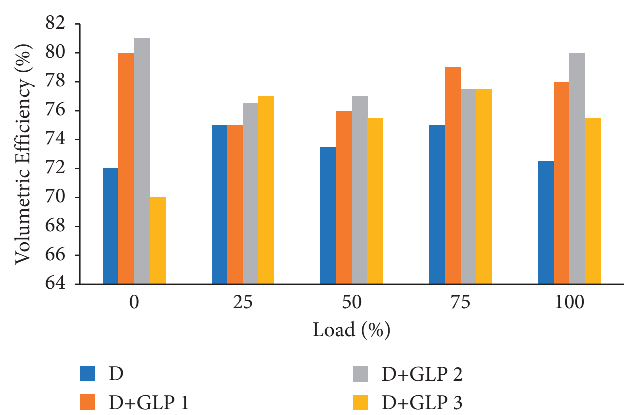

Figure 4: Volumetric efficiency vs load.

4.4. Carbon Dioxide Emissions. Carbon dioxide emissions in Figure 5 show a decreasing trend. This implies that as the load increases, the motor has a lean air-fuel ratio in air [20]. This occurs because of the amount of fuel that is injected into the cylinder when the butterfly valve opens. A reduction in CO_2 percentage was only observed for GLP 1, GLP 2, and GLP 3 mixtures when 80% of the load was applied. The combustion process is not complete by varying only 5% volumetric efficiency. The result of this is that there is insufficient oxygen to react with CO_2 in the atmosphere.

4.5. Carbon Monoxide Emissions. Carbon monoxide emissions are linked to carbon dioxide emissions. Carbon is inversely proportional to the air-fuel mixture since when combustion occurs inside the cylinder if and only if there is a lean air-fuel mixture, the reaction generates carbon monoxide as a consequence of the lack of oxygen to react to carbon dioxide. In Figure 6, the diesel produced higher CO emissions for all applied loads than mixtures [21–23]. It can be seen that emissions in all cases tend to increase when the load is greater.

4.6. Unburned Hydrocarbon Emissions. The use of mixtures at low loads is not suitable due to the generation of unburned hydrocarbons, being increased by 74% up to 16.4%

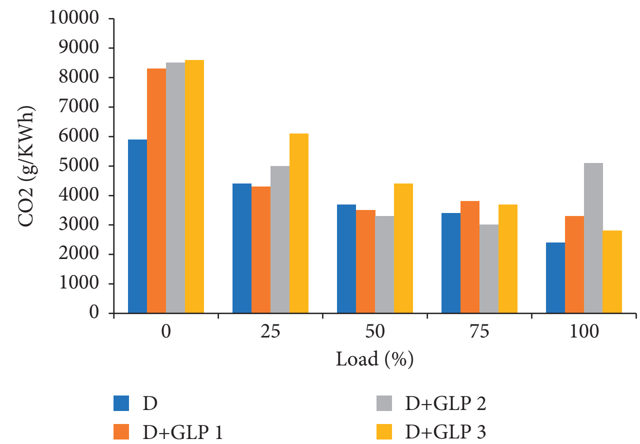

Figure 5: Carbon dioxide vs load.

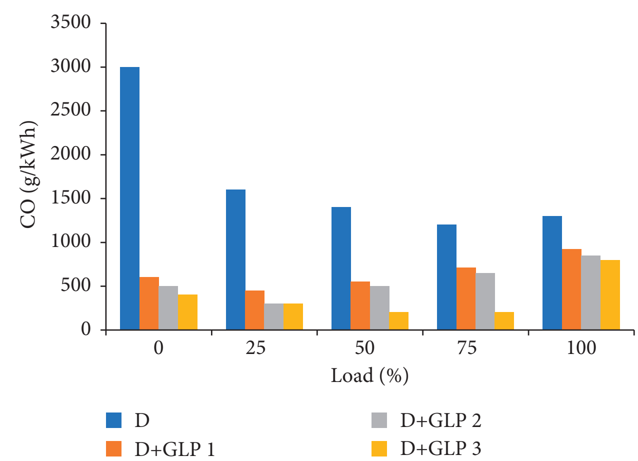

Figure 6: Carbon monoxide vs load.

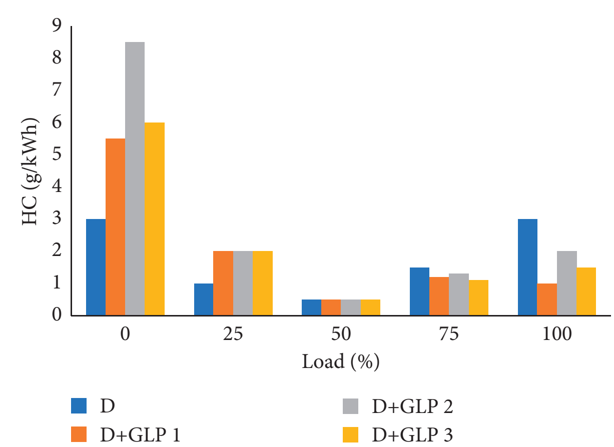

Figure 7: Hydrocarbon vs load.

(Figure 7). In order to achieve low emissions of HC with respect to diesel fuel, it is necessary to make the engine work with high loads, that is, in a range of 80% to 100% [24].

4.7. Operating Cost per Hour of the Engine. According to Figure 8, diesel fuel consumption decreases when mixed with GLP; these values are positive for research since it

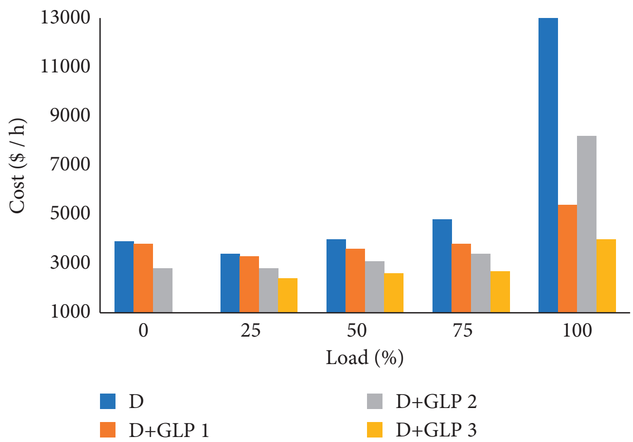

Figure 8: Cost analysis vs load.

complies with one of the specific objectives. The cost for diesel-LPG mixture 1 drops by only 3%, which is smaller, when a 20% load is applied. However, it has a decrease of 65% for the applied load of 100%. On the contrary, the diesel-LPG 2 mixture reduces the cost of low-load fuel by 28% and the high-load (100%) fuel by 47%. Finally, the diesel-LPG mixture 3 reduced costs by 29% for low loads and 74% for higher loads [25]. It should be noted that these percentages come out of the relationship between diesel as a reference and the costs of mixtures recorded [9].

5. Conclusions

The use of diesel-LPG mixtures without preheating below 80% of the load is not recommended because the combustion ratio inside the cylinder is poor in air, which does not allow this mixture to be used generating up to 16.3% of HC emissions, which are higher than those of diesel as opposed to when the engine works with loads in a range of 80% to 100%, which allows these emissions drop from 18% to 97% depending on the load. If it is necessary to reduce diesel consumption, it is recommended to increase the percentage of LPG in the fuel mixture since compared with the diesel-LPG mixture 2 and diesel-LPG 3 without preheating, the specific fuel consumption had a 20% decrease, which can generate an economic saving for power generation. The decrease in CO emissions and the increase in CO_2 confirm that the diesel-LPG blends without preheating have a rich air-fuel ratio with a minimum of 13% and a maximum of 17.9% and that diesel allows the oxygen obtained from the air to react adequately with CO to produce CO_2. The increase in thermal efficiency from 6% to 28.5% when working with the diesel-LPG mixture without preheating compared with when working with diesel is a positive indicator of engine performance, confirming that this mixture is effective for ignition engine compression and a possible alternative fuel for generating electrical energy. Compared to diesel-LPG blends without preheating, the best results were obtained with diesel-LPG 3, since it has a minimum thermal efficiency of 28%, a maximum thermal efficiency of 28.5%, and a reduction in diesel consumption on average of 45%. However, one of the factors to consider for this mixture is the load with which it works optimally since loads are less than 40%; the engine did not stabilize due to the lack of mass of the air and the low revolutions per minute. In comparison with previous studies, the LPG energy substitution can be accomplished up to 50% at lower loads and up to 25% at higher loads. Pure diesel engines perform better than a mixture of diesel and gasoline up to about 50% of loading on the engine. There are numerous advantages of operating the engine in a dual-fuel mode over operating it in a pure diesel mode at higher engine loads.

Data Availability

The data used to support the findings of this study are included in the article.

Disclosure

This study was performed as a part of the Employment of Institutions.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Research Article

Analysis of the Impact of Ecological Innovation and Green Investment on China's CO_2 Emissions

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In order to effectively address or eliminate the impact of CO_2 emissions, it is crucial to conduct a CO_2 emissions evolution analysis using a green investment model. Ecological innovation helps to limit carbon dioxide emissions, which is crucial to resource distribution and effectively summarizes the regularity and innovation of the process of limiting carbon dioxide emissions. Under the condition of fully grasping the principles of low-carbon city development and related policy protection, find a suitable low-carbon city development model. This paper analyzes the impact of ecological innovation and green investment on carbon dioxide emission limitations by building a data analysis model. The results of the case analysis show that the impact of the green investment scale on Chinese carbon dioxide emission restrictions is an inverted *U*-shaped relationship. The scale of green investment, economic competition, and marketization of capital allocation has a negative impact on Chinese carbon dioxide emissions, while green investment and ecological innovation have a positive effect on the green and low-carbon development of the Chinese economy.

1. Introduction

Green investment plays a very important role in promoting the green economy in China. The implementation of green investment can effectively reduce the consumption of carbon dioxide per unit in promoting ecological innovation. The development of the economy has made the investment of enterprises intensified, resulting in an increase in carbon dioxide emissions and the increase in consumer demand for household appliances, which has increased carbon dioxide emissions [1, 2]. But what is the impact of green investment on the limitation of China's carbon dioxide emission? How to achieve green and low-carbon development of the Chinese economy through green investment.

Real-time, rational, and precise monitoring of carbon dioxide emissions can also provide a theoretical basis for the decision-making analysis of relevant environmental protection testing departments, which is of great significance to the emergence of more ecological innovation projects [3, 4]. A detailed analysis of ecological innovation is carried out to explore the problems and shortcomings of the carbon dioxide emission process so as to formulate training and improvement plans in the later stage. In the traditional CO2 emission evolution analysis process, CO2 emissions and real-time risk alerts are also effective data collection and analysis processes for CO2 emission devices. To collect indicator data and feedback from CO2 emission process, the obtained data is used to analyze the performance of carbon dioxide emission, analyze the operation state of carbon dioxide emission, and diagnose the cause of failure, and can also be used to monitor the cause of failure. Carbon dioxide emissions and real-time risk alerts are an important manifestation of carbon dioxide emissions management and system integration, providing detailed data information for the operation and maintenance of carbon dioxide emissions. The ecological innovation, green investment, and development of carbon emissions have attracted more attention from researchers and scholars [5, 6]. Facts have proved that there are large gaps in carbon emissions changes under different systems in different environments. The man focusing on the earliest research on this issue was Panayotou. The research can prove that in the initial stage of regional economic growth, the per capita growth of green investment will lead to a rapid increase in carbon dioxide emissions. After green investment exceeds a certain value, with the growth of green investment, Carbon dioxide, on the other hand, showed a downward trend. Yu Yi verified the situation in China. The results of the analysis were different from those in the past. He concluded that there is a nonlinear relationship between carbon dioxide emissions, economic development, and capacity loss. There is a certain value in the development of the green investment. After the green investment reaches a certain value, the environmental pollution will double. The areas exceeding this value are distributed in the eastern area, followed by the middle area, and the western area is the least. Bin He invented a set of threshold models for per capita green investment in each region of China and the impact of the state-owned economy on carbon dioxide emissions. The data proves that the development of the state-owned economy has a threshold value. When the development reaches a fixed threshold value, carbon dioxide emissions and green investment show a "*U*"-shaped relationship, but in other intervals, it shows other shapes of curves. Based on the regional differences in carbon emissions and green investment development in the current ecological environment, measures are put forward on the factors affecting carbon emissions of economic growth, and the estimation and detection are carried out according to the revised STIRPAT module. By studying the situation of CO2 emissions in economically developing regions, the findings are shown to be nonlinear. In an environment with a low level of development through green investment, there is a direct link between faster economic development and carbon emissions. China has expressed its commitment to climate development, forced the development of low-carbon life, and made real improvements in the way of carbon reduction [7, 8]. This improvement determines the qualitative change in the living environment and proves that it has shouldered the burden of social responsibility. At the same time, it is a long development process to rectify and develop the structure of the industry. In the implementation stage, the emission reduction needs to be maximized. The Chinese environment study has entered a new course. The differences in economic development and economic situation in each region have a decisive impact on local carbon emissions [9, 10]. Change and role require lower carbon, greener, and less energy loss to generate maximum green investment. Due to the large differences in economic growth within regions, according to the level of economic development and carbon dioxide emissions within each country and the actual situation, formulating reasonable and scientific carbon emission reduction policy standards has become the first choice for the development of a low-carbon economy in China [11, 12]. When formulating low-carbon emission reduction policies, various countries need to effectively take into account their own basic economic development and social conditions, energy availability, and green-related policies, actively encourage the country to actively explore carbon dioxide emissions and renewable energy quotas suitable for its own region, and guide the whole society to save energy and improve energy efficiency to reduce environmental pollution.

There are obvious gaps in the relationship between domestic economic growth and carbon dioxide emissions. Some data show that after calculating the total carbon emissions, artificially distinguish regions and conduct research through factors in different regions. Questions are raised about the arrangement of such predistinguished regions, which should be distinguished according to regional carbon emissions. Because of the interference of the economy, it is necessary to make regular distinctions and then make distinctions according to the results and categories so that the carbon emission factors can be divided into regions. To study the relationship between economic growth and carbon emission growth changes, it is recommended to carry out effective carbon reduction strategies.

2. Theoretical Model Analysis

This paper confirms that there is a nonlinear relationship between the growth of green investment and carbon dioxide emissions. This is mainly because the growth of green investment in the Chinese economy varies across regions, and the impact on carbon dioxide emissions varies. Secondly, since economic growth is still at different levels, which will have different consequences, it is crucial to identify economic tipping points for CO_2 impacts.

The sample group $\{y_i, x_i, q_i\}_{i=1}^{n}$ selected in this paper is calculated as follows:

$$y_i = \theta_1' x_i + e_i, q_i \leq \kappa, \tag{1}$$

$$y_i = \theta_2' x_i + e_i, q_i \leq \kappa. \tag{2}$$

In the expression: q_i represents the threshold variable, κ represents the threshold value, and the constructed linear model $y_i = \theta_1' x_i + e_i$ can be divided into two different divisions: high and low. It should be noted that the threshold variable q_i can not only be used as an explanatory variable but also as an exogenous variable related to the model economy.

The nonlinear impact analysis of ecological innovation and green investment on carbon dioxide emissions is a linear model with finite parameters. On the basis of satisfying the finite parameter linear model, the finite parameter linear model can be used for optimization according to the steady-state ecological environment of the system [13]. In the process of dynamic monitoring of the ecological environment, the nonlinear impact of ecological innovation and green investment on carbon dioxide emissions can be analyzed. According to the problems analyzed above, the green investment demand function used in this paper is expressed as follows:

$$\begin{aligned} w &= \alpha L_Y^{\alpha-1} \int_0^A x(i)^{1-\alpha} \mathrm{d}i, \\ p(i) &= (1-\alpha) L_Y^{\alpha} x(i)^{-\alpha}. \end{aligned} \tag{3}$$

As the basis of ecological civilization construction, ecological environmental protection can realize real-time, rational, and precise monitoring of ecological, environmental protection and can also provide a theoretical basis for the decision-making analysis of relevant environmental protection testing departments, which is of great significance to the emergence of more emerging economic ecological transformation projects [14]. This paper conducts a detailed analysis of the ecological transformation of emerging economies to explore the problems and shortcomings in the process of ecological environmental protection so as to formulate training and improvement plans in the later stage. In the process of analyzing the evolution of ecological environment protection in the traditional emerging economy's ecological transformation, ecological environment protection and real-time risk alerts are also effective data collection and analysis processes for ecological environment protection. Collect indicator data from ecological environment protection and give feedback. According to the obtained data, it is used to analyze the performance of ecological environment protection, analyze the operation state of ecological environment protection, and diagnose the cause of failure, and can also be used to monitor the cause of failure.

Suppose the operation of group $k\,(k = 1, 2, \ldots, K)$ in the CO2 emission limit analysis can be expressed as follows:

$$\begin{aligned} s_1(t) = \sum_{m=0}^{M-1} \operatorname{rect}\left(\frac{t - mT_R - kMT_R}{T_p}\right) \\ \cdot \exp\left(j\pi\gamma\left(t - mT_R - kMT_R\right)^2\right) \\ \cdot \exp\left(j2\pi f_{sm}\left(t - mT_R - kMT_R\right)\right), \end{aligned} \tag{4}$$

In the formula, $t = \hat{t} + mT_R + kMT_R\,(m = 1, 2, \ldots, M)$ represents the entire computing time, $\hat{t}$ represents the fast time, and $\operatorname{tect}(u)$ represents the corresponding rectangular window.

If there are multiple feature points in the CO2 emission limitation analysis, then the coefficient of the features after the $p\,(p = 1, 2, \ldots, P)$ feature point can be expressed as σ_p, and if the corresponding time delay $\tau_p(t)$ value of the characteristic point p in the transition assistance in the carbon dioxide emission limitation analysis is not changed, then there will be $\tau_p(t) \approx \tau_p(t_{m,k}), t_{m,k} = mT_R + kNT_R$. At the same time, for the characteristic points of the carbon dioxide emission limit analysis, the mth subtransition boost under the k-th group of ecological innovation boosting high-performance computing can be expressed as follows:

$$\begin{aligned} s_2(\hat{t}, m, k) = \sigma_p \operatorname{rect}\left(\frac{\hat{t} - \tau_p\left(t_{m,k}\right)}{T_P}\right) \\ \cdot \exp\left(j\pi\gamma\left(\hat{t} - \tau_p\left(t_{m,k}\right)\right)^2\right) \\ \cdot \exp\left(j2\pi f_{sm}\left(\hat{t} - \tau_p\left(t_{m,k}\right)\right)\right) + \varepsilon(\hat{t}). \end{aligned} \tag{5}$$

In the formula, $\tau_p(t_{m,k}) = 2R_P(t_{m,k})/c$ and $R_P(t_{m,k})$ are successively expressed as the instantaneous slope distance between the p-th characteristic point and the emission limit analysis of the carbon dioxide emission limit analysis, c is the speed of light, and $\varepsilon(\hat{t})$ is the additive limit [15]. Then, for the transition-assisted frequency modulation processing, $\hat{f} = \gamma(\hat{t} - 2R(t_{m,k})/c)$ can be set, then the carbon dioxide emission limit analysis process is as follows:

$$\begin{aligned} s_3(\hat{f}, m, k) = \sigma_p \operatorname{rect}\left(\frac{\hat{f}}{\Delta f}\right) \exp\left(j\frac{4\pi}{c}\left(f_{sm} + \hat{f}\right)\Delta R\right) \\ \exp\left(j\frac{4\pi}{c}\left(\Phi_P + \Phi_B\right)\right) + \varepsilon(\hat{f}). \end{aligned} \tag{6}$$

In the formula, $\Delta R = x_p \sin\theta_{m,k} + y_p$, Φ_P, Φ_B, respectively, represent the phase error caused by the translation between the transition boosters and the phase error caused by the translation between the transition booster strings in the carbon dioxide emission limitation analysis.

The definition of life welfare is the effective combination of consumption and carbon dioxide emissions and the negative impact of emissions on the happy life of the family [16]. Suppose the expression of family life welfare is as follows:

$$\max \int_0^{+\infty} (\ln C - \beta \ln P) e^{-\rho t} \mathrm{d}t. \tag{7}$$

In the expression, C represents user consumption, P represents the stock of carbon dioxide, if $\beta > 0$ occurs, it represents the impact strength index of carbon dioxide emissions on family life, and if $\rho > 0$ occurs, it represents the family patience index. The family utilizes the selected optimal consumption combination to maximize the family life, and the carbon dioxide emission is externally given to the family [17]. The dynamic expression that can realize the accumulation of household consumption after dealing with the problem of household consumption is as follows:

$$\frac{\dot{C}}{C} = r - \rho. \tag{8}$$

In recent years, researchers of Jiang Guogang have studied China's emissions and regional economic differences through a nonlinear level. Through experiments, four dimensions were finally selected to establish a competitive index system. Through experiments, it is proved that each type of carbon reduction policy in each region directly affects the local low-carbon competitiveness, and it is proved that the incentive market carbon reduction policy can significantly improve the local competitiveness. They advocate that the government needs to enrich market strategies and adopt market policies to advocate low-cost enterprises to achieve the goal of reducing emissions and improve low-carbon competitiveness; based on the above analysis, it can be seen that the expression of carbon dioxide emissions given in this paper is as follows:

$$\dot{P} = \Omega F(Y, A). \tag{9}$$

In the expression, $\dot{P}$ represents the carbon dioxide emissions after green investment, Ω represents the growth rate of the green investment economy, if $F(Y, A) = Y^{\omega} A^{-\varphi}$, where $\omega > 0$, $\varphi > 0$. This paper mainly discusses the carbon dioxide emission limit. It can be obtained by dividing both sides of expression (9) by Y, respectively, as follows:

$$\frac{\dot{P}}{Y} = \Omega Y^{\omega - 1} A^{-\varphi}. \tag{10}$$

In order to ensure that the constraint parameters used in this paper satisfy the constraint $\omega = 1 + \varphi$. It is worth noting that, according to the above analysis and analysis from a technical point of view, it can be seen that the carbon dioxide emissions of green investment on the scale of green investment above can be regarded as a constant necessary condition.

With the continuous development of the green economy, the relationship between the amount of household capital consumption and the amount of carbon dioxide emissions consumed by daily use is expressed as follows:

$$K = \int_0^A x(i) \mathrm{d}i. \tag{11}$$

According to the principle of symmetry, if the green economy is in a state of equilibrium, it is necessary to conduct demand analysis for products with carbon dioxide emissions [18]. According to the carbon dioxide emission restriction conditions, the emissions of various products should also be the same, which needs to be satisfied: $x(i) = x, i \in [0, A]$. Substituting $x(i) = x$ into expression (11), it can be yielded as follows:

$$x = \frac{K}{A}. \tag{12}$$

Substituting expression (12) into expression (1) in turn, the total carbon dioxide emissions can be expressed as follows:

$$Y = (AL_Y)^{\alpha} K^{1-\alpha}. \tag{13}$$

According to the above analysis, if the convergence of green investment is on the path of balanced growth, and the growth rates of K, A, P and Y are the same, set Ω; L_A, L_Y, P_A, and x are all constants.

According to expression (13) and the growth of the green economy, $r = \rho + \Omega$ can be calculated, and the time t can be derived from both sides of expression (12); in turn, and combined with the scale of green investment, the expression can be obtained as follows:

$$P_A(t) = \frac{\pi(t)}{r(t)}. \tag{14}$$

Substituting expression (14) into expression (17) while satisfying the optimal problem, expressions (12), (13), (14), and the green investment scale condition can be obtained as follows:

$$\alpha \frac{L}{L_Y} L_A = \theta \frac{\alpha(1-\alpha)Y}{\rho + \Omega} \Omega. \tag{15}$$

Divide both sides of expression (15) by A, under the condition that $\Omega = \delta L_A$ is satisfied, combined with the economic equilibrium condition $L_A + L_Y = L$, and substitute this condition into expression (15); we can get the following:

$$\frac{\Omega}{\delta L - \Omega} = \frac{\theta(1-\alpha)\Omega}{\rho + \Omega}. \tag{16}$$

According to expression (16), the economic growth rate of green investment can be obtained as follows:

$$\Omega = \frac{\theta(1-\alpha)\delta L - \rho}{1 + \theta(1-\alpha)}. \tag{17}$$

According to expression (17), $\mathrm{d}\Omega/\mathrm{d}\theta > 0$ can be obtained. If the green investment is higher, then the local economic growth rate is higher. At the same time, combining the optimality of carbon dioxide emissions and household consumption choices, we can get the following:

$$r = (1-\alpha)^2 \left[\frac{Y}{K}\right] = (1-\alpha)^2 L_Y^{\alpha} \left[\frac{A}{K}\right]^{\alpha} = \rho + \Omega. \tag{18}$$

According to expression (18), we can get the following:

$$\frac{K}{A} = \left[\frac{(1-\alpha)^2}{\rho + \Omega}\right]^{1/\alpha} L_Y. \tag{19}$$

Combining the conditions of ecological innovation and the production function of green investment, the following expressions need to be satisfied:

$$L_Y = L - L_A = L - (\Omega/\delta). \tag{20}$$

Substituting the total carbon dioxide emission function of expression (20) into expression (19), the carbon dioxide emission under the average green investment can be obtained as follows:

$$\frac{\dot{P}}{Y} = \Omega \left[\frac{Y}{A}\right]^{\varphi} = \Omega L_Y^{\alpha\varphi} \left[\frac{K}{A}\right]^{(1-\alpha)\varphi}. \tag{21}$$

Substituting expressions (19) and (20) into expression (21), the expression that can use the economic growth rate as the limiting condition of carbon dioxide emissions is as follows:

$$\frac{\dot{P}}{Y} = \delta^{-\varphi} (1-\alpha)^{(2(1-\alpha)\varphi/\alpha)} \Omega (\delta L - \Omega)^{\varphi} (\rho + \Omega)^{-((1-\alpha)/\alpha)\varphi}. \tag{22}$$

Substituting expression (17) into expression (22), the condition of carbon dioxide emission limitation is expressed by the green investment function. According to expression (17), the degree of influence of green investment on the economic growth rate can be realized. According to expression (22), the carbon dioxide emission limit is changed according to the economic growth rate. Therefore, according to the qualitative analysis, green investment can realize the assessment of the impact of carbon dioxide emission limitation.

3. Empirical Model Setting and Variable Selection

In this paper, in the process of using the economic growth rate to evaluate the carbon dioxide emission limit, the expression (22) can be used to derive Ω, and we can get the following:

$$\frac{\mathrm{d}[\dot{P}/Y]}{\mathrm{d}\Omega} = \delta^{-\varphi}(1-\alpha)^{(2(1-\alpha)\varphi/\alpha)}(\delta L-\Omega)^{\varphi-1}(\rho+\Omega)^{-(1-\alpha/\alpha)\varphi-1} \times\left\{\left[\left(\frac{1-\alpha}{\alpha}-1\right)\varphi-1\right]\Omega^2 +\left[\delta L\left(1-\frac{1-\alpha}{\alpha}\varphi\right)-\rho(1+\varphi)\right]\Omega+\delta\rho L\right\}. \tag{23}$$

According to expression (23), if $((1-\alpha/\alpha)-1)\varphi-1<0.$ is satisfied, then the relationship between the growth rate of the green economy and the carbon dioxide emission limit can be represented by an inverted U shape. Using Q to represent the horizontal axis and $(\mathrm{d}[\dot{P}/Y]/\mathrm{d}\Omega)$ to represent the vertical axis, then the corresponding intercept of expression (23) on the vertical axis is not less than zero. If $(((1-\alpha)/\alpha)-1)\varphi-1<0$ is satisfied, then the relationship between $\delta L\ (1-(1-\alpha)\ \varphi/\alpha)-\rho\ (1+\varphi)$ and 0 has a certain value on the horizontal axis corresponding to the extreme point of expression (23) impact, according to three different scenarios in Figure 1. If $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)<0, 0$ is satisfied, then it corresponds to CASE1 in Figure 1; if $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)=0$ is satisfied, then it corresponds to CASE2; if $\delta L(1-(1-\alpha/\alpha)\varphi)-\rho(1+\varphi)>0$ is satisfied, then it corresponds to CASE3 in Figure 1. In the three cases in Figure 1, if the economic growth rate $\Omega>0$ is satisfied. In this paper, the intersection point with the horizontal axis in the interval not less than 0 for expression (23) is Ω^*. It can be concluded that if $0<\Omega<\Omega^*$, $\mathrm{d}(\dot{P}/Y)/\mathrm{d}\Omega>0$, the growth rate of the green economy keeps rising and the carbon dioxide emissions also increase; If $\Omega>\Omega^*$, $\mathrm{d}(\dot{P}/Y)/\mathrm{d}\Omega<0$ is satisfied, then the growth rate of the green economy will also rise, and carbon dioxide emissions will continue to decline. If $\Omega=\Omega^*$, $\mathrm{d}(\dot{P}/Y)/\mathrm{d}\Omega=0$, then the carbon dioxide emission will reach a maximum value at this time. According to the constructed model variables, $((1-\alpha/\alpha)-1)\varphi-1<0$ meets the criteria for green investment economic development [19–21]. This is because in the expression (13) used, α represents the share of economic income in the total income. According to the green economy income share, it generally needs to be maintained between 60% and 70%, and $(1-\alpha)/\alpha$ can be obtained <1, the condition of $((1-\alpha/\alpha)-1)\varphi-1<0$ needs to be met.

According to the above-detailed analysis, this paper can obtain the impact of green investment and ecological innovation on Chinese carbon dioxide emissions through quantitative analysis. In the process of given model data and variable selection, the impact of green investment and ecological innovation on carbon dioxide emissions is obtained according to the constructed regression equation as follows:

$$CO_2/\mathrm{GDP} = \alpha_0+\alpha_1\mathrm{Finance}+\alpha_2(\mathrm{Finance})^2 +\alpha_3\mathrm{Innovation}+\alpha_4\mathrm{Open}+\alpha_5\mathrm{Structure} +\alpha_6\mathrm{Urban}+\varepsilon. \tag{24}$$

Among them, in the constructed expression, the explanatory variable is the effect of limiting carbon dioxide emissions, and the core explanatory variables mainly include the level of green investment and ecological innovation. Combined with the model, the basic impact of green investment on carbon dioxide emissions can be effectively calculated. Therefore, this paper can analyze the factors affecting carbon dioxide emissions in detail. The calculation of carbon dioxide emissions is a dynamic continuity, and the constructed dynamic panel data model can be expressed as follows:

$$\frac{CO_2}{\mathrm{GDP}} = \alpha_0+\theta L\cdot\frac{CO_2}{\mathrm{GDP}}+\alpha_1\mathrm{Finance}+\alpha_2(\mathrm{Finance})^2 +\alpha_3\mathrm{Innovation}+\alpha_4\mathrm{Open}+\alpha_5\mathrm{Structure} +\alpha_6\mathrm{Urban}+\varepsilon. \tag{25}$$

In the expression, L. (CO2/green investment) is used to denote the emission limit of lagging CO2. In this paper, the estimated expression of carbon dioxide produced by fossil fuels is: $CO_2=\sum\alpha_i\beta_iE_i$, where α_i represents the conversion rate of the ith energy, β_i is the carbon dioxide emission coefficient of the ith energy, and E_i is the energy consumption of its energy. On this basis, divide the total CO2 emissions by the actual green investment to obtain the CO2 emissions from the average green investment. It is of great significance for the distribution of resources related to carbon dioxide emissions, the service level of flow planning, and safety monitoring. According to the obtained data, it is used to analyze the performance of carbon dioxide emission, analyze the operation state of carbon dioxide emission and diagnose the cause of failure, and can also be used to monitor the cause of failure. Carbon dioxide emission monitoring and real-time risk alerts are important manifestations of carbon dioxide emission management and systematic integration, providing detailed data information for the operation and maintenance of carbon dioxide emissions. CO2 emission performance analysis, abnormal monitoring, link status monitoring, and capacity planning all play an important role together. As the focus of current research in this field, carbon dioxide emission monitoring can be perfectly combined with different industries so that data from different industries can be fully used in the actual carbon dioxide emission monitoring environment.

4. Analysis of Demonstration and Results

This paper adopts the Chinese interprovincial panel model to express the relationship between ecological innovation

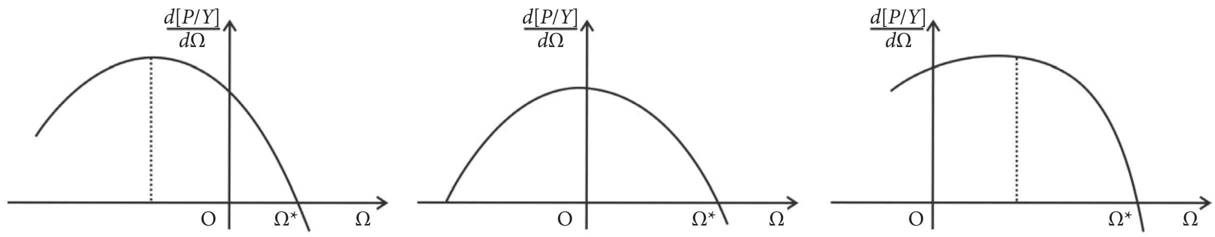

Figure 1: Visual analysis of the impact of economic growth rate on carbon dioxide emissions.

and green investment to limit China's carbon dioxide emissions as follows:

$$\text{Tech} = \beta_0 + \beta_1 L\text{Tech}_2 + \beta_2\text{Fin} + \beta_3\text{Fin}^2 + \beta_4\text{Control} + \varepsilon. \tag{26}$$

In (26), the explanatory variable is the ecological innovation Tech in the Chinese region, the explanatory variable is the green investment Fin, and Control represents the control variable of the model. Since Chinese productivity is compared against a comprehensive measure of ecological innovation, total factor productivity (TFP) is used as an ecological innovation variable.

The impact of domestic total factor productivity using the Solow residual method: If the conditional restriction function is $Y_{\text{it}} = A_{\text{it}}K_{\text{it}}^{\alpha}L_{\text{it}}^{\beta}$, Y_{it} in the expression represents the output of region i in year t, and A, K, and L correspond to ecological innovation, capital stock, and labor input in turn. If the constant return to scale is satisfied $(\alpha + \beta = 1)$, the model expressions $\ln(Y_{it}/L_{it}) = \ln A_{it} + \alpha \ln(K_{it}/L_{it}) + \varepsilon_{it}$ obtained above are obtained, respectively. According to the panel data of Chinese provinces, $\alpha = 0.65$ can be estimated, and then $\beta = 1 - \beta = 0.36$. Then, using the formula $\text{TFP}_{\text{it}} = Y_{\text{it}}/(K_{\text{it}}^{0.6465}L_{\text{it}}^{0.3635})$, the green investment rate of return of each province (autonomous region, city) in different years can be obtained according to the calculation of each province in China.

The test results according to the constructed model are shown in Table 1. In Table 1, it can be seen that Fin is calculated by using expressions (10) and (11) to be the comparison between the traditional economy and green investment in turn. It can be concluded that both the traditional economic investment and the green investment proposed in this paper are all positively correlated with the return on green investment; that is, green investment is also conducive to the progress and development of ecological innovation. In Table 1, the calculated results using expression (12) and expression (13), respectively, show that it is of great significance for limiting carbon dioxide emissions. According to the test results, it can be concluded that the corresponding Fin in expression (12) is the ratio of direct investment to indirect investment, and it can be concluded that the ratio obtained is positively correlated with the return on green investment, indicating that with the continuous development of green economy, the proportion of direct investment can be effectively increased, which in turn helps to improve ecological innovation. Through the investment proportion of Fin in expression (13), the research results show that green investment has certain advantages, which shows that the development of green investment can effectively increase the share of the traditional economy. The same amount of growth in green investment boosts TFP almost twice as much as in conventional economies. Fin in expression (15) is the proportion of ecological innovation, and this ratio is also significantly positively correlated with total factor productivity.

According to the above analysis, this paper also uses interprovincial panel data to analyze the relationship between green investment and economic structure. The model constructed is as follows:

$$\text{Struct} = \beta_0 + \beta_1 L\text{Struct} + \beta_2\text{Fin} + \beta_3\text{Fin}^2 + \beta_4\text{Control} + \varepsilon. \tag{27}$$

The explanatory variable Struct in the constructed model is used as the industrial structure index in this area, and LStruct represents the Struct with a lag of one period. The explanatory variable is the green investment Fin, and Control represents the control variable. The industrial structure is reflected by two indicators: (1) The proportion of the traditional economy. This paper first calculates the ratio of the difference to the regional green investment by subtracting the output value of the high-tech industry from the output value of the secondary industry, and uses this ratio to measure the proportion of the traditional economy. (2) The proportion of green investment. The proportion of the total output value of the high-tech industry and the tertiary industry in the green investment in the region is used as an indicator to measure the proportion of green investment.

The results available according to the constructed model are reported in Tables 2 and 3. According to Table 2, we can see the relationship between green investment and economic industries. The explained variables in expressions (15) and (16) are mainly the proportion of the traditional economy, and the proportion of green investment and traditional economy can be found; according to the explained variables in expression (17) and expression (18) in the proportion of green investment, these two expressions can effectively study the relationship between the proportion of green investment and green investment. According to expression (15) and expression (17), the corresponding Fin is taken as the ratio of the traditional economy to green investment. From expression (15), we can see that there is a negative correlation between the proportion of the traditional investment and the

Table 1: Relationship between green investment and total factor productivity.

Variable	Expression (10) Traditional innovation. economy	Expression (11) Green investment	Expression (12) Economic structure	Expression (13) Proportion of green investment	Expression (14) Proportion of ecological innovation
LTech	0.34*** (16.81)	0.32*** (14.91)	0.33*** (24.19)	0.33*** (10.95)	0.33*** (14.34)
Fin	0.023*** (25.44)	0.01*** (14.69)	0.02*** (9.22)	0.03*** (7.55)	0.26*** (8.13)
Edu	0.05*** (9.55)	0.03*** (9.96)	0.03*** (11.34)	0.03*** (10.32)	0.01* (1.94)
FDI	0.45*** (6.34)	0.56*** (3.42)	0.73*** (5.45)	0.65*** (3.55)	0.79*** (5.94)
Open	0.28*** (15.56)	0.27*** (20.42)	0.26*** (13.44)	0.26*** (18.55)	0.26*** (22.33)
Fiscal	0.03*** (7.66)	0.03*** (5.92)	0.02*** (2.56)	0.03*** (6.65)	0.04*** (3.73)
Abond P value	0.22	0.19	0.23	0.43	0.18
Sargan test	25.78	25.02	22.11	25.33	25.71

Table 2: Relationship between green investment and industrial structure.

Variable	The proportion of explained variables as the traditional economy		The proportion of explained variables as green investment	
	Expression (15) Traditional (17 economy)	Expression (16) Green investment	Expression (17) Traditional (17 economy)	Expression (18) Green investment
LStruct	0.33*** (47.23)	0.96*** (42.12)	0.95*** (35.11)	0.94*** (90.84)
Fin	−0.01*** (−4.78)	0.01*** (6.90)	0.003** (1.94)	−0.01*** (−9.25)
Fin^2		−0.001*** (−5.42)		0.001*** (6.91)
Consum	−0.13*** (−19.44)	−0.11*** (−11.03)	0.12*** (19.44)	0.11*** (21.44)
Labor	0.00 (0.04)	0.00 (0.12)	−0.002*** (−4.54)	−0.001** (−2.45)
Fiscal	−0.02%* (−2.29)	−0.03*** (−5.34)	−0.01 (−1.36)	−0.002 (−0.33)
Edu	−0.20*** (−23.33)	−0.22*** (−16.90)	0.12*** (11.69)	0.13*** (13.32)
Abond P value	0.29	0.55	0.14	0.19
Sargan test	28.56	27.39	28.33	28.45

traditional economy. It can be seen from expression (17) that the proportion of traditional investment and green investment is positively correlated. According to expression (16) and expression (18), Fin is the ratio of green investment to the traditional economy. According to the test results of expression (16), it shows that the proportion of green investment and traditional economy presents a U-shaped relationship. Green investment has not yet increased the proportion of the traditional economy. Green investment can have an inverted U-shaped relationship with the proportion of the traditional economy and a U-shaped relationship with the proportion of green investment, which is because green investment based on venture capital and private equity funds is in the initial stage. Investments in traditional economic sectors are often required. The analysis of the above results shows that both traditional economy and green investment, and after developing to a certain extent, can effectively reduce the proportion of the traditional economy and greatly increase the proportion of green investment; that is, green investment is conducive to the transformation and upgrading of industries.

Table 3 reflects the relationship between green investment structure and industrial structure. According to the explanatory variables, Fin of expression (19) and expression (20) are all economic structures, the explained variable of expression (19) is the proportion corresponding to the traditional economy, and the explained variable of expression (20) is the proportion of green investment. According to the analysis of the above two expressions, there is an inverted U-shaped relationship between the economic structure and the proportion of the traditional economy and a U-shaped relationship with the proportion of green investment. The analysis results of this example show that the proportion of green investment has an inverted U-shaped relationship with the proportion of the traditional economy and a U-shaped relationship with the proportion of green investment, indicating that the initial stage of green investment promoted the increase of the proportion of the traditional economy and the decrease of the proportion of green investment, but after it developed to a certain extent, it showed the inhibition effect on the proportion of the traditional economy and the promotion effect on the proportion of green investment. These two expressions show that the increase in the proportion of ecological innovation will help reduce the proportion of the traditional economy and increase the proportion of green investment, thereby promoting industrial transformation and upgrading.

Table 3: Relationship between green investment structure and industrial structure.

Variable	The explanatory variable is the economic structure		Explanatory variable is the proportion of green investment		Explanatory variable is the proportion of ecological innovation	
	Expression (19) Proportion of the traditional economy	Expression (20) Proportion of green investment	Expression (21) Proportion of the traditional economy	Expression (22) Proportion of green investment	Expression (23) Proportion of the traditional economy	Expression (24) Proportion of green investment
LStruct	0.94*** (32.12)	0.99*** (28.16)	0.94*** (49.23)	0.91*** (116.93)	0.91*** (35.34)	0.94*** (49.66)
Fin	0.01* (1.74)	−0.01*** (−5.67)	0.03*** (6.45)	−0.04*** (−11.84)	−0.30*** (−7.55)	0.20*** (11.44)
Fin1	−0.02** (−2.13)	0.02*** (2.73)	−0.01*** (−6.35)	0.01*** (12.86)		
Control	*Adjust and control*	*Adjust and control*	*Adjust and control*	*Adjust and control*	*Adjust and control*	*Adjust and control*
Abond *P* value	0.35	0.1071	0.44	0.39	0.36	0.25
Sargan test	27.22	27.21	29.12	28.86	27.18	28.34

5. Conclusion

This paper constructs a model of green investment, ecological innovation, and carbon dioxide emissions, studies the impact of green investment and ecological innovation on carbon dioxide emissions through data, and finds that there is an inverted *U*-shaped relationship between green investment and carbon dioxide emissions. In this study, it is found that the impact of green investment in different dimensions on carbon dioxide emission limitation cannot be determined. The relationship between the scale of green investment and carbon dioxide emission limits is similar to the relationship between ecological innovation and carbon dioxide emissions. In the proportion of green investment, economic competition, and ecological innovation invested in large amounts, compared with traditional policies and regulation, it has greatly reduced carbon dioxide emissions and has a positive role in promoting the long-term development of the domestic economy. Growth can also realize the optimization of the economic structure of the green investment. Ecological innovation and green investment have a certain restrictive effect on carbon dioxide emissions. At the same time, it is also necessary to vigorously develop the proportion of investment in the green economy, which also has a certain impact on ecological innovation.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Article

Groundwater Quality: The Application of Artificial Intelligence

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Humans and all other living things depend on having access to clean water, as it is an indispensable essential resource. Therefore, the development of a model that can predict water quality conditions in the future will have substantial societal and economic value. This can be accomplished by using a model that can predict future water quality circumstances. In this study, we employed a sophisticated artificial neural network (ANN) model. This study intends to develop a hybrid model of single exponential smoothing (SES) with bidirectional long short-term memory (BiLSTM) and an adaptive neurofuzzy inference system (ANFIS) to predict water quality (WQ) in different groundwater in the Al-Baha region of Saudi Arabia. Single exponential smoothing (SES) was employed as a preprocessing method to adjust the weight of the dataset, and the output from SES was processed using the BiLSTM and ANFIS models for predicting water quality. The data were randomly divided into two phases, training (70%) and testing (30%). Efficiency statistics were used to evaluate the SES-BiLSTM and SES-ANFIS models' prediction abilities. The results showed that while both the SES-BiLSTM and SES-ANFIS models performed well in predicting the water quality index (WQI), the SES-BiLSTM model performed best with accuracy ($R = 99.95\%$ and $\mathrm{RMSE} = 0.00910$) at the testing phase, where the performance of the SES-ANFIS model was $R = 99.95\%$ and $\mathrm{RMSE} = 2.2941 \times 100\text{-}07$. The findings support the idea that the SES-BilSTM and SES-ANFIS models can be used to predict the WQI with high accuracy, which will help to enhance WQ. The results demonstrated that the SES-BiLSTM and SES-ANFIS models' forecasts are accurate and that both seasons' performances are consistent. Similar investigations of groundwater quality prediction for drinking purposes should benefit from the proposed SES-BiLSTM and SES-ANFIS models. Consequently, the results demonstrate that the proposed SES-BiLSTM and SES-ANFIS models are useful tools for predicting whether the groundwater in Al-Baha city is suitable for drinking and irrigation purposes.

1. Introduction

Water is the most crucial of all resources and is essential for the survival of all forms of life. Unfortunately, it is constantly threatened by pollution caused by the same things that support life. Water is one of the most communicative media available, and it has a long range. Correspondingly, rapid industrialization has resulted in an alarming decline in the quality of drinking water worldwide. The World Health Organization estimates that 3.57 million people each year lose their lives as a result of diseases that are associated with water [1]. It has been known for a very long time that one of the most significant factors contributing to the proliferation of terrible diseases is insufficient water quality. According to figures provided by the World Health Organization, water-related illnesses claim the lives of 3.57 million people every year [2]. For a long time, poor water quality has been identified as a major factor in the spread of deadly diseases. Schistosomiasis is an acute and chronic sickness caused by parasitic worms that can be transmitted through contact with contaminated water, according to the World Health Organization [2]. Diseases, including diarrhea, typhoid fever, gastroenteritis, cryptosporidium infections, and hepatitis, are the most common cause of these disorders. Typhoid bacteria are responsible for most of these illnesses. Fresh water is found in rivers and groundwater alike, and it accounts for only three percent of the entire water supply on the planet [3].

The Kingdom of Saudi Arabia (KSA) relies heavily on groundwater to meet its needs for drinking water and irrigation. Groundwater extraction in the KSA has expanded over the past three decades, reaching a total of 17 billion m^3/year. Indeed, groundwater supplies 80% of the water requirements of the KSA [4]. Compared to the amount of water being drained each year, groundwater recharge is extremely low. The lowering of groundwater levels can also have a negative impact on the quality of the water [5]. The deep aquifers in the sedimentary strata that make up the Arabian shield have developed secondary porosities [6]. These porosities are located on top of the fractured Precambrian bedrock. There are also aquifers that are found, and while they are shallower than the valleys, they play a crucial role in the Arabian shields and coastal regions [7]. Agriculture was another industry that put a significant amount of weight on groundwater resources in the 1970s. Groundwater resources in an already water-stressed region have grown problematic in terms of both quantity and quality as a result of rapid urbanization, expanding industrial activity, and a growing population [8].

In addition, because of either anthropogenic or natural/geogenic causes, groundwater quality deteriorates [9]. Groundwater quality is a major concern in the study area due to local climatic and geological factors. The way in which water interacts with soils and sediments, the flow path, rock types, and common geochemical conditions such as dissolved oxygen, reduced oxygen, leaching, and ion exchange all have an effect on the quality of groundwater. These are just some of the many factors that influence groundwater quality [10]. Hence, water pollution is a serious problem in the KSA, harming the sustainability of water resources, which might create an insufficient water supply for all people, even when a great number of water resources are accessible [11].

Indeed, water is the most critical natural resource problem that humankind will have to handle in the 21st century. The combined consequences of human activity and climate change have resulted in considerable changes in runoff from numerous groundwater and growing water shortages. Water shortages not only present a danger to human life and social development but also have a considerable influence on the gross domestic product. To limit the effects of water pollution, the monitoring and evaluation of groundwater quality are vital [12].

The water quality index (WQI) provides decision makers with information that is crucial to their work. There is no common strategy for predicting and categorizing the WQI [13], though researchers have used the artificial intelligence (AI) method to address these difficulties [14]. AI-based modeling eliminates the need for subindex computations and delivers a WQI value in a short time. The AI technique, in addition, has the benefit of being less sensitive to missing values and being able to perform sophisticated mathematical calculations with a huge quantity of data and nonlinear structures. Many academics are paying close attention to the use of AI-based methodologies, such as machine learning, in their studies. A wide variety of works on machine learning models have been produced in the course of previous study. Some examples of these models include artificial neural networks, decision trees, *k*-nearest neighbors, Naive Bayes, and support vector machines. However, these typical machine learning approaches have several drawbacks, such as a high level of bias and overfitting [15]. Accordingly, machine learning algorithms that use ensemble approaches, such as bagging and boosting, to solve these challenges are being developed and improved [16]. Using ensemble models that combine the judgments of numerous base classifiers, more accurate predictions can be made. New machine learning techniques, such as gradient boosting [17] and the random forest approach [18–22], have been of great help in the prediction of water quality in recent years.

A number of research works have made use of ANN models in order to predict and anticipate the quality of the water. According to this body of research, ANNs are capable of reliably predicting the quality of drinking water. According to this work, the prediction and modeling of water quality are being improved by making use of a wide variety of cutting-edge technologies, such as fuzzy logic, stochastic, artificial neural networks (ANNs), and deep learning models [23, 24]. This is being done in order to better understand how water quality can be predicted and modeled.

An artificial neural network (ANN) model was developed by Palani et al. [25] for the purpose of forecasting DO, salinity, temperature, and chlorophyll-a concentrations in the coastal water of Singapore. The ANN model displayed an excellent correlation value of 0.8-0.9, as stated by Palani et al. ANFIS, the radial bias function, and multilayer sensory neural network models were utilized by Ahmed et al. [26] in order to estimate the ammoniacal nitrogen concentration of water samples. Wavelet data denoising was also utilized during this process. The authors discovered that removing noise from the data improved the performance of the prediction models. In order to estimate DO in sand media filters, Marti et al. [27] utilized ANN, GEP, and regression, which required a total of 769 data points derived from experimental results. The electrical conductivity, the pH, the amount of dissolved oxygen, and the head loss were the most useful parameters. Based on the findings, it was determined that the gene expression programming (GEP) model provided a more accurate estimation than the other approaches.

The authors of this work estimated the total suspended solids (TSS), biochemical oxygen demand, chemical oxygen demand, and total dissolved solids (TDS) in a drainage basin by using a regression tree and support vector regression models. According to the authors, the support vector regression (SVR) fared better than the RT in terms of accurately predicting the desired output. Sarkar and Pandey [28] employed ANN to make predictions for DO. Accurate ANN results with a correlation coefficient close to 0.9 were reported by the authors. Support vector machine (SVM) and ANN methods were used by Haghiabi et al. [29] to predict various water quality indicators. Both ANN and SVM were shown to be effective in the prediction of water quality by the authors. To predict the capacity of a water treatment facility, Zhang et al. [30] employed a hybrid neural network model. The study's findings demonstrated that employing a larger dataset improved the model's performance. Shafi et al. [31] used support vector machines, neural networks (NN), and deep neural networks (DNN) for prediction of WQI. A total of 25 parameters were integrated as input parameters into single feedforward neural networks to identify water quality [32]. Dissolved oxygen (DO) was predicted using an ANN model developed by Rankovic et al. [33]. Gazzaz et al. [34] predicted the WQI using ANN models and Internet of Things (IoT) technologies. ANN and regression were utilized by Abyaneh [35] to predict the chemical oxygen requirements. Sakizadeh [36] estimated the water quality indicator using ANNs with Bayesian regularization (WQI). This sort of neural network (ANN) model, known as the radial basis function (RBF), has been used to predict and characterize water quality.

Moreover, deep learning has recently become more popular in water quality modeling. In a deep learning approach, neural network topologies typically include one input layer, many hidden layers, and a single output layer [37–39]. Liu et al. [40] used LSTM networks to develop a drinking water quality model for the Yangtze River basin. When they assessed the pH, DO, COD, and the content of ammonium nitrate (NH3-N), they found that the suggested LSTM network could be used to predict drinking water quality indicators. A hybrid convolutional neural network (CNN) LSTM model was proposed by Barzegar et al. [41] for the purpose of estimating the concentrations of DO and chlorophyll-a (Chl-a) in the Small Prespa Lake in Greece.

As a result, the purpose of this study is to develop an improved hybrid model by making use of models that incorporate single exponential smoothing with bidirectional long short-term memory (SES-BiLSTM) and single exponential smoothing adaptive neurofuzzy inference system (SES-ANFIS). This will allow the researchers to determine whether or not the groundwater in the Al-Baha region is suitable for drinking and irrigation. This study will be helpful in the identification, within a short amount of time, of the appropriateness of drinking water and irrigation water, particularly in arid and semidry regions. The major contribution to research that was made by this paper may be stated as follows.

The groundwater quality in the region of Al-Baha was evaluated using WQI values:

Table 1: Details of the targeted wells.

Location	No. of wells	Altitude (m)	Latitude	Longitude
Mudailif	1	47	19.534829	41.050467
Bani Dabian	6	2.410	19.963037	41.503160
		2.393	19.965565	41.514047
		2.313	19.966935	41.490027
		2.304	19.970397	41.499260
		2.275	19.971517	41.495268
		2.133	19.995739	41.535219
Southeast of Al-Baha	3	612	19.702417	41.700848
		1.785	19.739621	41.926028
		1.624	19.865282	41.927247
East of Al-Baha	3	1.906	19.994561	41.660098
		1.866	20.097328	41.585645
		1.857	20.101866	41.580797
Baljurashi	3	2.026	19.851837	41.604840
		2.027	19.854214	41.564965
		2.037	19.859957	41.549216
Al-Mandag	2	2.224	20.107243	41.426129
		2.189	20.108782	41.288857
		2.151	20.123787	41.288205

(i) An adaptive neurofuzzy inference system (SES-ANFIS) was developed, and a demonstration of the computing capability of single exponential smoothing (SES) with bidirectional long short-term memory (BiLSTM) was presented

(ii) The suggested model's general framework was delineated for groundwater prediction

(iii) The use of correlation coefficients was tested efficiently to find the best groundwater parameters

(iv) An alternative technique, a neural network model, was developed to predict groundwater quality directly

2. Materials and Methods

2.1. The Study Area. In this work, water samples from 19 groundwater wells in the Al-Baha region of Saudi Arabia were collected. These wells have long served as the main source of drinking and irrigation water. The locations and altitudes of these wells are presented in Table 1. Subsequently, water samples were analyzed to obtain their physical, chemical, and bacterial properties (i.e., water quality data). These data include pH, total dissolved solids (TDS), turbidity, iron (Fe) concentration, manganese (Mn) concentration, sulfate (SO_4^{2-}) concentration, nitrate (NO_3^-) concentration, nitrite (NO_2^-) concentration, and the colony-forming unit (cfu) of coliform bacteria per 100 milliliters (ml). The details of the water sampling and analysis are reported elsewhere [42].

2.2. Water Quality Index and Classification. The water quality index (WQI) can be used to evaluate the water quality as per the measured values of some parameters affecting water quality. In this investigation, nine parameters, mentioned earlier, were measured and used for the WQI calculations as follows:

Table 2: Parameters' standard values according to the Saudi standards [42].

Parameters	S_i
pH	7.5
TDS, mg/l	500
Turbidity, NTU	1
Fe concentration, mg/l	0.3
Mn concentration, mg/l	0.4
SO_4^{2-} concentration, mg/l	250
NO_3^{-} concentration, mg/l	50
NO_2^{-} concentration, mg/l	0.2
Coliform bacteria, cfu/100 ml	100

*Values of the Saudi standards are less than or equal to the WHO standards.

$$\mathrm{WQI} = \frac{\sum_{i=1}^{N} q_i \times x_i}{\sum_{i=1}^{N} x_i}, \quad (1)$$

where N, q_i, and x_i are the number of parameters, the quality rating scale of each parameter, and the unit weight of each parameter, respectively. The following equations can be used to calculate q_i and x_i:

$$q_i = 100 \times \left(\frac{P_i - P_{\mathrm{Ideal}}}{S_i - P_{\mathrm{Ideal}}}\right),$$
$$K = \frac{1}{\sum_{i=1}^{N} S_i}, \quad (2)$$
$$x_i = \frac{K}{S_i},$$

where P_i and P_{Ideal} are the measured and ideal values of parameter i, respectively, and S_i is the KSA standard value of parameter i, as shown in Table 2.

The generic framework of the proposed system for prediction and classification of the water quality is presented in Figure 1.

2.3. Preprocessing Methods

2.3.1. Min-Max Normalization. The Min-Max normalization was utilized in order to scale the input variables to a range that was comprised of zeros and ones. As part of the data preparation process for machine learning, data normalization is performed. Changing the values of input and output variables to a single scale is the purpose of normalization. For the normalization process, $x_{\min}$ and $x_{\max}$ are, respectively, the minimum and maximum values for the i^{th} attribute.

$$x = \frac{x - x_{\min}}{x_{\max} - x_{\min}}. \quad (3)$$

For example, $x_{\min}$ is equal to the normalized value of the input variable x_i divided by the maximum input variable $x_{\max}$ and minimum variable $x_{\min}$.

2.3.2. Single Exponential Smoothing (SES) Model. One of the statistical procedures that is used most frequently, known as the single exponential smoothing model, is used to anticipate data that does not have a trend and does not have seasonal variations. The model only uses the weighted observation data to obtain prediction data, and it only uses one significant parameter (alpha). The metrics of evaluation will guide the selection of appropriate values for these parameters:

$$\ell_0 = \overline{X} = \frac{\sum_{t=1}^{n} X y_t}{n},$$
$$P_{T+1} = \alpha y_t + (1 - \alpha) P_t, \quad (4)$$

ℓ_0 is the level of trend, X is the level of trend, and n is the number of samples in the dataset. The output is y_t. When smoothing out the training data, the alpha values are set to 0 on a scale of 10–1, $0 \le \alpha \le 10 \le \alpha \le 1$.

2.4. Prediction Models

2.4.1. Bidirectional Long Short-Term Memory (BiLSTM) Algorithm. Recurrent neural networks, often known as RNNs, are a special kind of neural network with the ability to acquire new knowledge over the course of time. RNNs can be broken down into several subtypes, one of which is called long short-term memory (LSTM) neural networks. These networks are able to acquire knowledge on long-term dependencies. Each and every RNN has the same core structure, which consists of repeating neural network modules that are coupled to one another [40, 42–44]. LSTM networks, which are used to store information and have this chained in a similar pattern, also use purpose-built memory cells to store the information; however, the repeating module in an LSTM has a distinct structure. As can be seen in Figure 2, an LSTM cell is composed of four distinct layers that are capable of interacting with one another.

There are two memory vectors (h and C) and cell activation matrices (C) in Figure 2, both of which have the same size as the hidden vector h. The logistic sigmoid function is σ. Tanh's function task is to keep the numbers in the range of −1 to 1. The RNN's internal structure, for example, a tanh layer, is based on a neuron. To protect and control the memory state, LSTM uses three switches: the input gate (i_t), the output gate (o_t), and the forgotten gate (f_t), together with a memory cell as a gate. These switches have varying weights and will be weighted according to the input data. Afterward, each switch determines whether it is on or off.

To begin, you must decide which messages in memory cells, such as (5), should be eliminated. When the timing is t, the weight matrix is W, the output is h_{t-1}, the input is x_t for time t, and the bias value is b_f. The sigmoid layer converts these to values ranging from 0 to 1. For the final forgotten gate, f_t represents the output, while the value of 1 is reserved for exclusive use.

Forget gate layer:

$$f_t = \sigma\left(W_{ef} X_t + W_{ef} h_{t-1} + W_{cf} C_{t-1} + b_f\right). \quad (5)$$

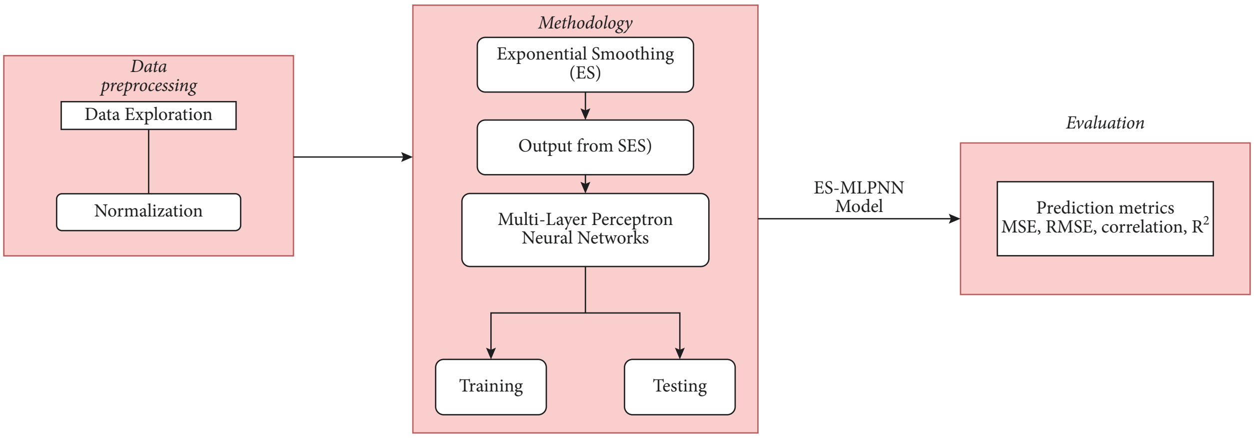


Figure 1: A generic framework.

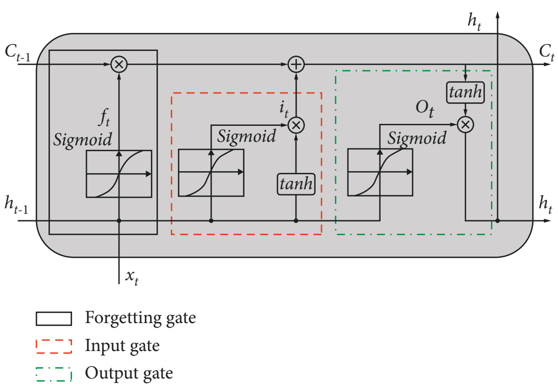


Figure 2: LSTM model.

The decision of which new messages to store in the memory unit and to split into two sections, adding temporary states and updating old states, needs to be made once more. The sigmoid layer determines which values require an update, and the tanh layer creates a vector that can be used to find new candidate values in (6) and (7). Weight matrix W_i, W_c is updated in equation (6), which multiplies old state C_{t-1}/f_t by new candidate value i_t (it will be in C_t, b_i, and b_c) to determine whether to forget the message. The new candidate value i_t (it will be in the new state C_t) is the bias value.

$$\text{Input gate layer: } i_t = \sigma\left(W_{xi}X_t + W_{hi}h_{t-1} + W_{ci}C_{t-1} + b_i\right), \tag{6}$$

$$\begin{gathered}\text{New memory cell:}\\ C_t = \sigma\left(f_t c_{t-1} + i_t \tanh\left(W_{xc}X_t + W_{hc}h_{t-1} + b_c\right)\right).\end{gathered} \tag{7}$$

Equations (6) and (7) use a sigmoid layer to determine which sections of the memory unit need to be outputted, and the state of memory unit is passed on in the final decision of the output message. To get the output, multiply o_t by tanh (C_t) and then by h_t after the tanh layer is applied. This value lies between -1 and 1, depending on the temperature. The bias value is b_0.

$$\begin{gathered}\text{Output gate layer: } o_t = \sigma\left(W_{xo}X_t + W_{ho}h_{t-1} + W_{co}C_{t-1} + b_o\right),\\ h_t = O_t \times \tanh\left(C_t\right).\end{gathered} \tag{8}$$

The BiLSTM network is shown schematically in Figure 3. Each training sequence in the BiLSTM model contains two circulating neural networks, one backward and one forward, each connected to a single output layer. The model receives and exports training materials in both ways. Two RNNs are used to determine the final output based on the status of both RNNs' hidden layers, which are connected to each other via an output layer.

ANFIS is a well-known hybrid AI model that combines artificial neural networks and fuzzy logic (FL). It was first proposed by Jang in the 1990s. Fuzzification, rule, normalization, defuzzification, and aggregation are the five main layers of the ANFIS architecture. It has been demonstrated that neural networks are capable, when given such a framework, of deducing the parameters of the FL algorithm [43]. The ANFIS fuzzy inference system makes use of Takagi-Sugeno if-then rules, together with an appropriate membership function. As with ANN, hybrid ANFIS may also detect nonlinear relationships between inputs and outputs. Several studies, such as those in [45–49], have shown that ANFIS has a higher prediction efficiency than individual ANNs or FL. As a sort of artificial neural network, the ANFIS system relies on the Takagi-Sugeno fuzzy inference system, which combines the advantages of ANN and fuzzy logic in one framework.

$$\begin{gathered}\text{Rule1: if } x \text{ is } A_1 \text{ and } y \text{ is } B_1, \text{then } f_1 = p_1x + q_1y + r_1,\\ \text{Rule1: if } x \text{ is } A_2 \text{ and } y \text{ is } B_2, \text{then } f_1 = p_2x + q_2y + r_2,\end{gathered} \tag{9}$$

where A_1 and B_1 represent the fuzzy sets and p_1, p_2, q_1, q_2, and r_1 represent the subsequent parameters that are used to determine their values during the training stage. The five layers are fuzzification, inference, normalization, outcome, and output. There are five layers in ANFIS's architecture: inference, normalization, outcome, and output. Figure 4 depicts these layers:

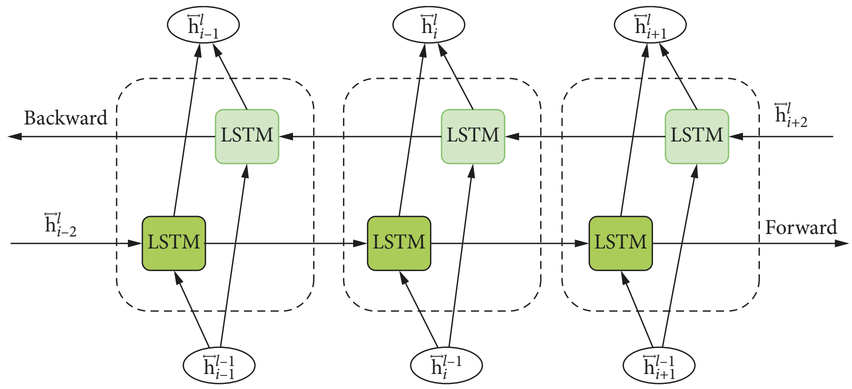


FIGURE 3: BiLSTM structure algorithm.

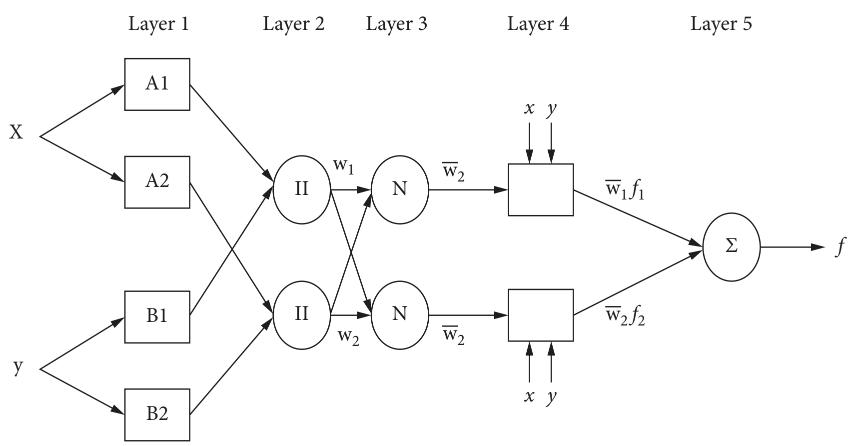


FIGURE 4: Structure of ANFIS model for predicting WQ.

Layer 1. Each node in the "premise parameters" layer generates a "fuzzy membership degree" as a result of the parameters in this layer. In the first-level iteration, assume that $O_{1,i}$ is its i^{th} level and j^{th} node.

$$O_{1,i} = \mu A_i(x), \quad \text{for } i = 1, 2, \tag{10}$$

$$O_{1,i} = \mu B_i(y), \quad \text{for } i = 1, 2, \tag{11}$$

$$\mu A_i(x_1) = \frac{1}{1 + \left((x - c)_i/\sigma_i\right)^{2b_i}}. \tag{12}$$

In equations (10) and (11), the fuzzy membership functions $\mu A_i(x)$ and $\mu B_i(y)$ are used (MF). The fuzzy sets are represented by A_i and B_i. The formula for the Gaussian MF (GMF) is based on a Sugeno-type fuzzy inference system, where x and σ_i refer to the average and variance of the GMF, respectively.

Layer 2. The firing strength of each rule is calculated by multiplying the values of the nodes in the second layer:

$$O_{2,i} = w_i = \mu A_i(x) * \mu B_i(y), \quad i = 1, 2. \tag{13}$$

Layer 3. As stated above, the primary goal of this layer is to compute $O_{3,i}$ normalization:

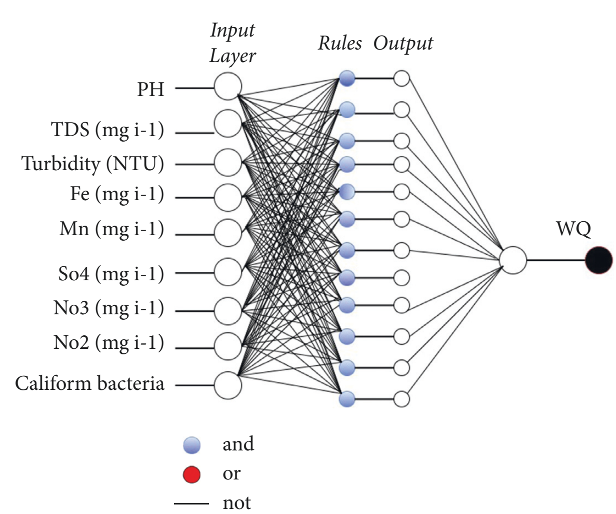


FIGURE 5: Topology of ANFIS system for predicting WQ.

$$O_{3,i} = \overline{w_i} = \frac{w_i}{w_{1+w_2}} \quad i = 1, 2. \tag{14}$$

In this case, $O_{3,i}$ is the output of layer 3, and, $\overline{w}$ is the inference system rules' normalized firing strength.

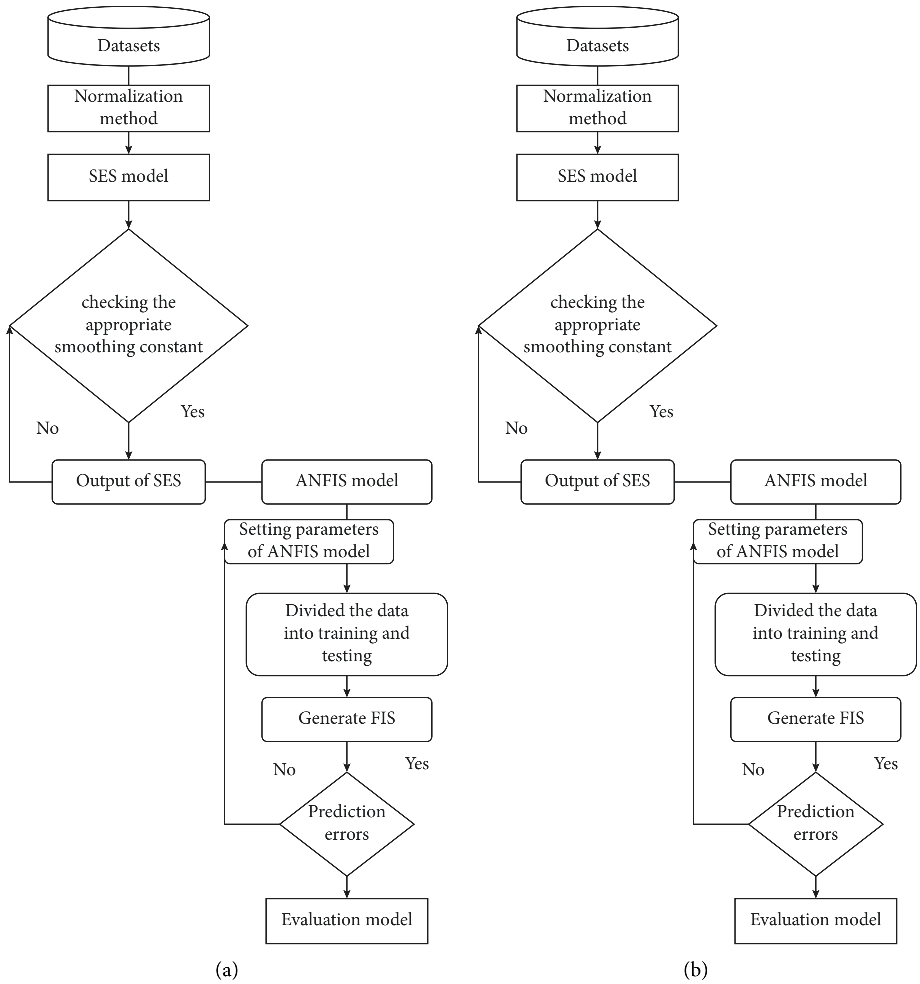


Figure 6: Flowchart of developing system. (a) SES-ANFIS; (b) SES-BiLSTM model.

Layer 4. This layer has nodes that may adapt. It allows the adaptive nodes to be customized through the use of three parameters.

$$O_{4,i} = \overline{w_i}.f_i = \overline{w_i}.\left(p_i x + q_i y + r_i\right), \tag{15}$$

where p_i, q_i, and r_i are the parameters of the inference system in the form of $O_{4,i}$ of layer 4.

Layer 5. This is the inference layer, and its purpose is to produce the overall output by using the information from the layers that came before it.

$$O_{5,i}\text{overall output} = \sum \overline{w_i} f_i = \frac{\sum_i \overline{w_i} f_i}{\sum_i w_i}. \tag{16}$$

The topology of ANFIS model is presented in Figure 5.

For the purpose of predicting water quality, we have developed a prediction system that combines the single exponential smoothing (SES) algorithm with the bidirectional long short-term memory (SES-BiLSTM) algorithm and an adaptive neurofuzzy inference system (SES-ANFIS). The output from the single exponential smoothing (SES) algorithm was then processed by the LSTM and ANFIS models. This was the first step in the procedure. The development process is depicted in the flowchart shown in Figure 6.

2.5. Performance Measurement. The mean square error (MSE), root-mean square error (RMSE), mean absolute error, and coefficient of correlation are the metrics that are utilized in the analysis of artificial intelligence models for the forecasting of WQ (CC). The definitions of the metrics are as follows.

2.5.1. Mean Square Error (MSE). The estimator mean square error (MSE) quantifies the average square of the errors, that is, the average square of the difference between the observation's values $y_{i,\text{observ}}$ and estimated values $y_{i,\text{estim}}$.

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}\left(y_{i,\text{observ}} - y_{i,\text{estim}}\right)^2. \tag{17}$$

2.5.2. Root-Mean Square Error (RMSE). The RMSE value indicates a better fit between observations $y_{i,\text{observ}}$ and estimated values $y_{i,\text{estim}}$, divided by number of observations (n).

Table 3: Results of the proposed model at training process.

Models	MSE	RMSE	R (%)
SES-BiLSTM	0.00707	0.0841	99.82
SES-ANFIS	7.8088×10^{-08}	0.000279	100

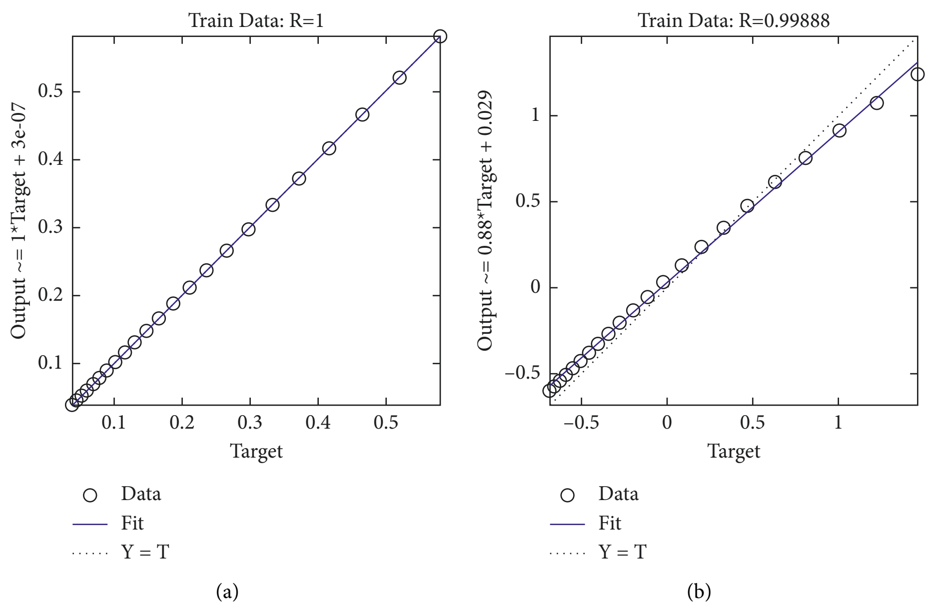


Figure 7: Regression plot of the proposed system: (a) SES-ANFIS model and (b) SES-BiLSTM model at training process.

$$\mathrm{RMSE} = \sqrt{\sum_{i=1}^{n} \frac{\left(y_{i,\mathrm{observ}} - y_{i,\mathrm{estim}}\right)^2}{n}}. \quad (18)$$

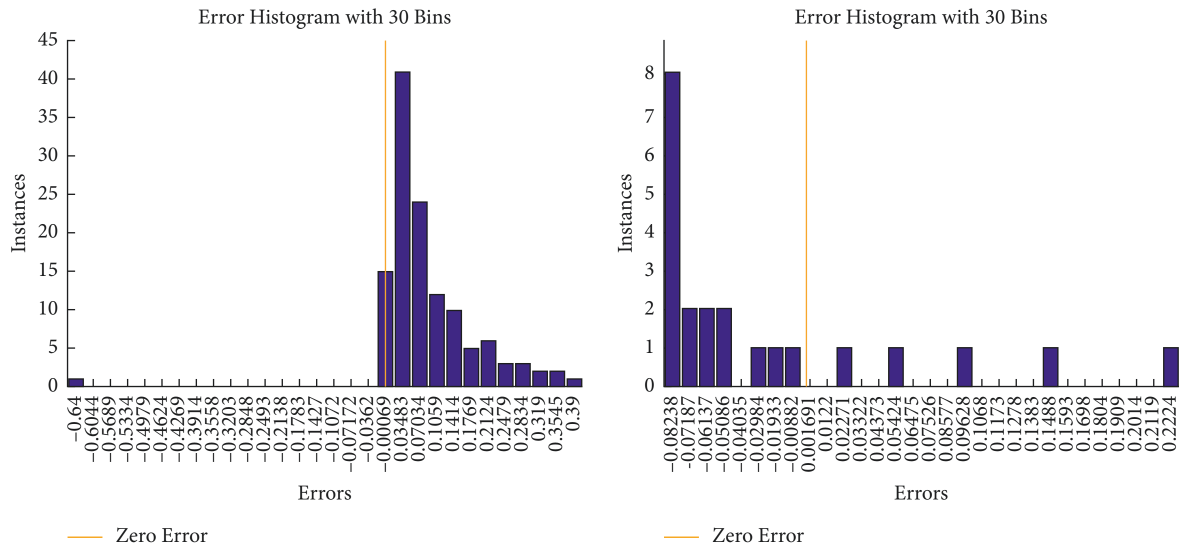
2.5.3. Coefficient of Correlation (CC). Coefficient (r) goes from -1 to 1 and reflects the weight of the correlation between observations and prediction. The closer you get to zero, the less linear the relationship between observations and predictions becomes. The strong negative linear relationship between -1 and 1, for example, is represented by the number zero, while the strong positive linear relationship between the number 1 and the number 0 is represented by the number one.

$$R\% = \frac{n\left(\sum_{i=1}^{n} y_{i,\mathrm{observ}} \times y_{i,\mathrm{estim}}\right) - \left(\sum_{i=1}^{n} y_{i,\mathrm{observ}}\right)\left(\sum_{i=1}^{n} y_{i,\mathrm{estim}}\right)}{\sqrt{\left[n\left(\sum_{i=1}^{n} y_{i,\mathrm{observ}}\right)^2 - \left(\sum_{i=1}^{n} y_{i,\mathrm{observ}}\right)^2\right]\left[n\left(\sum_{i=1}^{n} y_{i,\mathrm{estim}}\right)^2 - \left(\sum_{i=1}^{n} y_{i,\mathrm{estim}}\right)^2\right]}} \times 100. \quad (19)$$

3. Experiment

Improvements to the LSTM and ANFIS models, the SES preprocessing method, were applied in this study for predicting water quality. The LSTM and ANFIS models were used to forecast water quality characteristics in groundwater in Al-Baha region. When developing the model, the training phase utilized seventy percent of the data, while the testing phase made use of thirty percent of the data. MATLAB 2020 was used to perform the analysis on the data. In order to carry out the simulation, we made use of a computer that had an Intel i7 processor and 8 gigabytes of random access memory.

3.1. Training Process. It is a collection of data samples that are utilized in the process of fitting the parameters of a prediction model to the training of observational data regarding the water quality. It is a necessary part of all ANNs models, and its inclusion enables these models to produce accurate forecasts or do the functions that are required of them. In this investigation, a training process consisting of



(a) (b)

FIGURE 8: Histogram plot of the proposed system: (a) SES-ANFIS model and (b) SES-BiLSTM model at training process.

TABLE 4: Results of the proposed model at testing process.

Models	MSE	RMSE	R (%)
SES-BiLSTM	0.00910	0.0954	99.95
SES-ANFIS	2.2941×100^{-07}	0.000478	99.95

seventy percent of the dataset has been used in order to validate the effectiveness of the LSTM and ANFIS models. This study made use of three distinct model efficiency statistics. These statistics were the mean square error (MSE), the root-mean square error (RMSE), and the standard deviation of the mean square error (SDME). These statistics were used to measure how far the actual values deviated from the expected values. Table 3 shows the results of the proposed models at training phase for predicting water quality. In addition, the SES-ANFIS model has achieved very low values of $\text{MSE} = 2.2941 \times 100^{-07}$ and $\text{RMSE} = 0.000478$.

Figure 7 demonstrates that there is a perfect match between the observed values and the prediction values of water quality. This was accomplished by plotting the developing system along the y-axis and the experimental values along the x-axis. The SES-ANFIS model has achieved R value of 100%, while the SES-BiLSTM model has achieved R value of 99.82%.

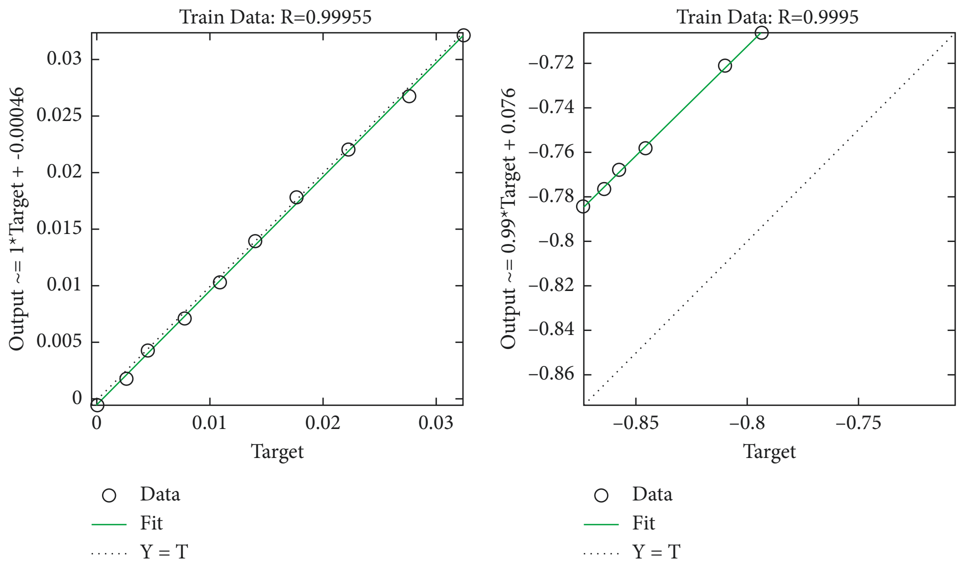
In the training stage, the predicted values' histogram error is shown in Figure 8. Metrics such as the error histogram may be used to identify discrepancies between the expected and observation values. These error numbers might be negative, since they indicate how the prediction values differ from the training target values. An error of SES-ANFIS model is 0.00069, where error histogram of SES-BiLSTM is 0.001691.

3.2. Testing Process. Testing phase is utilized in the process of selecting the model's parameters, whereas test set is utilized in the process of evaluating the effectiveness of the model on an unexplored (real world) dataset. 30% of the dataset was considered as testing for validating the SES-BiLSTM and SES-ANFIS models for predicting water quality. Table 4 shows the results of SES-BiLSTM and SES-ANFIS models for predicting WQ. The results have revealed that the developing system SES-BiLSTM and SEE-ANFIS models were successfully predicting. It is observed that the two models were found to be capable of predicting the groundwater with great accuracy. According to the MSE metric, the SES-ANFIS model has achieved much less prediction ($\text{MSE} = 2.2941 \times 100^{-07}$).

The WQ values that were predicted are depicted as a regession plot in Figure 9, which is used throughout the testing phases. In order to determine the degree of correlation that exists between the projected values and the actual values, Pearson's correlation is used in this graphic. The numbers along the x-axis represent the experimental data, while the values along the y-axis represent the prediction values generated by the SES-BiLSTM and SES-ANFIS models. Both models have been proved to have earned the same score, which is 99.95%.

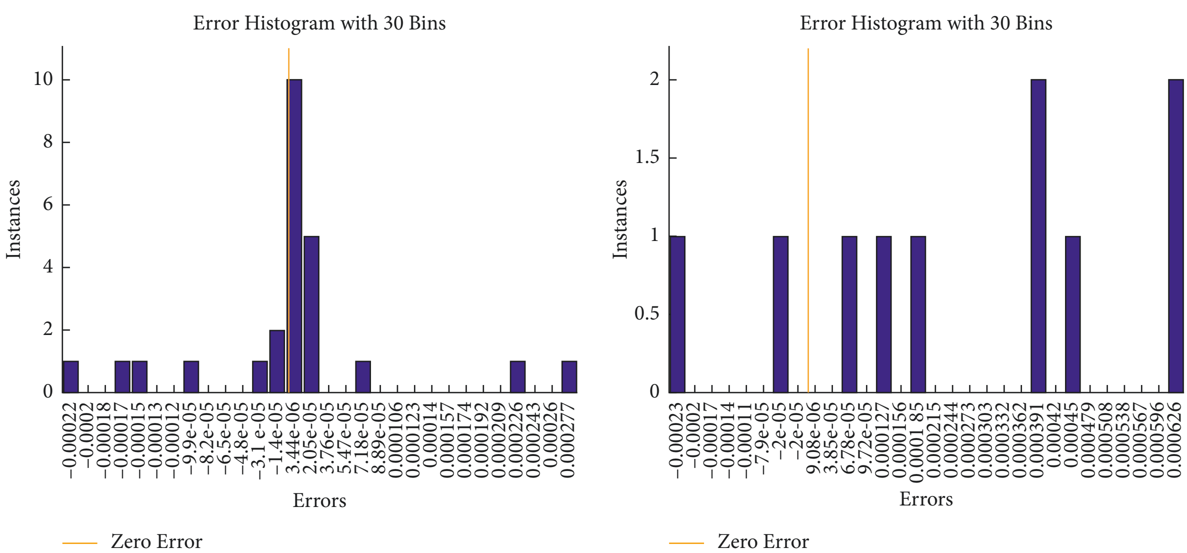
The error histogram of the proposed system's SES-BiLSTM and SES-ANFIS models at testing phase is presented in Figure 10. The error histogram metrics are used to compute the error between the testing observation values and testing target values at 30 bins. It is observed that the error histogram of SES-ANFIS is 5.44×10^{-06} and the error histogram of SES-BiLSTM is 2×10^{-05}.

Therefore, there is a good correlation between the predictions generated by the model and the actual data,



(a) (b)

FIGURE 9: Regression plot of the proposed system: (a) SES-ANFIS model and (b) SES-BiLSTM model at testing process.



(a) (b)

FIGURE 10: Histogram plot of the proposed system: (a) SES-ANFIS model and (b) SES-BiLSTM model at testing process.

which implies that SES-ANFIS and SES-BiLSTM models may be made with confidence, and this information can be utilized to develop laws and procedures to safeguard water sources.

3.3. Selective Analysis for Finding Significant Parameters. Many engineering and scientific sectors are adopting sensitivity analysis, which encompasses nearly all data processing and computational modeling and process simulation operations. A good indicator for the quantitative and qualitative management of surface water resources in arid and semiarid environments can be found in the upstream discharge planning of regulated groundwater and the relationship between water quality measures. The correlation coefficient method was applied to examine the effectiveness of inputs parameters, namely, pH, TDS (mg/l), turbidity (NTU), Fe (mg/l), Mn (mg/l), SO_4^{2-} (mg/l), NO_3^- (mg/l), and NO_2^- (mg/l) with WQ parameter for predicting water quality. For each of these eight water quality factors, the input parameter's percentage effect may be shown in Figure 11. As an example, PH, NO_2^- (mg/l), NO_3^- (mg/l), TDS (mg/l), and SO_4^{2-} (mg/l) were the most important input characteristics for predicting groundwater in Al-Baha region. NO_2– (mg/l) and pH have scored the highest percentages of R: 100% and 95.59%, respectively.

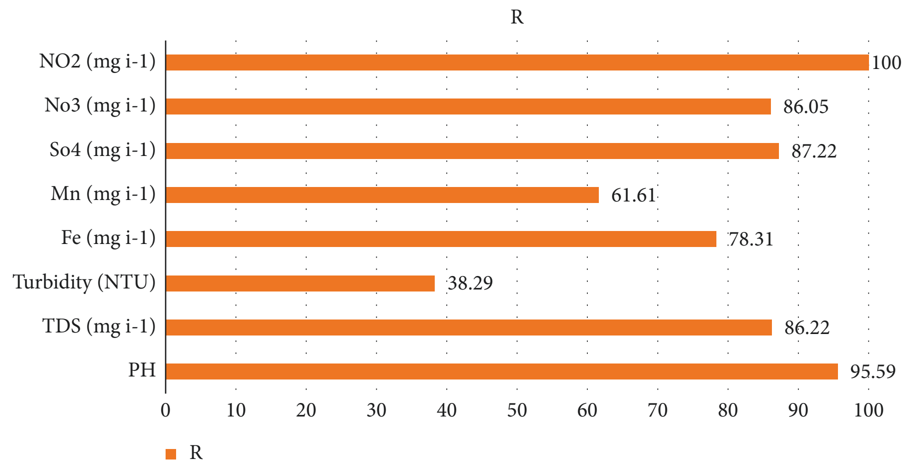


Figure 11: Important parameters.

Table 5: Comparison results between the proposed system and existing systems.

Reference	Years	Input parameters	Results	Models	Types of water
Ref. [50]	2021	pH, T-Alk, T-hard, DO, TS, MPN	$R = 0.999$ MRE = 0.775	Feedforward back-propagation	Drinking water
Ref. [44]	2021	DO, pH, EC, BOD, N-NO_3, fecal coliform, total coliform	$R = 96.1\%$ RMSE = 0.0029	ANFIS	Drinking water India
Ref. [51]	2021	TDS, N-NO^{2+}, N-NO_3^-, Ca, Mg, Na, K, Cl^-, SO_4^{2-}, CO_3^{2-}, HCO_3^-, F^-, pH, TH, SAR, RSC	RMSE = 0.057 testing RMSE = 0.066 training	ANN	Drinking water India
Ref. [52]	2021	pH, DO, BOD, turbidity, TS	MSE = 2.08 $R = 99.07\%$ testing	ANN	River India
Ref. [53]	2020	pH, WT, OS, TDS, NTU, N-NO_3, P-PO_4, BOD5, COD, Cl–	RMSE = 0.007 $R^2 = 81.01\%$ testing RMSE = 0.009 $R^2 = 92.09$ training	Multilayer perceptron neural networks	River (Algeria)
Ref. [54]	2016	DO, BOD, COD, pH, SS, N-NH3	$R^2 = 98.01$ RMSE = 1.598	ANN	Water river (Malaysia)
Ref. [34]	2012	pH, EC, TDS, NTU, WT, BOD, DO, N-NH3, Mg, Cl, F, TH, Fe, Zn, As, total coliform bacteria, *E. coli* bacteria, SS, N-NO_3,	RMSE = 1.633 $R = 0.977$	Artificial neural network	River (Malaysia)
Proposed system SES-ANFIS	2022	PH, TDS (mg/l), turbidity (NTU), Fe (mg *i*-1), Mn (mg *i*-1), So_4 (mg *i*-1), No_3 (mg *i*-1), and NO_2 (mg *i*-1)	MSE = 7.8088×10^{-08} RMSE = 0.000279 $R = 100\%$ at training MSE = 2.2941×100^{-07} RMSE = 0.000478 $R = 99.95\%$	SES-ANFIS	Groundwater Saud Arabia

4. Results and Discussion

The modeling and prediction of water quality have played a vital and substantial role in the reduction of the amount of time as well as the number of resources that are necessary for laboratory analysis. The use of artificial intelligence algorithms as a potential replacement for more traditional approaches to estimating and forecasting water quality was investigated. The case study was conducted in Al-Baha region, Saud Arabia, including groundwater.

Using our technology, we are certain that we can keep a close eye on both the water supply and the wastewater stream. It is our goal to create a real-time system and test an alternate way utilizing a sophisticated artificial intelligence model for accurately predicting and classifying water quality. To correctly replicate water levels and quality, this study recommends using a combination of the artificial intelligence techniques presented in this study. In this way, a more sustainable and effective approach to water management and sustainability can be developed. Our model has performed well when it comes to analyzing contaminants with the bare minimum of parameters. There was a total of eight parameters included in the dataset. In addition, we have determined that the four following factors are extremely important: PH, NO_2–

(mg/l), NO_3^-, and SO_4^{2-}. Table 5 provides a summary of the findings of the existing models in comparison to our suggested system. Several of the research works that have been conducted have utilized machine learning models for the purposes of modeling and predicting.

According to the article, the SES-BiLSTM and SES-ANFIS models may be used to predict water quality and can be used in the development and implementation of integrated water protection systems, as well as in the implementation of sound environmental management practices. The SES-BiLSTM and SES-ANFIS techniques have various advantages over the computational approach in forecasting WQI.

This study attempted to prove that the SES-BiLSTM and SES-ANFIS models are effective tools for forecasting water quality and may be used to construct integrated water protection systems while applying appropriate environmental management practices. The proposed models have several advantages over the computational approach when it comes to forecasting WQI. A minimum of four different water quality measures must be calculated and then transformed into partial indications to use the second technique. The WQI is calculated using a formula that relies heavily on subindices. As a result, implementing an existing ANN model based on raw data is substantially simpler because no new calculations are required. To develop the model, certain water quality characteristics are needed, minimizing the cost of water quality monitoring, among other things.

5. Conclusion

In groundwater studies, one of the most difficult problems to solve is the prediction of groundwater level (GWL) using geoelectric characteristics. This is due in part to the fact that an empirical relationship between the level of groundwater and the geoelectric parameters has not been established yet. In this study, an effort was made to circumvent these obstacles by investigating the capacity of advance artificial neural networks (ANNs) to simulate nonlinear systems:

(i) The artificial intelligence models were designed to forecast and categorize the quality of drinking water by utilizing data from groundwater gathered in a variety of places in Al-Baha region. The goal of the models was to improve water quality for human use. WQI was used to determine the values of eight significant parameters: pH, TDS (mg/l), turbidity (NTU), Fe (mg/l), Mn (mg/l), SO_4^{2-} (mg/l), NO_3^- (mg/l), and NO_2^- (mg/l). These were regarded as important factors for determining the quality of the water. Developing new methods that make use of more advanced SES-BiLSTM and SES-ANFIS algorithms is one way to contribute to the preservation of a secure environment.

(ii) In the SES-ANFIS and SES-BiLSTM models, the correlation coefficient was found to be 99.95%, and the MSE was found to be equivalent to 2.2941×100^{-07} for testing. The suggested model was used to generate these findings, and the set was divided as follows: 70% was used for training, and 30% was used for testing. The SES-ANFIS and SES-BiLSTM models that were proposed in this paper have several benefits, one of which is the ease with which groundwater pollution levels can be evaluated. In addition, making use of these models makes it possible to skip the time-consuming calculations that are a part of the conventional WQI that is most commonly used.

(iii) In further research, the authors want to try to accurately anticipate the quality of the water by making use of indications that are dependent on the location of the various pollution sources.

(iv) The authors plan to discuss evaluating the quality of groundwater in further articles; in doing so, they hope to make use of more machine learning strategies. The findings that were achieved via the use of various approaches will be compared, and the influence that these methods have on the quality of the prediction will be studied. The limitation of this proposed work is using small datasets; therefore, we did not apply classification algorithms for categorizing the types of water.

Data Availability

The dataset is collected from https://bbrc.in/assessment-of-water-quality-in-some-wells-in-albaha-region-and-its-surrounding-area-saudi-arabia/.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Conceptualization was developed by Mosleh Hmoud Al-Adhaileh, Theyazn H.H Aldhyani, and Fawaz Waselallah Alsaade; methodology was proposed by Mosleh Hmoud Al-Adhaileh. Theyazn H.H Aldhyani, Fawaz Waselallah Alsaade, and Mohammed Al-Yaari; software was developed by Theyazn H.H Aldhyani; validation was performed by Ali Khalaf Ahmed Albaggar and Theyazn H.H Aldhyani; formal analysis was done by Mosleh Hmoud Al-Adhaileh, Theyazn H.H Aldhyani, and Mohammed Al-Yaari; investigation was done by Mohammed Al-Yaari and Ali Khalaf Ahmed Albaggar; resources were given by T.H.H.A; data curation was performed by Ali Khalaf Ahmed Albaggar; original draft preparation was done by Mosleh Hmoud Al-Adhaileh, Theyazn H.H Aldhyani, Mohammed Al-Yaari, Ali Khalaf Ahmed Albaggar, and Fawaz Waselallah Alsaade; review and editing were carried out by Mosleh Hmoud Al-Adhaileh, Theyazn H.H Aldhyani, Fawaz Waselallah Alsaade, and Ali Khalaf Ahmed Albaggar; visualization, supervision, and project administration were performed by Mohammed Al-Yaari; funding acquisition was performed by Theyazn H.H Aldhyani. All authors have read and agreed to the published version of the manuscript.

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Research Article

Agricultural Economic Evidence and Policy Prospects under Agricultural Trade Shocks and Carbon Dioxide Emissions

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With the development of the market economy, agricultural trade has become more and more significant for the development of the agricultural economy, which has triggered people's further thinking and exploration on the impact of agricultural trade on agricultural carbon emissions. This paper takes the measurement of trade implied carbon as the carbon dioxide emission index under the impact of agricultural trade and analyzes the impact of trade implied carbon and implied carbon balance on carbon emission. Taking the impact of Sino-US agricultural trade as an empirical background, this paper measures the impact of environmental changes in agricultural trade opening on China's agricultural development and its carbon emissions, so as to predict changes in China's regional agricultural carbon emissions performance. After calculation, it is found that the scale of China's exports has decreased by 0.089%, which is lower than the decline of 0.361% in the United States. The trade conflict has a significant impact on China's import and export structure. Under the scenario of mutual tariffs on agricultural products, China's exports to the United States are expected to decrease by 6.28%, while China's imports from the United States decreased by 13.02%. The Sino-US agricultural trade dispute will reduce China's carbon emissions by 0.013% and the United States' carbon emissions by 0.024%, which is related to the negative impact on the economy. Improving the performance of agricultural carbon emissions is not only the need for the green and sustainable development of the agricultural economy but also conducive to improving the international competitiveness of agricultural products.

1. Introduction

China's economic construction is gradually in line with the world, and the economic status has been continuously improved. Behind the great achievements, it is also necessary for people to become more rational and sober. The development imbalance between regions or between urban and rural areas is becoming more serious. The quality and structural level of development are low. The existing agricultural production efficiency is still low, and the driving force and level of rural economic development need to be improved. The income gap between rural residents and urban residents has further widened and most of them are still in poverty. Therefore, the key to developing the rural economy, promoting agricultural development, and improving farmers' income is to scientifically and effectively handle the problems of rural areas, agriculture, and farmers. The development of low-carbon agriculture in China has potential, motivation, and pressure. Therefore, in order to fulfill the responsibility of a big country, it is necessary to develop a low-carbon economy. To develop a low-carbon economy, people must give priority to the development of modern low-carbon agriculture. Therefore, it is of great significance to study the low-carbon development of agricultural trade.

There is a balanced relationship between agricultural economic development and social and ecological environment. Li et al. identified and quantified agricultural residues [1]. Cole and Xiong studied agricultural insurance (AI) schemes in developing countries [2]. Mason et al. believed that the fertilizer subsidy program will become a policy [3]. Luo et al. compared the decoupling of China's agricultural carbon dioxide emissions and agricultural output in different regions and years [4]. Li et al. believed that crop prices are the most sensitive influencing factors [5]. Their study of agricultural economics did not take environmental factors into account. This article will locate how agricultural trade conflicts play out in the agricultural economy, with a view to discovering its value in this area.

The agricultural trade shock has an important impact on the fluctuation of the agricultural economic cycle. Eor analyzed the agricultural production factors of various countries [6]. Udoh and Adelaja used regression analysis to evaluate agricultural trade data [7]. Li and Andreosso-O'Callaghan analyzed and compared the advantages of EU27 countries (excluding the UK) and China [8]. Mizik et al. aimed to analyze the comparative advantage model of the commonwealth of independent states agriculture [9]. Widyasari et al. forecast future direction and trends in agricultural trade [10]. To a certain extent, agricultural economic growth can reduce the growth rate of carbon dioxide emissions. This paper will make further research on the impact of agricultural trade.

At present, there are three main means to reduce embodied carbon emission: management emission reduction, technical emission reduction, and structural emission reduction. This paper will study in detail the impact of country sources, product distribution, and transportation means of embodied carbon emissions in international trade in agricultural products. It will provide constructive decision-making suggestions for optimizing the structure of agricultural trade, further improving the production of agricultural products and the low-carbon development of the industrial structure. The research method of this paper is mainly based on the multi-regional input-output model (MRIO), which can make up for the current agricultural carbon footprint research that only focuses on the carbon emissions in production or logistics transportation, while ignoring the impact of agricultural import and export trade on carbon footprint. In this way, a more comprehensive method is constructed to measure the scale, country and product distribution of China's agricultural trade embodied carbon in the context of agricultural trade globalization. It is found that the embodied carbon of China's agricultural export trade increased by 118.69%, and the trade volume increased from 4.609 billion yuan to 16.275 billion yuan during the same period, with an increase of 253.10%.

2. Agricultural Economics Analysis

2.1. Agricultural Economic Policy. With the continuous improvement of China's agricultural policy, China's economy has maintained a rapid and steady growth. Through the analysis of the influencing factors such as the total power of agricultural machinery, the amount of fertilizer application, and labor input, the government can better guide the government to clarify the purpose of the special agricultural subsidy funds, such as subsidies for agricultural machinery and motivation. Positive policies that benefit farmers can promote the development of agriculture, further guide farmers' motivation for farming, and are also beneficial to agricultural income and improve the overall quality of life of farmers. This can also enhance the pertinence of the government's agricultural expenditure and the efficiency of the use of funds [11, 12]. Agricultural production activities directly affect the natural environment. With the development of chemical agriculture and mechanical agriculture, agriculture has become an important source of greenhouse gas emissions.

3. Agricultural Trade and Low-Carbon Economy

The main features of a low-carbon economy are "low consumption, low emissions, and low pollution". In the partial equilibrium model of green agricultural trade policy, if a country's trade of a certain green agricultural product is so large that it affects the world market price, it is called a major trading country of this agricultural product. In reality, it is often a developed country and tends to adopt positive support policies. Correspondingly, countries that cannot cause significant fluctuations in world market prices are called small trading countries of such agricultural products, which are often in developing countries that tend to adopt negative support policies. The large country model is used for the positive support policy of agricultural trade, and the small country model is used for the negative support policy of agricultural trade. Through the analysis of the green agricultural trade support policies of developing and developed countries, the government's intervention policies may appear to be too costly in terms of national economic welfare. This exacerbates price fluctuations in the world market, distorts the flow of agricultural trade, and leads to an imbalance in the allocation of world resources [13]. China is not only relatively scarce in land resources, but also has a high cost of land use. It should reduce the production scale of land-intensive agricultural products and increase their imports, so as to improve the efficiency of resource allocation.

Agricultural production emits large amounts of greenhouse gases such as carbon dioxide, methane, and nitrous oxide. Among them, carbon dioxide mainly comes from the use of energy. Methane mainly comes from ruminant animal feeding, rice cultivation, and animal excretion. Nitrous oxide mainly comes from the use of chemical fertilizers and animal manure. The particularity of agriculture is determined by its own characteristics. That is, agricultural production activities will not only emit a large amount of greenhouse gases to cause climate change, but more importantly will be adversely affected by climate change to a greater extent. The essence of low-carbon agriculture is the scientific and rational use of chemical fertilizers and energy, optimization of planting technology and structure, etc., in order to achieve the "three lows" development of agriculture, so that the environment and agricultural economic development achieve harmony and unity. Low-carbon agriculture is the embodiment of a low-carbon economy in the process of agricultural development, which is an indispensable part of the process of low-carbon economic development. The impact of agricultural trade liberalization on the agricultural environment is shown in Figure 1 [14].

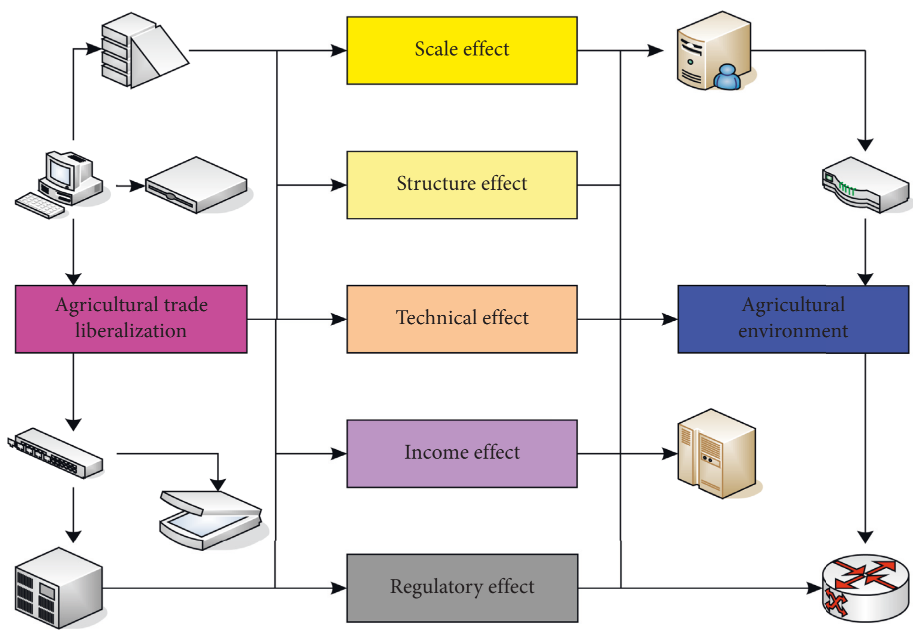

Figure 1: Impact of agricultural trade liberalization on the agricultural environment.

4. Calculation Model of Carbon Embodied in Trade

With the increasing scale of foreign trade in agricultural products, the greenhouse gas emissions caused by foreign trade cannot be underestimated for the reduction of greenhouse gas emissions from agricultural production. Compared with a single factor, this paper not only examines CO_2 output from the perspective of agriculture, but also examines the impact of different input factors and their alternative factors on carbon emission efficiency. Therefore, the measurement of agricultural CO_2 needs to be more comprehensive. Based on the total factor productivity theory, this paper takes the expected output of agricultural carbon emissions as the expected performance of carbon measurement. Some scholars take other pollutants as unexpected outputs to measure and measure carbon emissions. This paper will measure the performance of agricultural carbon emissions from the perspective of agricultural total factor productivity.

Without considering international trade, the total output of a sector in a country can satisfy all intermediate and final demands for the products produced by that sector. Therefore, the basic model of input-output analysis can be defined as follows [15]:

$$\sum_{j}^{m} a_{ij} x_j + y_j = x_i. \tag{1}$$

In formula (1), a_{ij} represents the direct emission factor. The model can detect the magnitude of the variable response value after a given system shock, the direction of change (positive and negative), and the number of cycles affected by the system after the shock.

The carbon dioxide emission coefficient of each energy source per unit mass is given as follows:

$$AC_i = C_i * \left(1 + H_i\right). \tag{2}$$

In formula (2), AC is the adjusted CO_2 emission factor [16].

The theoretical analysis model of the relationship between agricultural carbon emissions and agricultural economic growth is shown in Figure 2. Through the analysis of green agricultural trade support policies in developing and developed countries, the government's intervention policies may appear too costly in terms of national economic welfare. This exacerbates price fluctuations in the world market, distorts the flow of agricultural trade, and leads to an imbalance in the allocation of world resources. In economically developed countries, people's institutional demands on the environment are stronger, and they begin to put pressure on the government. They force the government to adopt the trade policy supply that serves the environmental goal, leading to the change of the environmental protection system and the trade support system, which becomes a typical induced system change. In the process of sustainable agricultural development, it is currently facing three pressures: the lack of resources, ecological pollution, and the international commitment to reduce carbon emissions.

5. Data Source and Processing

The empirical analysis of the MRIO model (It is a regional input-output model which is an input-output model prepared for a region and a component of the overall input-output model.) requires three parts of data, namely, the import and export trade volume between China and its trading partners, the direct carbon emission coefficient by industry, and the input-output table. The import and export trade volume data between China and its trading partners is taken from the 0ECDSTAN Bilateral Trade Database (BTD),

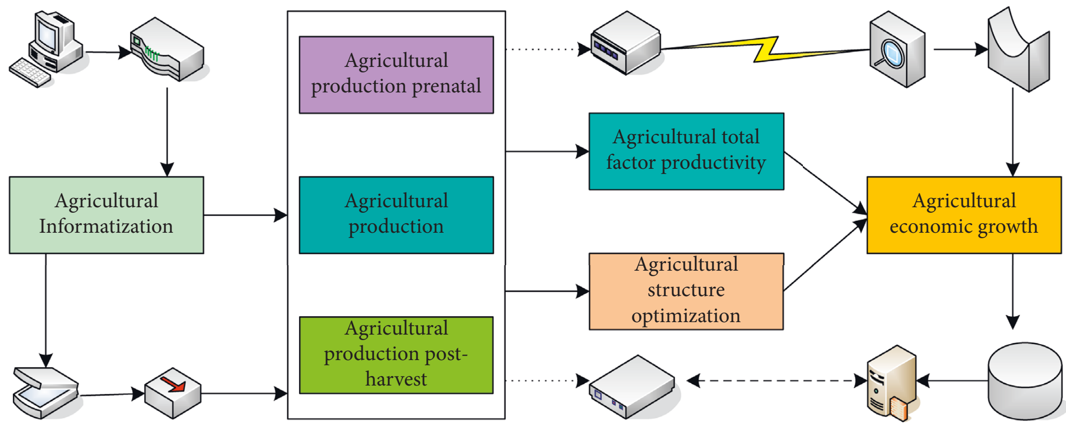

FIGURE 2: Theoretical analysis model of the relationship between agricultural carbon emissions and agricultural economic growth.

and the industry is classified with reference to the International Trade Classification Standard (ISICRev4.0). The carbon direct emission coefficient and input-output table data by industry are taken from the WIOD database. This paper adopts the estimation method based on fuel classification. In specific operations, the total amount of carbon dioxide emissions is obtained by summing up the estimated carbon dioxide emissions from various types of energy consumption, and its calculation formula is given as follows [17]:

$$C = \sum (AC_i * EC). \tag{3}$$

In formula (3), C is the total carbon dioxide emissions, and EC is the total energy consumption.

6. Evaluation of the Transformation of Agricultural Economic Growth Mode

The large-scale management of farmland not only is reflected in the increase of input of production factors and the progress of technical level, but also makes the allocation ratio of various production factors better. The combination of various factors has the highest production efficiency under a certain technical level. That is to say, agricultural large-scale production reduces marginal production costs, increases scale returns, and improves agricultural production efficiency by expanding crop planting area and rationally matching capital, technology, and human capital investment. This paper uses the total factor productivity method to evaluate the agricultural economic growth mode. The main input elements of agricultural economic growth include capital, labor, and land, so its growth rate equation is given as follows [18]:

$$G = G_A + \delta G_M + \mu G_N + \varepsilon G_P. \tag{4}$$

In formula (4), G represents the growth rate of agricultural output, and GA represents the total factor growth rate.

This paper adopts the total agricultural output value as an indicator reflecting the total agricultural output. In the process of traditional agricultural growth, the expansion of land use has always been the most important factor in agricultural growth. With the advancement of technology, the improvement of the level of agricultural material and technical equipment, the increasing population and the contradiction between the non-renewable land resources have become prominent. The growth of modern agriculture mainly depends on the improvement of the depth of land use.

7. Evaluation of the Process of Transformation of Agricultural Economic Growth Mode

Quantitative evaluation of the transformation of agricultural economic growth mode must be based on the actual situation and the method chosen. The deviation value is equal to the difference between the actual value and the target value, and its main meaning is the gap between the indicators of agricultural growth mode and the daily target of primary intensive management. The dispersion method comprehensively reflects the degree to which the evaluation index of the agricultural economic growth mode approaches the standard value, that is, the comprehensive level of the achieved degree that the agricultural growth mode has changed from extensive to intensive. The dispersion method can test whether the difference between the means of two or more samples is statistically significant. The formula for calculating the dispersion level of each indicator is given in as follows [19]:

$$G = \sum_{i=1}^{3} \left(\sum_{j=1}^{n} X_{ij} * w_{ij} \right). \tag{5}$$

In formula (5), G is the agricultural growth intensification level index.

With the acceleration of urbanization in China in recent years, urbanization has promoted the adjustment of agricultural economic structure. First, urbanization integrates the current rural production factors and resources. On the one hand, many farmers migrated to cities and towns, making land resources more concentrated. Many of the original small-scale farmers with decentralized operations

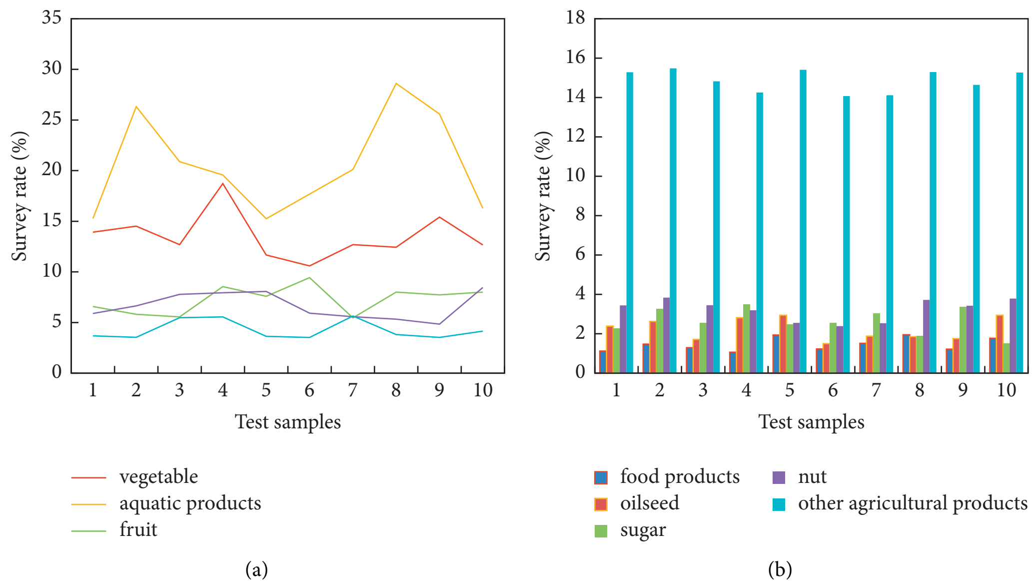

FIGURE 3: China's agricultural products export survey. (a) Vegetables, aquatic products, fruits, livestock products, and beverages. (b) Grain products, oilseeds, sugar, nuts, and other agricultural products.

have been transformed into large-scale farmers and new production forms such as farms and cooperatives. The adjustment of the agricultural structure requires a certain amount of land as support, so urbanization meets the requirements of agricultural structure adjustment for land. Second, in the past, the agricultural products produced by farmers under the family based production method were often small in scale and complete in variety, but the emergence of urbanization made farmers produce specific agricultural products in a targeted manner. There is demand among farmers who produce different agricultural products, which promotes the specialized production and regionalization of agriculture. This change makes the production factors recombine and gives play to the regional comparative advantage, promoting the optimization and adjustment of the agricultural structure. In this paper, the ADF unit root test method is used to test the two variables, LnAI and LnTAP, to judge their single integer order. In the ADF test, if the series is stationary, there is no unit root. Otherwise there is a unit root. The method of ADF unit root test is given as follows [20]:

$$W_t = \alpha t + \beta + \delta W_{t-1} + \theta_{t-i} + \varepsilon_i. \tag{6}$$

In formula (6), α, β, δ, and θ are parameters; t is a time trend factor; ε is a random error term.

8. Results of Agricultural Economy

Among the proportions of various agricultural products in 2019, vegetable exports accounted for 20.5%. Aquatic products exports accounted for 30%. Fruit exports accounted for 10.4%. Livestock products exports accounted for 9.4%. Beverage exports accounted for 6.3% (The statistics of vegetables, aquatic products, fruits, livestock products, and beverages are shown in Figure 3(a)). Exports of food products accounted for 2.5%. Oilseed exports accounted for 2.3%. Sugar exports accounted for 2.3%. Nut exports accounted for 1.6%. The total export of other agricultural products accounted for 18.6%. The total exports of fruits and vegetables accounted for 30.9% (Grain products, oilseeds, sugar, nuts, and other agricultural products are shown in Figure 3(b)). China's labor resources are abundant but land resources are scarce. According to the theory of comparative advantage, with the continuous improvement of agricultural trade openness, the agricultural production structure will also change. Agricultural infrastructure inputs affect trade, transportation costs, etc. The level of agricultural infrastructure has a certain impact on the scale of trade, and then the trade will have different effects on agricultural carbon emissions performance due to the different levels of infrastructure in each region. The low-carbon agriculture theory is the demand of this research and the support of this paper. The total factor productivity theory is the theoretical basis for the calculation and decomposition of carbon emission performance.

The import proportion of China's agricultural products is aquatic products (9%), vegetable oil (5.7%), beverages (5.2%), grain (5.2%), fruit (5%) (The statistics of imported aquatic products, vegetable oils, beverages, grains, and fruits are shown in Figure 4(a)), cotton and linen silk (2.4%), grain products (1.6%) (%), and other products (11.4%). Oilseeds and livestock products together account for more than 50% of imported agricultural products. The source countries of China's imports are mainly concentrated in some European and American countries (The statistics of imported cotton and linen silk, grain products, other products, oilseeds, and livestock products are shown in Figure 4(b)).

The content of sustainable agriculture theory includes: respecting nature, protecting agricultural resources and environment, and rational and orderly utilization of resources.

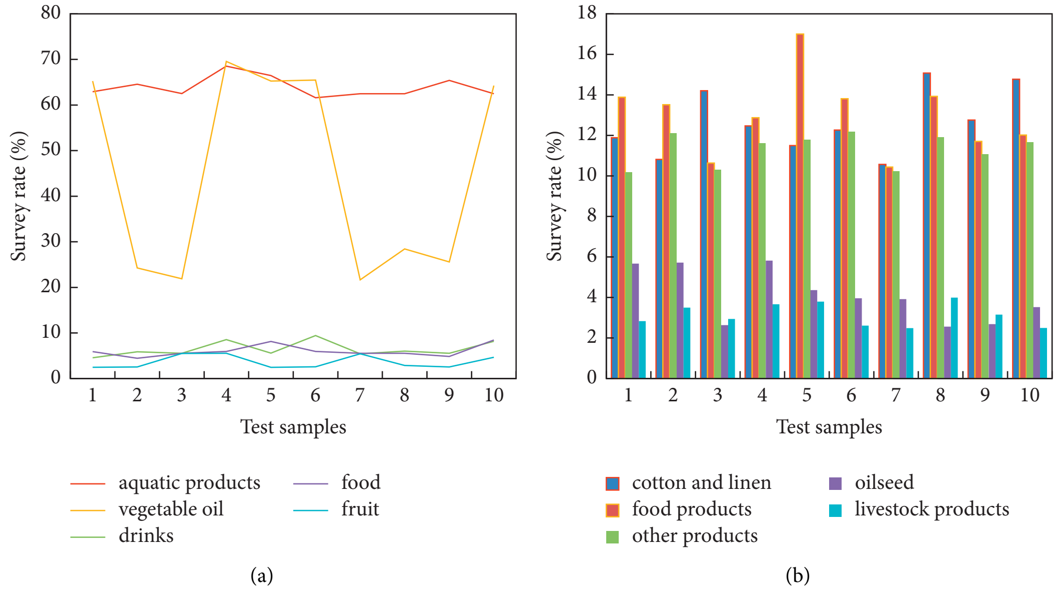

Figure 4: China's agricultural product import surveys. (a) Aquatic products, vegetable oils, beverages, grains, and fruits. (b) Cotton and linen silk, grain products, other products, oilseeds, and animal products.

Table 1: Direct CO_2 emissions from export trade.

Department	2018	2019	2020	2021
Agriculture, forestry, animal husbandry, and fishery (kg/dollar)	0.38	0.33	0.35	0.31
Mining industry (kg/dollar)	1.70	1.11	0.89	0.81
Food, beverage, and tobacco products (kg/dollar)	0.69	0.31	0.13	0.11
Textile industry (kg/dollar)	0.51	0.18	0.13	0.16

The agricultural production not only meets the needs of modern people, but also meets the survival and development of future generations. The sustainable development trade system of agricultural trade is inseparably linked with society and the environment, and the integration of different dimensions into a systematic analysis is a current research hotspot. Such systematic research takes the production and trade of agricultural products as the carrier, including trade-resources-environment, trade-water-energy, trade-health, and so on.

According to Table 1, the CO_2 complete emission coefficient of China's export trade can be obtained. In the horizontal sector comparison, the "electricity, gas, steam and air conditioning supply" had the highest CO_2 complete emission coefficient and the largest change, which was from 34.01 kg/USD in 2019 to 15.79 kg/USD in 2021. The CO_2 direct emission coefficient of "agriculture, forestry, animal husbandry and sideline fishery" was the lowest among all measured industries, but its change trend was different from other sectors. From 2018 to 2021, it showed a downward trend, which was from 1.81 kg/USD to 1.29 kg/USD. The direct CO_2 emissions from export trade are shown in Table 1.

Agricultural production and agricultural environment have always been one of the research hotspots. Under the background of climate change, carbon emission has been recognized by experts and scholars as a proxy variable of agricultural production environmental pollution. The measurement of agricultural carbon emissions solves the problem that agricultural environmental pollution is difficult to quantify. In the past, agricultural environmental pollution was mostly studied by quantifying pesticides, chemical fertilizers, and unreasonable farming. Therefore, incorporating agricultural carbon emissions into the agricultural production performance evaluation framework enriches the existing theoretical basis of agricultural production and environmental protection. The research on the impact of trade on economic growth and the research on the impact of trade on the environment helps to clarify the mechanism of the impact of trade on agricultural economic growth and agricultural production environment. In addition, this paper measures agricultural carbon emission performance from the perspective of total factor productivity, so the research on the impact of trade on total factor productivity and green total factor productivity also has important reference significance for this paper.

In general, the trend of China's agricultural export trade is basically the same as the embodied carbon, showing an upward trend. From 2018 to 2019, the embodied carbon of China's agricultural export trade increased rapidly, from 7.14 mt to 15.62 mt, with an increase of 118.69%. In the same period, the trade volume increased from 4.609 billion yuan to 16.275 billion yuan, with an increase of 253.10%. The growth rate of implied carbon was smaller than that of trade volume. Among them, the growth rate of embodied carbon in exports was relatively obvious between 2017 and 2018 and from 2019 to 2020. From 2019 to 2020, the embodied carbon of China's agricultural export trade increased rapidly, from 6.23 mt to 8.94 mt, with an increase of 43.54%. In the same period, the trade volume increased from 4.293 billion yuan to 6.821 billion yuan, with an increase of 58.89%. From 2020 to 2021, the embodied carbon of China's agricultural export trade increased rapidly, from 11.39 mt to 15.82 mt, with an increase of 38.92%. In the same period, the trade volume rose from 9.736 billion yuan to 14.004 billion yuan, with an increase of 43.83%. The comparison of embodied carbon growth rate and trade volume is shown in Figure 5.

The direct cause of international trade between the two countries is the difference in product price caused by the difference in production costs between the two countries. That is, if there is still a price difference between the products of the two countries after deducting the export freight, the two countries can conduct international trade. The import trade of agricultural products is conducive to the introduction of clean technology. When agricultural trade develops to a certain extent, the competition of agricultural products will intensify, such as carbon emission taxes and fees, which will cause environmental costs to rise. Products with high agricultural carbon emission performance meet the needs of the market, and agricultural producers are forced to develop new technologies to accommodate low-carbon production requirements. The scale of agricultural trade expands the existing economies of scale, promotes technological progress, and guides changes in environmental regulations and policies, which may promote the use of carbon emission reduction technologies so as to reduce agricultural carbon emissions, improving agricultural carbon emissions performance. The expansion of the agricultural economic scale will increase the per capita income of agricultural producers, and people's requirements for the quality of the production environment will be further improved. Therefore, the willingness to purchase agricultural products with higher carbon emission performance begins to germinate, which promotes the progress and promotion of emission reduction technologies.

Overall, there are large differences in agricultural carbon emissions between provinces. Affected by the impact of imported products, the sales prices of agricultural products in various provinces and cities have decreased. Affected by this, agricultural exports expanded the most in province A ($19.62 million), province B ($20.44 million), province C ($21.33 million), province D ($32.86 million), and province E ($34.17 million). The five provinces with the largest changes in carbon emissions from agricultural exports are the same as the first three scenarios, namely, province G (81.95 million tons), province E (68.18 million tons), province F (66.44 million tons), province A (53.12 million tons), and province D (44.33 million tons). The United States imposed a 25% tariff on agricultural exports to China, while China lifted the tariffs on US agricultural products. The cumulative trade volume of agricultural exports and the carbon emissions of agricultural exports in various regions of China have increased, but the impact of the increase is very small. Compared with other provinces, the increase in

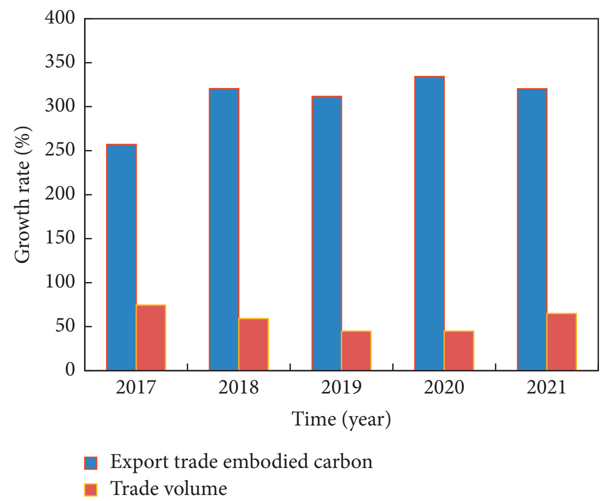

Figure 5: Comparison of embodied carbon growth rate and trade volume.

carbon emissions from agricultural exports in provinces G and F increased significantly. The performance of agricultural carbon emissions and changes in agricultural products under the impact of imported agricultural products are shown in Table 2. Export trade is conducive to full interaction with consumers in the market, and new technologies and knowledge can be obtained in the process of interaction, which is conducive to the improvement and promotion of agricultural production technology.

As for imported products, if the trading partner countries have higher requirements for carbon emission standards, to a certain extent, it will give the exporting countries the motivation to promote the innovation and research and development of low-carbon technologies. For exporting countries, it is beneficial to reduce carbon dioxide emissions. From the perspective of countries, from 2022 to 2030, the Sino-US agricultural trade dispute will be detrimental to the economic growth of both countries. Under the scenario of mutual tariffs on agricultural products between the two countries, China's real GDP fell by 0.0218% cumulatively, which was higher than the 0.0015% decline in the United States over the same period. The Sino-US agricultural trade conflict is not conducive to the import and export trade of the two countries, but the decline in the United States is higher than that in China. After calculation, it is found that the scale of China's exports has decreased by 0.089%, which is lower than the decline of 0.361% in the United States. The trade conflict has a significant impact on China's import and export structure. Under the scenario of mutual tariffs on agricultural products, China's exports to the United States are expected to decrease by 6.28%, while China's imports from the United States will drop by 13.02% during the same period. Related to the negative economic impact, the Sino-US agricultural trade dispute will reduce the carbon emissions of the two countries by 0.013% and 0.024%, respectively. Figure 6 shows the calculation of carbon emissions and agricultural economics in China and the United States. If the gap between economic interests can be broken, and intellectual property barriers can be eliminated, as well as the

Table 2: Agricultural carbon emission performance and changes in agricultural products under the impact of imported agricultural products.

Different provinces	Changes in cumulative agricultural exports (USD million)	Carbon emissions (million tons)
A	19.62	53.12
B	20.44	15.22
C	21.33	10.33
D	32.86	44.33
E	34.17	68.18
F	12.15	66.44
G	14.32	81.95

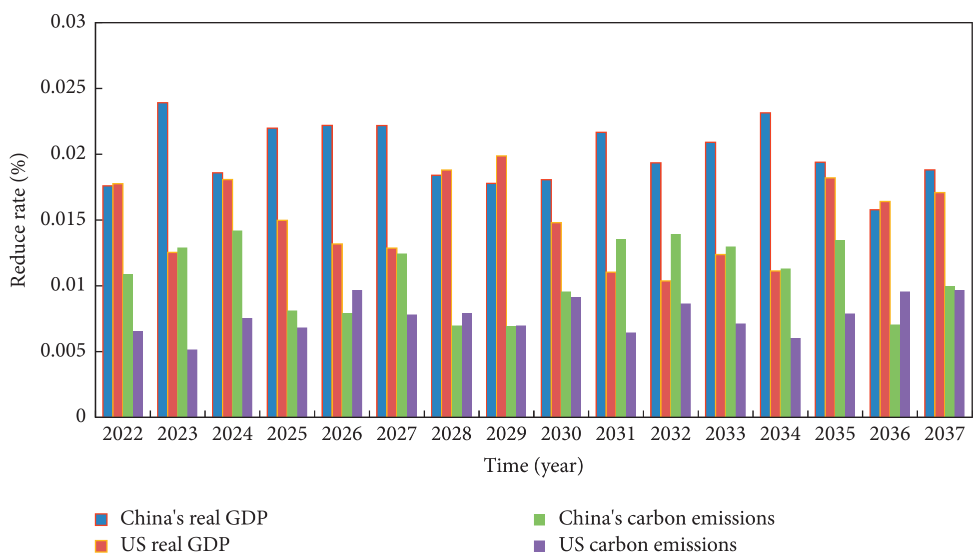

Figure 6: China and the United States carbon emissions and agricultural economic calculation.

differences in technology and management levels between countries and regions can be reduced, then the technology transfer and the transformation of scientific and technological achievements between countries brought about by global cooperation will accelerate the elimination of carbon leakage in international trade. Therefore, it is necessary to formulate a reasonable agricultural carbon emission performance evaluation system to provide policy guidance and institutional guarantee for evaluating the coordinated development of China's agricultural production and agricultural environment. At present, most of China's low-carbon production work focuses on industrial emission reduction. Although industrial carbon reduction has achieved results, insufficient attention has been paid to agricultural carbon emissions, and agricultural production models with high energy consumption, high investment, and low efficiency still exist. Agricultural production in some areas is still in a nonrecyclable state.

9. Conclusion

With the consolidation of China's international status, China's import and export trade has made great progress compared with investment and consumption. For agricultural production, the level of agricultural carbon emission performance is an important indicator to measure whether agricultural production is of high quality and meets green standards. The high-carbon production of agricultural products faces the threat of carbon tariffs in developed countries, so reduces agricultural carbon emissions and increases the import of agricultural products on the premise of ensuring food security. The high-carbon production of agricultural products faces the threat of carbon tariffs in developed countries, so agricultural carbon emissions are reduced. Under the premise of ensuring food security, the import of agricultural products has been increased. This paper takes agricultural trade as the research object, analyzes the resource flow and carbon emissions behind the trade, and combines the trade, resources, and environmental systems for analysis to provide a research basis for sustainable development. This paper makes an objective evaluation and analysis of China's agricultural development of carbon finance from the actual point of view, which provides a more feasible theoretical basis and policy ideas for the development of carbon finance in the field of the agricultural economy. Under the background of global climate and environmental change, the research on agricultural production development policy oriented toward low-carbon and high-efficiency is not only a hot spot concerned by all countries in the world, but also an important strategic issue related to the development of China's low-carbon agricultural economy. However, this study does not further analyze the factors of carbon dioxide emissions. The work in the future can further explore the development of carbon finance in the field of the agricultural economy.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Research Article

Role of Managerial Ability in Environmental, Social, and Economics Sustainability: An Empirical Evidence from China

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The current study analyzed whether the enhancement in managerial ability accelerates the environmental, social, and economic sustainability practices or not. Using panel data methodology on Chinese listed firms data from 2010 to 2019, we report that CEOs' managerial ability impacts the overall (environmental, social, and economic) sustainability practices of the firms positively. Moreover, we find that social sustainability and economic sustainability also increase with the increase of the CEO's managerial ability in the firm. The results remain robust after several alternative empirical tests. The findings justify the relationship between management skills and sustainability and demonstrate how each one of the sustainability pillars is affected individually. The support for sustainability practices that can be achieved through the communication of management skills is an essential conclusion for practitioners. Findings establish the link between CEO's managerial ability and environmental, social, and economic sustainability performance by taking insights from upper echelon theory.

1. Introduction

The consequences of industrialization including depleting supplies, ruined ecosystems, and the misuse of both natural resources and human labor are some of the reasons driving stakeholders to demand greater corporate accountability, especially in terms of sustainability. The United Nations has established 17 global sustainable development goals (SDGs) with 169 related targets, reflecting its commitment to solving global environmental and sustainable development issues. Griggs, et al. [1] highlighted social, environmental, and economic aspects as the main pillars of sustainable development and redefined them to include "development that meets current needs while safeguarding the Earth's life-support system, upon which the welfare of current and future generations is contingent." Focusing on the firm's "triple bottom line" functioning should be the contemporary approach toward accountability [2]. Sustainability could only be achieved by equally valuing all its aspects (social, environmental, and economic). For this reason, the Global Reporting Initiative's (GRI) sustainability indicators are structured to provide insight into a company's major economic, environmental, and social consequences, as recommended by the GRI's sustainability reporting criteria [3, 4]. Achieving a balance between the sustainability pillars requires a thorough grasp of how society and industrial actions affect the environment, as well as how today's decisions may affect future generations. As a result, a greater understanding and awareness of the concerns surrounding sustainable development is required.

Institutional factors and organizational attributes are found as primary determinants of sustainability by past researchers [5, 6]. However, the trend is shifting now, and some recent research has focused on the chief executive officer (CEO) and its role in transparency and accountability [7]. Under this prism, researchers have tried to link sustainability and CEO traits (e.g., power, educational background, political ideology, gender, age, experience, personality, media exposure, religiosity, leadership style, and experience) [8–10].

This study aims to investigate the relationship between a chief executive officer's (CEO) management ability and the company's sustainability performance (SP). Although a vast body of literature is available separately for sustainability performance and managerial ability, the need is to bridge this relationship. A more extensive examination of the relationship between the CEO's managerial competence and sustainability characteristics is required for a complete understanding. There have only been a few attempts to understand this link. Recently and Yuan et al [5], García-Sánchez et al [8] have tried to explain the link between CEO's managerial ability and CSR (Corporate Social Responsibility)/Sustainability performance. Still, both of these studies have not digested the sustainability deeper and did not employ a triple-down approach. In contrast, our empirical contribution takes into account three perspectives of sustainability.

Moreover, the above studies did not study the relation between ability and sustainability in developing economies like China, as this study has done. This research discovers numerous aspects of the management ability-sustainability nexus by individually assessing the various components of sustainability. By this, the study presents a multi-faceted view of sustainability on one. It highlights the role of the ability of the corporate level management to make the firm accountable on economic, social, and environmental grounds. This study adds to the body of research concerning the ties between leadership competencies and sustainability dimensions, substantiating statements about the interrelationships and relative importance of various sustainability aspects [11].

We conduct such rigorous research since the existing literature does not cover the influence of the CEO's managerial ability on all three elements of business sustainability. We use the GRI's SP reporting framework to accomplish this. Businesses must disclose both positive and negative results on all aspects of sustainability, assuming that each is equally vital for long-term development, according to sustainability reporting rules (sustainability reporting guidelines, GRI 2006. (Vol. G3)) [2]. This study reveals multiple aspects of the management-sustainability nexus by quantifying the various sustainability features independently [11].

Scientists have examined sustainability from several theoretical vantage points, including resource dependence [12], resource-based [13], stewardship [14, 15], and neo-institutional [16]. But any theory separately falls short in explaining the link completely [2], and no single hypothesis can adequately explain the expected links [17]. Theoretically, our research contributes to different managerial-related, governance-related, and society related different paradigms. Our main hypothesis was developed through upper echelon theory. The upper echelon theory says that a manager's personality is the key determinant of how a company makes decisions. Since it was impossible to ignore the role of different corporate governance systems as mediators in the management-sustainability nexus, agency theory concepts were also used to figure out how managerial competence and sustainability are related. The study also took insights from stakeholder theory [18] in highlighting the multi-faceted view of sustainability. Our findings may also help guide future research: because the projected influence is often focusing on just one aspect of sustainability (either environmental or social), it necessitates assessing the triple bottom line sustainability performance.

Section 2 will discuss the literature review and hypothesis development in detail. Data and Research methodology details are in section 3. Followed by discussions of results and conclusions, respectively in Sections 4 and 5.

2. Literature Review and Hypothesis Development

In the literature, several organizational, individual, societal, and institutional elements of SP have been identified. There is a recent drive to explore the influence of CEO conduct on SP [19], based on the idea that CEOs establish the driving mechanism of the organization. In their capacity as chief executive officers, CEOs are responsible for assessing the requirements of all stakeholders and organizing the company's production to satisfy those needs [20, 21]. This is why making sustainability a high priority is essential [22]. Several qualities of CEOs, including their values [23], incentives [24], narcissism [25], career horizon [26], hubris [27], education [28], political ideology [28], have been cited as determinants impacting SP in the literature.

The relationship between CEOMA and SP is well confirmed by the upper echelon theory. This idea says that the strategic decisions and results of businesses are affected by the personalities and skills of the CEOs. [19]. CEOMA is associated with an improved grasp of firm's operation and performance drivers [29, 30], better utilization of organizational resources [31], appraising new business ventures, as well as to deal with uncertainty [5], to comprehend and respond to environmental motivations [27], embracing innovative strategies [32, 33], and take risks [34].

According to Porter [35], managers may prioritize research and development, advertising, and employee training above fulfilling quarterly and yearly goals. When outcomes are unsatisfactory, it is usual practice to alter management [36, 37], and former leaders may have difficulty reentering the workforce [38]. Consistent with the theory that management turnover is proportional to performance [39], firms with more competent management are more likely to implement sustainable practices. Long-term investments in CSR provide delayed and unforeseeable returns [40–42]. CEOs may be less inclined to invest in CSR if doing so may be detrimental to their careers. CEOs with exceptional skills have less need to be concerned about their career fate [29] and are able to ignore pressure to engage in high-returning ventures. Moreover, because of their ability to deal with ambiguity, more successful CEOs are less likely to be intimidated by the uncertainty associated with CSR investment. Since CSR strategy is often long-term and hazy, the capacity of CEOs to affect their firms' CSR actions is vital [5]. Therefore, competent managers are more inclined to undertake CSR activities despite the risks and long-term consequences [43]. According to prior research [5, 30], the CSR investments and performance of a firm are strongly connected with the managerial competence of the CEO.

We suggest that skilled leaders are more likely to prioritize corporate social responsibility. Competent CEOs would choose for more successful CSR initiatives to further enhance sustainability in environmental, social, and economic dimensions [27, 30].

H1: CEO's management skills are positively related to corporate sustainability performance.

2.1. Managerial Ability and Social Sustainability. Traditionally, social sustainability has been seen as a government responsibility, but firms are increasingly recognized as significant players. Relationships with employees, consumers, suppliers, and communities are examples of socially sustainable activity.
Social sustainability is defined as a system's ability to maintain an adequate level of social well-being. Thus, an organization is socially sustainable when its activities promote future generations' abilities to maintain healthy communities. Some topical topics in social sustainability include child labor, ethical trading, and supply chain management. Although child labor is prohibited in most countries, it is nonetheless widely practiced. Ethical trading means trading with integrity and legality. Among unethical trading, practices are bribery, anti-competitive behavior, corruption, extortionate pricing, unethical marketing, and market power abuse. Many organizations, particularly multinationals, have broad and complex supply lines. Corporate accountability is increasingly demanded, not just for their activities but also for those of their suppliers. Those firms are more likely to avoid social sustainability, which does not employ optimal use of firm resources. The firm's route to long-term competitive advantage is aided by efficient resource usage and market understanding [44]. Firms with CEOs of superior managerial ability make the best utilization of firm resources [31, 45]; thereby, these firms do not need to indulge in antisocial sustainability practices [5].

H2: CEO's management skills are positively associated with social sustainability performance.

2.2. Managerial Ability and Environmental Sustainability. Environmental sustainability comprises making responsible decisions and taking action to protect the natural world, with a focus on human life-support [46]. Environmental sustainability has various compelling arguments. Sustainability is crucial from a humanistic standpoint since humans depend on nature for survival and must address the challenges it causes. Climate change, waste, and pollution are among the other environmental issues [47]. A sustainable future is unfairly burdened on future generations, according to the intergenerational argument. Naturalists argue that nature has intrinsic value and should be preserved. While some of these arguments may be more persuasive than others, they all add to a compelling case for environmental sustainability. Given their increased risk aversion, CEOs with weaker managerial competence will make short-term investment decisions, avoiding riskier assets [48]. Short-term investments, low-risk ventures, and quick talent transfer are preferred by less capable CEOs [49]. Keeping all these in mind, we hypothesize that CEOs with superior managerial ability will not hesitate to invest in environmental protection.

H3: CEO's management skills are positively associated with social sustainability performance.

2.3. Managerial Ability and Economic Sustainability. The economic dimension of sustainability addresses an organization's impact on local, national, and global economic systems. It implies maximizing existing resources for a business entity so that the organization can function at a given level of activity for many years. The goal is to encourage long-term use of those resources. Economic sustainability involves the long-term viability of the businesses and the stability of the economic system. One of the most critical aspects of economic sustainability is transparency, openness, and authenticity about a corporation's operations and strategy. Transparency allows external stakeholders to assess a corporation's risk exposure. CEOs with superior managerial ability demonstrate deep knowledge of their business, leading to better judgments and estimates; leading to better reporting quality and transparency [31].

H4: CEO's management skills are positively associated with economic sustainability performance.

3. Research Methodology

3.1. Data Description. Financial and corporate governance data for all 4,132 A-shares issued between 2010 and 2019 on the Shanghai and Shenzhen exchanges were made accessible through a popular Chinese website " (China Stock Market and Accounting Research)." In 2010, we started collecting data after China's Thousand Talents Plan [50], which assisted in the recruitment of CEOs based on their management skills, was introduced at the end of 2008. Using the HEXUN website, we acquired RKS ratings for every A-share Chinese listed business. The HEXUNRKS rankings are based on the social, environmental, and economic elements, as well as the overall CSR score, of each year's reviewed Chinese enterprises. As far as, we can ascertain, all publicly listed Chinese firms that submit sustainability reports are included. These databases are widely used in Chinese-related research [51, 52]. To limit the risk of outliers, we eliminated financial institutions from the data set and sorted continuous observation variables with a 1% tail. If a company's values were missing for three consecutive years, they were eliminated from consideration. The whole dataset consists of 3,052 enterprises with 20,651 firm-year observations ranging from 1,373 in 2010 to 2,663 in 2018. This dataset is not uniformly distributed across the sampled companies (lowest to highest).

3.2. Variables Design

3.2.1. Dependent Variable. Third-party rating agencies such as HEXUNRKS evaluate long-term performance sustainability. Sustainable performance is the total of a company's contributions to CSR programs and their consequences on the environment, society, and bottom line over time. These numbers are continuous variables from the HEXUN database that may take on values between 0 (the lowest rating score) and 100 (the highest rating score) (the highest rating score).

3.2.2. Independent Variable. Management skills are assessed by researchers using a variety of metrics, including corporate size [53], historical stock returns [54], and media evaluation [43, 55]. Measures based on such variables are not thought to be very reliable because they do not have a lot of testing power and most people think they only show talent in management at a median level [45].

This research derives the notion of chief executive officer management skills (CEOMA) from [56]. This statistic is used to assess a CEO's performance compared to others in his or her profession since it assumes that managers who are able to create more with the same set of inputs are more effective. Management ability is intangible and can only be deduced from strategic resource use outcomes. CEOs do two things to improve the appraisal of [45]'s managing skills.. The primary purpose of Data Envelopment Analysis (DEA) was to measure the efficiency of a corporation year-over-year and sector-by-sector. The input and output variables must be specified for this method to function. In order to accomplish this, they accounted for seven distinct figures: (I) cost of goods sold (CGS), (II) selling, general, and administrative expenses (SGA), (III) property, plant, and equipment (PPE), (IV) operating lease (OLease), (V) research and development cost (RD), (VI) goodwill (GW), and (VII) other intangibles (OtherInt). The output variable is the amount of net sales. Initially, they apply DEA to determine the best solution to the following optimization issue:

$$\max_y \theta = \frac{\text{Sales}}{v_1 CGS + v_2 SGA + v_3 PPE + v_4 OLease + v_5 R\ D + v_6 GW + v_7 \text{Other Int}}. \tag{1}$$

For the efficiency measure, any number between 0 and 1 may be utilized (as determined by the aforementioned DEA model). Due to the dual ownership of the company's efficiency, total production efficiency was split between management and the business as a whole. Six criteria were then identified as either facilitating or inhibiting management help. Company size, market share, positive cash flow, and age (management-supporting parameters), as well as complex multi-segment and international operations, were all regressed against overall company efficiency (factors that hinder management). In particular, they determine the Tobit regression in the following manner:

$$\begin{aligned} \text{Firm Efficiency} = {} & \beta_0 + \beta_1 Ln(\text{Total Assets}) + \beta_2 \text{Market Share} + \beta_3 \text{Positive Free Cash Flow} + \beta_4 Ln(Age) \\ & + \beta_5 \text{Business Segment Concenttration} + \beta_6 \text{Foreign Currency Indicator} + \text{Year Indicators} + \epsilon. \end{aligned} \tag{2}$$

The Model 2 residual exemplifies managerial expertise. This study employs the decile rank of managerial ability (CEOMA) by year and industry to make the score more comparable across time and industries and to reduce the impact of outliers [45].

3.3. Control Variables. To avoid misleading conclusions, we consider a number of firms, board of directors, and chief executive officer-related control criteria. To examine the likelihood that SP is associated with firm performance, growth possibilities, financial health, and firm size, we apply the methodology of [30, 57] and add control variables such as ReturnonAsset, Tobin's *Q*, and Size (log of total assets). The controlled variables Duality (equals 1 if the CEO is also the chairman), CEOGender (equals 1 if the CEO is male), and RetiringCEO (equals 1 if the CEO is 63 or older) are related to the CEO. Board size (the total number of directors on boards), board independence (the proportion of independent directors to total directors), and board meetings (the frequency with which the board meets) are all examples of corporate governance characteristics that may influence management performance (number of board meetings in a year). Following the work of Yuan et al [5], we also employ HHI and FirmAge to analyze the impact of market age on companies (firm age). The Herfindahl–Hirschman Index (HHI) is an indicator of market competition (the sum of the squared market shares of all firms in the same industry, measured at the end of the fiscal year). The financial flexibility of an organization may be controlled by assessing its net operating assets (NOA) and utilizing Altman's z-score (ZScore) to account for the sector and period-level influences, respectively.

3.4. Econometric Model. The following model was used to establish the link between CEO's managerial skills and sustainability performance, (SP Social, SP Env, and SP Eco), alternatively.

$$
\begin{aligned}
SP_{it} &= \beta_0 + \mathrm{CEOMA}_{it}\beta_{\mathrm{CEOMA}} + Z_{it}\beta_Z + \epsilon_{it},\\
SP\_\mathrm{Social}_{it} &= \beta_0 + \mathrm{CEOMA}_{it}\beta_{\mathrm{CEOMA}} + Z_{it}\beta_Z + \epsilon_{it},\\
SP\_\mathrm{Env}_{it} &= \beta_0 + \mathrm{CEOMA}_{it}\beta_{\mathrm{CEOMA}} + Z_{it}\beta_Z + \epsilon_{it},\\
SP\_\mathrm{Eco}_{it} &= \beta_0 + \mathrm{CEOMA}_{it}\beta_{\mathrm{CEOMA}} + Z_{it}\beta_Z + \epsilon_{it}.
\end{aligned}
\tag{3}
$$

i and t denote the company and the time period, respectively. The vector space of control variables is denoted by Z.

Table 1: Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
SP	20643	23.331	14.961	0	73.31
CEOMA	20653	0.001	0.157	−314	0.391
BSize	20651	8.569	1.699	0	20
BMeeting	20651	9.611	3.941	0	56
CEOGender	20651	0.938	0.242	0	1
BIndependence	20633	0.374	0.052	0.333	0.571
DebttoAssets	20651	0.415	0.215	0.049	0.944
ROA	20651	0.037	0.065	−299	0.191
RetiringCEO	20651	0.023	0.149	0	1
Duality	20651	0.291	0.454	0	1
HHI	20651	0.319	0.267	0	1
NOA	20651	2.092	2.841	−373	111.143
Size	20651	21.941	1.204	19.639	25.565
TobinsQ	20651	2.038	1.367	0	8.792
AgeofFirm	20651	20.805	5.406	4	41
ZScore	20651	0.838	5.015	−569.231	72.59

3.5. Descriptive Statistics. The detailed descriptive statistics are presented in Table 1. The average SP score for Chinese firms came out to be around 23 with minimum score of 0 and maximum of 73. CEO managerial score has a mean of 0.001 with a range from −0.314 to 0.391. Additionally, BoDs in Chinese companies typically consist of 8 to 9 people and have 9 sessions every year. Furthermore, as shown in Table 1, descriptive statistics for the control variables are consistent with prior research [58].

Table 1 provides descriptive statistics for all variables included in the baseline model. Each variable's definition may be found in section 3.2.

4. Results and Discussion

4.1. Findings on Panel Data Estimations. Panel data estimations using the random effect model technique for models 3–6 present results for the effect of a CEO's managerial ability on sustainability performance as depicted in Table 2. We use a random effect regression model based on the Hausman specification test to examine the impact of *CEOMA* variables on *SP, SP_Social, SP_Env*, and *SP_Eco*. Column 2 in Table 2 shows that the impact of CEO's managerial ability on overall sustainability performance is positive. Specifically, the coefficient is 3.267 at the 1% significance level, implying the positive effect of managerial ability in improving the sustainability-related performance. We hypothesized (H1) that CEO's managerial ability is positively related to sustainability performance. So, our H1 is substantiated. This is in line with our expectations as well as the findings of prior studies like [5, 8, 30, 59]. Previous literature has already identified the importance of superior managerial ability for firms by claiming that managerial ability is a key determinant of firm financial performance [31, 60, 61], we add our findings that managerial ability is also essential for nonfinancial performance (CSR) for the firms. Increasing the management ability increases socially responsible practices and decreases irresponsible behavior related to society, environment, and economy.

We used social SP as the initial dimension for measuring SP. The social performance index is a metric that measures how well a company performs in the areas of labor, human rights, society, and product responsibility. Table 2 shows the findings of the social sustainability analysis (column 3). Our random effect model results reveal that CEOMA is significantly and positively related to SP_Social. The coefficient is 1.401 at a 1% significance level, representing managerial ability has a positive impact on the social dimension of sustainability performance.

The second dimension of sustainability is environmental sustainability (*SP_Env*). This represents the Sustainability performance in relation to environmental practices. The results of *CEOMA* and *SP_Env* are presented in Table 2 (column 4). Our random effect model results reveal that *CEOMA* is negatively but insignificantly related to *SP_Env*. This is contrary to our expectations and hypothesis H3. We hypothesized that increase in managerial ability affects environmental sustainability positively. Despite the fact that these results are contrary to our assumptions, they guide the thinking process toward bettering sustainability strategies. The results are not according to our expectations theoretically, but it is true practically. After the start of thousands of talent programs, Chinese firms performed impressively specifically in terms of growth and market performance; but environmental effects could not be controlled. Still, China is the largest emitter of carbon dioxide and it has the 20 most polluted cities in the world [52, 62, 63]. It means managerial ability is not successful on environmental grounds despite the tremendous efforts of the Chinese government.

The last dimension of sustainability used in this study is economic sustainability. Economic performance is the betterment of the local, national, and international economy. It helps to improve the quality of life of all stakeholders by employing transparency and accountability in entrepreneurial activities. The panel data estimations of economic sustainability are presented in Table 2 (column 4). Our random effect model results reveal that *CEOMA* is

Table 2: Impact of CEO's Managerial Ability on Social, Environmental, and overall sustainability performance.

Variables	(1) *SP*	(2) *SP_Soc*	(3) *SP_Env*	(4) *SP_Eco*
CEOMA	3.627***	1.401***	−0.349	2.907***
	(0.720)	(0.213)	(0.247)	(0.210)
BSize	0.721***	0.0633***	0.263***	0.0471**
	(0.0792)	(0.0235)	(0.0271)	(0.0231)
BIndependence	11.04***	2.985***	3.458***	−1.060
	(2.281)	(0.660)	(0.783)	(0.658)
BMeeting	−0.105***	−0.00187	−0.0411***	−0.0283***
	(0.0249)	(0.00695)	(0.00857)	(0.00708)
CEOGender	0.435	0.00101	0.245*	−0.0218
	(0.425)	(0.123)	(0.146)	(0.123)
RetiringCEO	−1.104*	0.0401	−0.371*	−0.0999
	(0.616)	(0.172)	(0.212)	(0.175)
Duality	−0.562**	−0.0953	−0.284***	0.206***
	(0.230)	(0.0662)	(0.0790)	(0.0662)
DebttoAssetsRatio	−2.896***	0.463**	0.527**	−4.574***
	(0.633)	(0.185)	(0.217)	(0.183)
ROA	85.44***	14.47***	2.270***	63.33***
	(1.598)	(0.437)	(0.551)	(0.450)
Size	1.891***	0.281***	0.272***	0.731***
	(0.118)	(0.0355)	(0.0405)	(0.0346)
TobinsQ	−0.125*	−0.0749***	0.0392	−0.237***
	(0.0716)	(0.0197)	(0.0247)	(0.0202)
AgeofFirm	0.102***	0.0994***	0.0263***	−0.0879***
	(0.0257)	(0.00898)	(0.00872)	(0.00793)
HHI	6.068***	0.446***	2.103***	0.192**
	(0.314)	(0.0855)	(0.109)	(0.0883)
NOA	−0.136***	−0.0203**	−0.0285**	−0.0847***
	(0.0347)	(0.00970)	(0.0119)	(0.00987)
ZScore	−0.0515***	−0.00728	−0.000741	−0.0449***
	(0.0166)	(0.00444)	(0.00573)	(0.00463)
Constant	−33.16***	−6.093***	−9.479***	0.144
	(2.702)	(0.823)	(0.924)	(0.794)
Observations	20,625	20,625	20,625	20,625
Number of id	3,052	3,052	3,052	3,052

Notes: Table 2 presents the random effect panel data estimation results of econometric models 3–6. Definition of each variable can be found in section 3.2. Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

significantly and positively related to *SP_Eco* (Coef. 2.907, $p < 0.01$). It implies that an increase in managerial ability increases the economic sustainability practices of Chinese firms.

4.2. Robustness Tests

4.2.1. Sensitivity Analysis and Endogeneity Tests. Furthermore, we use various sensitivity analyses to assess the robustness of our primary findings. Our study's sensitivity analysis and endogeneity checks are detailed in Table 3. First, we analyze the impact of CEO managerial skills on future sustainable performance (from Models 3–6) by taking the dependent variables one at a time $(t + 1)$ for reverse causality in our regression equations. The results of our random effect panel data analysis corroborate our major findings. We discovered comparable results in our secondary regression analysis as we did in our first regression study. Panel 1 of Table 3 (model 1–4) depicts that CEOMA is significantly and positively associated with overall next year's sustainability performance, social sustainability, and economic sustainability, whereas for environmental sustainability, the coefficient of CEOMA is negative and not significant.

We followed past studies to avoid concerns about endogeneities, simultaneities, and firm-specific heterogeneities in our main regressions [64, 65] and used sGMM (system generalized method of movement) in re-estimating our results. The results are shown in panel B of Table 4. Our findings are very similar to the primary findings, and they show that our findings are robust to possible spurious correlations caused by heterogeneities or endogeneities. Overall, our sensitivity analysis, endogeneity check, and sample selection test suggest that our primary findings are resistant to the existence of any of these statistical issues.

4.2.2. Alternative Definitions of Managerial Ability. According to existing research, CEOs have a wide range of talents, and business performance is a strong indicator of

Table 3: Robustness Tests for reverse causality and endogeneity.

	Panel 1				Panel 2			
Variables	(1) SP ($t+1$)	(2) SP_Soc ($t+1$)	(3) SP_Env ($t+1$)	(4) SP_Eco ($t+1$)	(5) SP	(6) SP_Soc	(7) SP_Env	(8) SP_Eco
l.SP					0.254***			
					(0.00607)			
l.SO_Soc						0.113***		
						(0.00655)		
l.SP_Env							0.303***	0.219***
							(0.00631)	(0.00437)
CEOMA	3.624***	1.235***	−0.398	2.563***	2.849***	1.559***	−0.102	1.447***
	(0.833)	(0.245)	(0.259)	(0.321)	(0.577)	(0.163)	(0.198)	(0.153)
BSize	0.737***	0.0624**	0.264***	0.0388	0.469***	0.0219	0.155***	0.0334**
	(0.0906)	(0.0267)	(0.0282)	(0.0350)	(0.0626)	(0.0176)	(0.0215)	(0.0166)
BInd	10.41***	2.528***	3.353***	−1.208	8.558***	2.169***	2.669***	−1.032**
	(2.651)	(0.756)	(0.827)	(1.025)	(1.939)	(0.548)	(0.666)	(0.515)
BMeeting	−0.134***	−0.00348	−0.0373***	−0.0681***	−0.0718***	0.0244***	−0.0380***	−0.0126**
	(0.0298)	(0.00810)	(0.00939)	(0.0116)	(0.0237)	(0.00668)	(0.00813)	(0.00628)
CEOGender	0.191	−0.136	0.286*	−0.150	0.282	−0.300***	0.198	0.126
	(0.502)	(0.144)	(0.157)	(0.194)	(0.360)	(0.102)	(0.124)	(0.0957)
RetiringCEO	−1.652**	−0.362*	−0.421*	−0.0989	−1.103*	−0.0116	−0.264	−0.110
	(0.774)	(0.210)	(0.244)	(0.301)	(0.590)	(0.167)	(0.203)	(0.157)
Duality	−1.049***	−0.104	−0.392***	0.118	−0.399*	−0.0842	−0.152**	0.156***
	(0.274)	(0.0777)	(0.0856)	(0.106)	(0.205)	(0.0579)	(0.0705)	(0.0546)
DebttoAssetsRatio	−3.807***	0.0981	0.792***	−5.980***	−2.455***	0.754***	0.0743	−3.394***
	(0.746)	(0.215)	(0.233)	(0.288)	(0.528)	(0.148)	(0.180)	(0.145)
ReturnonAssets	50.22***	4.866***	3.355***	35.43***	75.69***	15.27***	1.164**	60.00***
	(2.093)	(0.552)	(0.662)	(0.816)	(1.597)	(0.449)	(0.545)	(0.436)
Size	1.780***	0.158***	0.295***	0.784***	2.008***	0.262***	0.347***	0.748***
	(0.138)	(0.0407)	(0.0427)	(0.0530)	(0.0960)	(0.0262)	(0.0322)	(0.0253)
WobinsQ	0.396***	0.0266	0.108***	0.0189	−0.0657	−0.0486**	0.0148	−0.127***
	(0.0862)	(0.0228)	(0.0272)	(0.0336)	(0.0711)	(0.0201)	(0.0244)	(0.0189)
AgeofFirm	0.0950***	0.0996***	0.0168**	−0.0672***	0.0857***	0.0916***	0.0109**	−0.0402***
	(0.0278)	(0.00961)	(0.00847)	(0.0106)	(0.0155)	(0.00443)	(0.00534)	(0.00415)
HHI	5.995***	0.561***	1.907***	0.485***	4.894***	0.880***	1.368***	0.229***
	(0.389)	(0.101)	(0.123)	(0.152)	(0.331)	(0.0932)	(0.114)	(0.0873)
NOA	−0.182***	−0.0132	−0.0415***	−0.105***	−0.111***	0.0235***	−0.0368***	−0.0608***
	(0.0410)	(0.0112)	(0.0129)	(0.0159)	(0.0308)	(0.00869)	(0.0106)	(0.00818)
ZScore	−0.0226	0.00471	$5.61e-05$	−0.0245***	−0.0432***	−0.00615	−0.00137	−0.0381***
	(0.0219)	(0.00567)	(0.00697)	(0.00858)	(0.0153)	(0.00432)	(0.00526)	(0.00406)
Constant	−29.85***	−2.899***	−10.13***	−0.191	−38.41***	−5.761***	−9.528***	−5.350***
	(3.090)	(0.931)	(0.958)	(1.190)	(2.126)	(0.588)	(0.726)	(0.553)
Observations	17,071	17,071	17,071	17,071	17,075	17,075	17,075	17,075
Number of id	2,931	2,931	2,931	2,931	2,930	2,930	2,930	2,930
R2	0.37	0.41	0.17	0.57				
AR1 test value					−36.98	−32.98	−31.98	−30.09
AR1 significance					3.83	3.09	3.29	3.28
AR2 test value					−6.34	−6.36	−6.46	−6.63
AR2 significance					2.45	1.98	1.87	1.93

Notes: Panel 1 depicts the random panel data estimation results whereas panel 2 presents system GMM estimation results. Test statistics and standard errors (in parentheses) of all variables in the regressions are asymptotically robust to heteroscedasticity. Definitions of all variables can be found in section 3.2. $^{***}p<0.01$, $^{**}p<0.05$, and $^{*}p<0.1$.

CEO competence. e.g., [60, 66]. As a robustness test, we re-estimate our models using industry-adjusted return on assets (IndAdjROA) as a surrogate for CEO competency (3–6). For each company year, the IndAdjROA is calculated by subtracting the average industry ROA from the income before unusual items multiplied by the average total assets. The estimated panel data are shown in Table 4. The coefficients of industry-adjusted ROA come out to be significant and

Table 4: Robustness Tests: Alternative definition of managerial ability.

Variables	(1) *SP*	(2) *SP_Soc*	(3) *SP_En*	(4) *SP_Eco*
IndAdjROA	5.167**	2.616***	0.0326	2.482***
	(2.041)	(0.526)	(0.723)	(0.513)
BSize	0.864***	0.0583*	0.311***	0.0568*
	(0.128)	(0.0329)	(0.0454)	(0.0308)
BIndependence	14.15***	3.313***	4.514***	−1.399
	(3.580)	(0.924)	(1.272)	(0.878)
BMeeting	−0.128***	0.00922	−0.0495***	−0.0390***
	(0.0391)	(0.0101)	(0.0139)	(0.00976)
CEOGender	−0.124	−0.140	0.113	−0.0285
	(0.719)	(0.186)	(0.256)	(0.176)
RetiringCEO	−1.160	−0.154	−0.276	−0.317
	(1.112)	(0.287)	(0.394)	(0.278)
Duality	−0.665*	−0.0366	−0.322**	0.187*
	(0.402)	(0.104)	(0.143)	(0.0987)
DebttoAssets	−5.947***	0.374	−0.543	−4.706***
	(1.019)	(0.263)	(0.362)	(0.248)
ROA	92.70***	16.02***	4.395***	66.43***
	(2.669)	(0.688)	(0.944)	(0.675)
SizeTA	3.682***	0.355***	0.727***	1.201***
	(0.201)	(0.0519)	(0.0716)	(0.0485)
TobinsQ	−0.331***	−0.0681***	−0.0906***	−0.122***
	(0.0979)	(0.0252)	(0.0346)	(0.0247)
AgeofFirm	0.142***	0.124***	0.0210	−0.0683***
	(0.0485)	(0.0126)	(0.0175)	(0.0110)
HHI	1.868***	0.435***	0.782***	−0.123
	(0.567)	(0.146)	(0.201)	(0.142)
NOA	−0.208***	−0.0369***	−0.0371**	−0.101***
	(0.0514)	(0.0133)	(0.0182)	(0.0128)
ZScore	−0.0559***	−0.00729	−0.00615	−0.0384***
	(0.0217)	(0.00559)	(0.00766)	(0.00553)
Constant	−69.51***	−7.993***	−17.94***	−10.85***
	(4.655)	(1.202)	(1.660)	(1.114)
Observations	11,007	11,007	11,007	11,007
Number of id	2,147	2,147	2,147	2,147
R^2	0.389	0.487	0.385	0.329

Notes: Table 4 represent the panel data estimations of the relationship of industry-adjusted ROA with *SO, SP_Soc, SP_Env, and SP_Eco*. Definitions of all variables can be found in section 3.2, except the definition of industry-adjusted ROA, which is given in section 4.2. *** $p < 0.01$, ** $p < 0.055$, and * $p < 0.1$.

positive except for the coefficient of IndAdjROA with *SP_Env* sustainability, which is although positive but not significant. These results confirm our previously obtained results and strengthen our deduction that managerial ability positively impacts sustainability practices along with all its pillars.

5. Conclusions and Policy Implementations

This study has linked two important streams; CEO's managerial ability and corporate sustainability performance. The study is critical because it investigates the most important requisite of the organization's leader, "the ability of the CEO." Moreover, it establishes the stance on how the ability impacts the sustainability practices of the organization. While digging deep, this study presents the triple-down analysis of sustainability performance, i.e., three pillars of sustainability, namely social sustainability, economic sustainability, and environmental sustainability. This is the first study that has (1) researched the relation of a CEO's managerial ability with sustainability in a developing economy and (2) classified sustainability into its main pillars and studied each one with CEO's ability. Using panel data methodology on Chinese listed firms from 2010 to 2019, we report that CEO's managerial ability impacts the overall sustainability practices of the firms positively. Moreover, we find that social sustainability and economic sustainability also increase with the increase of the CEO's managerial ability in the firm. We could not reach any significant relationship between environmental sustainability with managerial ability. Our results remain robust after utilizing various methodologies and definitions. Our findings confirm the upper echelon theory's insights that illustrate that the firm's top leadership characteristics influence firm-level decisions.

There are several policies and regulatory ramifications for our research. There are several policies and regulatory ramifications for our research. One implication of our findings is that Chinese listed firms may need to increase top management's capabilities and expertise (particularly CEOs) to ensure that sustainable policies are effectively implemented. In this instance, the Thousand Talents Plan can be more effective. The Thousand Talents Plan appears to have had a significant impact on the development of modern China since Chinese professionals have joined organizations and made significant contributions to the formulation of strategic policies. The effectiveness of such programs is demonstrated by China's unwavering commitment to environmental and climatic challenges, as evidenced by its signing of the Paris Climate Agreement in 2016. Furthermore, our findings suggest that it is critical to improve CEOs' abilities to foster a positive relationship with and dedication to improving sustainable practices in Chinese businesses. The findings also help strengthen the continuing standard-setting process, especially the in-depth revision of all essential dimensions of sustainability under the new GRI framework.

There are also substantial practical and societal ramifications for policymakers who emphasize CSR. Our research implies that policymakers should consider managers' career concerns when establishing policies to encourage managers to invest in CSR. For example, when assessing the managers' capability, it should be linked with sustainability. It can be achieved by revising the definition of managerial ability. The new definition should be like "managerial ability is a measure to what extent firm utilizes its resources into social, environmental and economic output." By this, managers will not only utilize their ability and skills on financial performance; relatively sustainable performance will also be equally valued. Our findings are equally applicable to companies that prioritize sustainability. One strategy to encourage sustainable performance is to use incentive systems that compensate CEOs for long-term achievement. One of the most important implications is to educate the firm to perform comprehensive sustainability practices, i.e., social, environmental, and economic sustainability, along with other aspects.

Finally, despite new contributions and significant findings, this study has some limitations that should be acknowledged, and that can also serve as future research areas. First, this study ignored some fundamental aspects of the CEO's traits like his education, financial expertise, and political affiliation with the communist party; all these, among other aspects, influence the managerial ability of China. The best would be to add CEOs' extensive personality index based on the CEO's observable and cognitive characteristics and managerial ability. Second, we have only looked at CEOs from top management. The study can be made more fruitful by including the traits and capabilities of other directors and top management teams. Finally, we only looked at a large sample from a Chinese viewpoint; future studies could provide fresh insights by comparing emerging markets to those in the United States or Europe. The results might differ in other regions as sustainability issues, and managerial capability levels vary from region to region. Our core measure of CEO ability is more dependable and accurate than previous studies' measures; nonetheless, it is probable that our ability measure still captures some features of firms' operational, investing, and financing environments that have not been effectively controlled for. Future research could concentrate on generating more accurate assessments of managerial skills.

Data Availability

This study is based on secondary data. All the data are available on the CSMAR data stream.

Ethical Approval

There is no ethical issue involved in this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

All authors contributed to the study's conception and design. Data collection and analysis were performed by Muhammad Kaleem Khan and Muhammad Jameel Hussain. Khurram Shahzad and Mbwana Mohamed Kitendo validated the findings. The first draft of the manuscript was written by Muhammad Kaleem Khan and R.M. Ammar Zahid and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. All the authors agreed to publish.

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Research Article

Based on Contaminated Water and Human Health to Change of China's International Image Under Mainstream Media Reports During the COVID-19 Pandemic

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As water quality can be an indicator of public health, it cannot be ignored. We can regard the international image of a country as a kind of soft national power, which embodies the comprehensive strength of the country and plays a very important role in safeguarding the interests of a country. This article aims to study the changes in China's international image under mainstream media reports during the COVID-19 pandemic. This article is based on contaminated water and human health to study the concept of the international image, the optimization path of China's international image, and the SEIR model. The SEIR model is one of the classic infectious disease models. Because the virus infection rate in this model is constant, it is difficult to accurately determine the spread of new coronary pneumonia. To model and complete the pandemic trend prediction and other issues, this article proposes a virus infection rate prediction method based on the long short-term memory network (LSTM), and combines it with the SEIR model to establish a new crown pneumonia pandemic trend prediction model (LS-Net). The conclusion of this article shows that in the fight against the novel coronavirus infectious pneumonia pandemic, the Chinese people have demonstrated the style of a big country. I have unreservedly passed on my own experience in pandemic prevention and control to countries around the world, and dispatched medical teams to provide the world with Chinese "prescriptions." Chinese diagnosis and treatment programs are the crystallization of common wisdom of Chinese medicine and Western medicine to support the world. All countries fight the pandemic together. In this analysis, Pakistan, Kenya, and Nigeria hold 84%, 85%, and 75% of China's positive views, respectively, 61% of Russians also have a positive attitude toward China.

1. Introduction

1.1. Background of Topic Selection. As China has made a huge contribution to the world's new crown pandemic, mainstream media's attention to China has gradually increased, reports have continued to increase, and the scope of coverage has continued to expand. In particular, the rapid rise of mainstream media reports during the COVID-19 pandemic has given coverage and content. Both methods have undergone profound changes. China's internal affairs and diplomatic performance have been well received by mainstream media during the COVID-19 pandemic. China's international influence has gained wider attention and recognition. A comprehensive, objective, and true image of modern China is being formed during the COVID-19 pandemic. The development of the media is becoming more and more diversified. All of this makes the sense of time and space between countries, between countries and citizens, and social organizations so weakened.

1.2. Significance of the Research. The research significance of this article is to classify and analyze the current research on the construction of China's international image under mainstream media coverage during the new crown pandemic from a micro and macro perspective, and to conduct a more systematic and in-depth study of this topic. The previous research is needed to put forward its point of view to supplement the current gaps in related research. The main body of this research is the media. It not only includes the analysis of cases of international media communication behaviors, but also systematically studies the communication of national image building with the participation of the database, and studies the international media communication. On this basis, I would like to supplement the research on the "national image" from the perspective of news and communication to the relevant analysis of the Chinese media in shaping and enhancing China's national image, and hope to use this as a basis. Put forward overall directions for future in-depth research.

1.3. Work Related to the Changes in China's International Image. In the fight against the novel coronavirus infectious pneumonia pandemic, the Chinese people have demonstrated the style of a big country. Unreservedly spread their own experience in pandemic prevention and control to countries around the world, dispatched medical teams to support countries around the world to jointly fight the pandemic, and provide the world with China's "prescription" Chinese diagnosis and treatment plan is a joint fight against the pandemic by Chinese and Western medicines. Hartig studies the hegemonic narrative advocated by the mainstream media, the content is China's response to the COVID-19 pandemic and its facts. The COVID-19 pandemic has triggered multidimensional crises including public health and political economy. Disagreements between countries on public health and economic policy responses have led to a propaganda war. After roughly examining the time trajectory of China's public health response and its underlying factors, this article continues to study some controversial issues regarding China's public health response to the COVID-19 pandemic highlighted in hegemony [1]. However, our understanding of the dynamics of this exposure response during the COVID-19 pandemic is still limited. Benabdallah believes that the elderly have received great media attention during the COVID-19 pandemic because they are considered susceptible to this new virus based on clinical data and epidemiological evidence. A large number of media reports have played an important role in calling for the improvement of public health services for the elderly population. However, during a pandemic, problematic media coverage of the elderly may cause or exacerbate age discrimination. Therefore, this study uses empirical data collected from five mainstream media in China from January 3 to May 3, 2020, to study how the media constructs the vulnerability of the elderly and their potential age perception during the pandemic. The survey results show that the media clearly tends to portray the elderly as passive recipients, while seeking resources from families, public institutions, and governments at all levels to deal with the COVID-19 pandemic [2]. Niu researches that the exposure and consumption of information during an pandemic may change perceptions of risk, trigger changes in behavior, and ultimately affect the development of the disease. Therefore, it is very important to disseminate map information through mainstream media and public response [3]. However, our understanding of the dynamics of this exposure response during the COVID-19 pandemic is still limited.

1.4. Innovation Points of This Research

(1) China's international image has undergone tremendous changes under mainstream media reports during the COVID-19 pandemic. In the fight against the novel coronavirus-infected pneumonia pandemic, the Chinese people have demonstrated the style of a big country. Unreservedly spread their own experience in pandemic prevention and control to countries around the world, dispatched medical teams to support countries around the world to jointly fight the pandemic, and provide the world with China's "prescription" Chinese diagnosis and treatment plan is a joint fight against the pandemic by Chinese and Western medicines. The crystallization of common wisdom makes people all over the world look at the Chinese with admiration.

(2) The SEIR model is one of the classic infectious disease models. Because the virus infection rate in this model is constant, it is difficult to accurately model the spread of new coronary pneumonia and complete the pandemic trend prediction. In response to this problem, this article proposes a virus infection rate prediction method based on long short-term memory (LSTM) network, and combines it with the SEIR model to establish a new crown pneumonia pandemic trend prediction model (LS-Net).

2. Method of the Change of China's International Image

2.1. Concept of International Image. The research on international image mainly focuses on the external construction of the country itself [4]. External construction includes international self-construction and feedback from the international media on the international image. The main audience of the international image includes not only the nationals of the country, but also the international exchanges abroad. China's media and national image have different forms in different media [5]. The representative views of foreign scholars on the definition of the national image are mainly shown in Table 1.

It can be seen that the concept of international image is an open and variable concept, and different scholars have different definitions of it in different periods. According to the definition of the above scholars, the author believes that the international image is the result of the combination of "self-shaping" and "other shaping." It is dynamic, including images at home and abroad, with different cognitive themes, cultural backgrounds, and values and information. Depending on the channel, the domestic image and the foreign image are usually different [6].

2.2. Role of International Image. The international image is the embodiment of a country's comprehensive national strength. In today's world of economic globalization and political diversification, shaping and maintaining a good international image is the expectation of every country. International image is the passport of a country entering the

Table 1: Representative views of foreign scholars on the definition of national image.

years	Scholar	View
2003	Ale R. Holsti	It is believed that the international image is connected with the belief system of the country, and the international image is the "part of the belief system" formed by perceiving a country.
2010	Alpo Rusi	The international image is the image displayed by a sovereign country on the world stage and its reflection in international public opinion.
2012	Robert Jervis	The international image is defined as the image of a sovereign country in the flow of international news or in international news or speech reports.
2015	Gordeyeva	The international image is defined as the comprehensive evaluation and overall impression of other countries on the country, generally based on the international image reflected in the news media and public opinion of other countries.

international arena. The role of enhancing the internal demand of the country's overall national strength and international image can be explained from the following two perspectives:

(1) Economically, with the development of economic globalization, trade cooperation and competition between countries have become the norm [7]. In recent years, China's position in the international economy and trade has become more and more important, especially with the launch of the Asian Investment Bank and the "One Belt, One Road" strategy proposed by China this year [8]. A good country image helps promote trade between the country and other countries.

(2) From a social and cultural perspective, a good national image can create a positive, friendly, peaceful, and profitable atmosphere, and play an important role in the development of a country's culture [9]. In recent years, the rise of Chinese, the increase in the number of Chinese students studying abroad, and the establishment of Confucius Institutes around the world may all reflect the influence of China's national image on promoting social and cultural exchanges between the two countries.

2.3. Optimization Path of China's International Image. General Secretary Xi Jinping once pointed out that "it is necessary to promote the construction of international communication capacity, tell Chinese stories, spread Chinese voice, show the world a true, three-dimensional and comprehensive China, and improve the country's cultural soft power and Chinese cultural influence [10]." West The image of society's prejudice against China has not been eliminated with the rise of China's economy. China's national image is still largely shaped by Western media, even though China has tried to change this through a series of official and private measures. With the global outbreak of the new crown pneumonia pandemic, Western public opinion is still full of prejudice, discrimination, and ideological struggles in shaping China's image. Therefore, China needs to change this phenomenon by optimizing the international image shaping path, as shown in Figure 1.

2.3.1. Improve the Level of Domestic Crisis Handling. Whether it was the SARS pandemic in 2002 or the new crown pneumonia pandemic, there were problems that local governments did not handle well at the beginning of the pandemic. Mistakes in the work of local governments caused the masses to lose confidence in the openness and transparency of government information. Negative public opinion is often adopted by Western media and continuously amplified, which ultimately leads to the deterioration of China's international image [11]. Therefore, in shaping China's excellent image internationally, the most important thing is to continuously improve the level of domestic local governments in dealing with major crises, and to guide rational public opinion through the effective implementation of General Secretary Xi Jinping's people-centered thinking. Solve the problem of external factors through continuous improvement of internal factors [12].

2.3.2. Flexible Application of Social Media Platforms. In the era of the popularization of smartphones, social media platforms have become one of the main sources for ordinary people to obtain information, and social media is the only way for a very large number of young people. Due to low cost and high speed, social media platforms have become the main channel for the spread of major emergencies [13]. Due to the different ways of information publishing and dissemination subjects, information on social media platforms is mixed, and many messages are full of prejudice and discrimination. Relevant departments of the Chinese government should flexibly use various social media platforms to publish relevant news instantly and transparently, leading the trend of public opinion and avoiding similar incidents like Dr. Li Wenliang [14].

2.3.3. Properly Handle False News Immediately. In the context of the Internet age, the West will pay attention to false news in China and expand it through social media platforms and other channels, which will eventually lead to prejudice, discrimination, and racism [15]. Relevant departments of the Chinese government should respond to all kinds of false news in a timely manner, by inviting domestic and foreign experts in relevant fields and dealing with all kinds of false news, through scientific research and judgment, clarifying to the people at home and abroad, combining with the use of social media platforms. The false remarks of the Western media counterattacked, destroying the West's intention to discredit China's image [14].

2.3.4. Change the International Image Publicity Strategy. In the past, China mainly used the dissemination of historical culture and natural scenery to shape China's

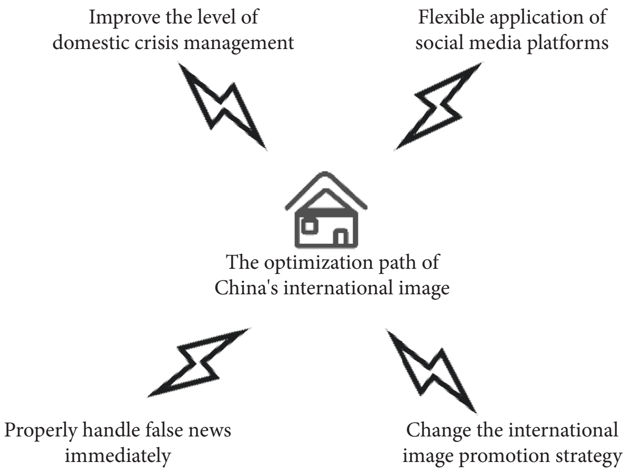

Figure 1: The optimization path of China's international image.

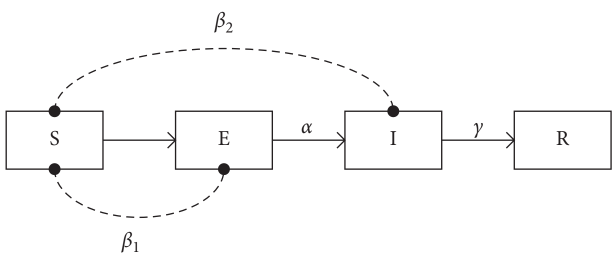

Figure 2: SEIR model.

international image, rather than contemporary China's development stories. In the context of the new crown pneumonia pandemic, China's political system has frequently become the target of Western media attacks. Therefore, China is bound to strengthen the advantages of the system and establish an international image communication strategy with contemporary China as the main body [16]. The masses should be guided and encouraged to publicize the advantages of China's system on various Internet media, to form China's international Internet voice, and to refute the false statements of the West that slander China's image. By telling the story of contemporary China, it shows China's contribution to the fight against the new crown pneumonia pandemic and other major international events, and constantly uses vivid deeds to shape China's responsible international image and spread the concept of a community with a shared future for mankind [17].

2.4. Infectious Disease Transmission Model: SEIR. The SEIR model is a classic infectious disease model. It divides the population into four categories: infected (I), the total number of confirmed patients who have been infected with the virus and have symptoms; removed (R), the total number of people who die or are successfully cured after being infected with the virus; susceptible (S), the total number of healthy people who may be infected with the virus; and exposed (E), the total number of people who have been infected with the virus but still have no symptoms. In the COVID-19 pandemic, the transformation relationship of the four groups of people in the SEIR model is shown in Figure 2. In the figure, β_1 is the probability of the latent person transmitting the virus to the susceptible person and β_2 is the probability of the infected person transmitting the virus to the susceptible person, α is the probability of a latent person being transformed into an infected person, and γ is the probability of an infected person being transformed into a remover. The kinetic equation of SEIR is:

$$\frac{dS}{dt} = -\frac{-b_1 SE}{N} - \frac{-b_2 SI}{N}, \tag{1}$$

$$\frac{dE}{dt} = \frac{b_1 SE}{N} + \frac{b_2 SI}{N} - aE, \tag{2}$$

$$\frac{dI}{dt} = aE - gI, \tag{3}$$

$$\frac{dR}{dt} = gI. \tag{4}$$

In the equation, t is the time step; $N = S + E + I + R$, which is the total number of people.

The calculation method of virus infection rate β_1, β_2 is calculated by equation (5):

$$\begin{aligned} \beta_1 &= k_1 b, \\ \beta_2 &= k_2 b. \end{aligned} \tag{5}$$

In the formula, k_1 and k_2 are the average number of people in contact with each latent person and each infected person each day; b is the transmission rate of the virus, which can be calculated by the SIR model. The SIR model is similar to the SEIR model. It divides the population into three categories: susceptible, infected, and removed. In the SIR model, since the number of people infected is small at the beginning of the virus infection, N is approximately equal to S:

$$\frac{dI}{dt} = \frac{\beta SI}{N} - \gamma I \approx (\beta - \gamma) I. \tag{6}$$

From formula (6), we can get:

$$I(t) = \exp[(kb - \gamma) I]. \tag{7}$$

From equation (7), b can be calculated, and by putting it into equation (5), β_1 and β_2 in the SEIR model can be calculated.

In the traditional SEIR model, β_1 and β_2 are often constants derived from data statistics. In reality, the infectious ability of the virus will be greatly affected by the outside world, so β_1 and β_2 should be constantly changing [18]. In the above method, both β_1 and β_2 are calculated by the SIR model, and the virus infection of patients during the incubation period is not considered.

2.5. New Crown Pneumonia Pandemic Trend Prediction Model: LS-Net. Aiming at the problem that the virus infection rate in the traditional SEIR model cannot be automatically and dynamically predicted and the infection status

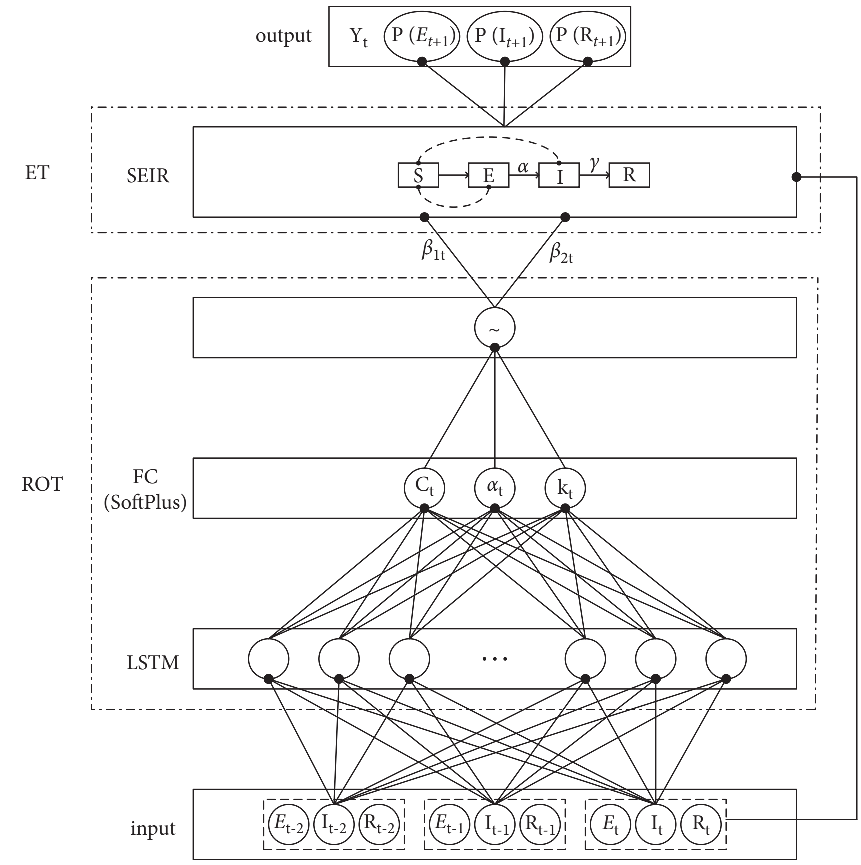

Figure 3: LS-Net overall framework.

of patients in the incubation period is not considered, this article proposes LS-Net [19, 20] based on the LSTM and SEIR models. This section will introduce LS-Net in detail.

The overall structure of LS-Net is shown in Figure 3. It contains two modules: a virus infection rate prediction module and an pandemic trend prediction module. The pandemic trend prediction module includes the SEIR model layer to realize the prediction of the new crown pandemic trend [21]. The virus infection rate prediction module includes an LSTM layer, a fully connection (FC) layer, and a nonlinear transformation layer to realize the prediction of the new coronavirus infection rate β_1 andβ_2.

The virus infection rate prediction module is based on LSTM and predicts the infection rate based on the law of virus transmission. In order to better learn the correlation information between time series data, LS-Net uses the three-day incubation period, the number of infected persons, and the number of removed persons as input. The later changes of the virus infection rate are closely related to the prevention, control, diagnosis, and treatment measures in the early stage of the pandemic. Therefore, the prediction of the virus infection rate needs to be combined with historical information and current information to be analyzed together [22, 23]. LSTM can learn and generate data containing historical information and current information. It includes three types of gates: input gate i_t, forget gate f_t, and output gate o_t. The LSTM update process is shown in equations (8)–(13), X_t is the input at time t [24].

$$i_t = s\left(W_{ii}X_t + b_{ii} + W_{hi}h_{i-1} + b_{hi}\right), \tag{8}$$

$$f_t = s\left(W_{if}X_t + b_{if} + W_{hf}h_{i-1} + b_{hf}\right), \tag{9}$$

$$\tilde{c}_t = s\left(W_{ii}X_t + b_{i\tilde{c}} + W_{hi}h_{i-1} + b_{h\tilde{c}}\right), \tag{10}$$

$$o_t = s\left(W_{io}X_t + b_{io} + W_{ho}h_{i-1} + b_{ho}\right), \tag{11}$$

$$c_t = f_t c_{t-1} + i_t \tilde{c}_t, \tag{12}$$

$$h_t = o_t \tanh\left(c_t\right). \tag{13}$$

Input the features containing timing information output by h_t into the FC layer. The FC layer calculation process is shown in equation (14), where C_t, a_t, and k_t are all control parameters for predicting β_1 and β_2 at time t.

$$\begin{cases} C_t = \lg\left(1 + \exp\left(W_C h_t\right)\right) \\ a_t = \lg\left(1 + \exp\left(W_a h_t\right)\right) \\ k_t = \lg\left(1 + \exp\left(W_k h_t\right)\right) \end{cases}. \tag{14}$$

3. Experiments on the Response of the Chinese People during the New Crown Pandemic

3.1. Research Experiments in the Context of the New Crown Pandemic. In December 2019, new coronary pneumonia

(COVID-19) was successively discovered in Hubei Province and other parts of the country. With further development over time, the number of confirmed and suspected patients has continued to increase. After the outbreak of the new crown pneumonia pandemic, the impact of pandemic has brought an impact on the public's psychology. The new coronary pneumonia has become a public health emergency of international concern. The National Health Commission issued Announcement No. 1 on January 20, 2020, including pneumonia caused by the new coronavirus into the Class B infection stipulated in the "Law of the People's Republic of China on the Prevention and Control of Infectious Diseases." However, the prevention and control measures of Class A infectious diseases shall be adopted, and they shall be included in the management of quarantine infectious diseases. After the outbreak of the new crown pneumonia pandemic, the impact of the pandemic has brought an impact on the public's psychology. The outbreak of the new crown pneumonia caused the entire China to press the pause button, and more than one billion Chinese people were trapped at home. Everyone controls not to go out. You must also wear a mask when you go out, so as to prevent yourself from being infected and to reduce trouble for the country. The new coronary pneumonia picture is shown in Figure 4.

Figure 4: Coronavirus disease (This picture is borrowed from the Internet).

3.2. Differences in Mental Health Among People in Different Regions Under the Pneumonia Pandemic. Using a factor of variance to analyze different aspects of the mental health of people outside Hubei Province, Wuhan City, it shows that people in different regions have no significant differences in the degree of fear and the level of stress. There is no significant difference in the degree of anger among people in the region. However, there are significant differences in the degree of depression among people in different regions. Further comparative analysis after multiples found that there are significant differences in the size of individual depression in areas outside Hubei and Wuhan, as shown in Table 2.

The independent sample t-test was used to further analyze the differences in the various dimensions of mental health among people of different genders in different regions. The results show that there are significant differences in the fear and anxiety dimensions of the mental health scale for individuals of different genders in Wuhan, and women have higher levels of fear and anxiety than men. Individuals of different genders in Hubei non-Wuhan area only have significant differences in the dimension of fear, among which the fear level of women is significantly higher than that of men. Individuals of different genders outside Hubei have significant differences in the dimensions of fear, anxiety, and anger. Among them, the level of fear, anxiety, and anger of women is significantly higher than that of men as shown in Table 3.

3.3. Differences in Mental Health among People of Different Occupations Under the Pneumonia Pandemic. An independent sample t-test was used to analyze the different dimensions of the mental health of people in different occupations. It shows that people of different occupations have no significant differences in the dimension of fear and depression, and people of different occupations are in the dimension of anxiety. The difference is not significant; people of different occupations do not have significant differences in the dimension of anger as shown in Table 4.

3.4. Differences in Mental Health Among People of Different Ages Under the Pneumonia Pandemic. Using one-way variance to analyze the different dimensions of people's mental health at different ages shows that there is no significant difference in the dimensions of fear, depression, anxiety, and anger as shown in Table 5.

4. Changes in China's International Image

4.1. Situation Under Mainstream Media Reports at the Beginning of the Outbreak of the New Crown Pneumonia. In the early stage of the outbreak of the new crown pneumonia pandemic, the mainstream media in the West mostly reported negative images of China. They can be divided into three categories. The first category is "regionalization," which links the virus with China to make ordinary people feel more about China. Views are "viralized." The second type is "politicization," which is to combine the spread of the pandemic with China's political system to attack China's political system. The third type is "failed," that is, to criticize China's adoption of the double standards act and turn a blind eye to the success achieved. Through three methods of reporting, Western media has portrayed China as an "undemocratic and irresponsible dictatorship" country, which is widely disseminated among ordinary people.

4.2. China's International Image After the Successful Control of the New Crown Pneumonia Pandemic. After the new crown pneumonia pandemic has spread globally on a large scale, the domestic situation in China is in sharp contrast with that in Western countries. Against this background, there have been fewer and fewer reports of demonizing and stigmatizing China's image in the early stages of the outbreak of the new crown pneumonia pandemic, and China's international image has gradually become a "leadership role" in the reports of mainstream Western media as "Great country." The number of new cases in China has been declining, and the number of cases in most provinces has been cleared. The prevention and control of the new crown pneumonia pandemic have achieved initial success. However, because Western countries have not taken decisive and resolute

Table 2: Differences in the mental health of the public in different regions under the pneumonia pandemic.

Subdimension	Outside Hubei province M (SD)	Hubei province (not Wuhan) M (SD)	Wuhan M (SD)	*F*	*P*
Fear	2.67	2.56	2.79	1.15	0.54
Depression	1.89	1.99	2.34	3.43	0.05
Anxiety	3.14	3.23	3.18	0.13	0.87
Anger	3.21	2.99	3.16	1.69	0.21
N	811	666	654		

Table 3: Differences in the mental health of different genders in the pneumonia pandemic.

Area	Gender	Fear		Depression		Anxiety		Anger	
		M	SD	*M*	SD	*M*	SD	*M*	SD
Wuhan	Male	2.11	0.65	1.78	0.79	3.03	0.83	3.01	0.91
	Female	2.45	0.76	1.98	0.98	3.06	0.85	3.11	0.94
Hubei province (not Wuhan)	Male	2.65	0.87	1.87	0.91	3.01	0.89	3.02	0.90
	Female	2.42	0.88	1.96	0.75	3.11	0.87	3.06	0.93
Outside Hubei province	Male	2.52	0.89	1.89	0.76	3.12	0,91	3.03	0.95
	Female	2.34	0.91	1.99	0.78	3.08	0.87	3.08	0.92

Table 4: Differences in the mental health of different occupations under the pneumonia pandemic.

Sub-dimension	Student group M (SD)	Staff member M (SD)	*t*	*p*
Fear	2.54	2.13	0.78	0.44
Depression	1.78	1.78	−0.23	0.83
Anxiety	3.10	3.12	−1.41	0.11
Anger	3.03	3.10	−1.42	0.12
N	1881	231		

Table 5: Analysis of differences in mental health among people of different ages in the pandemic of pneumonia.

Subdimension	Under 20 M (SD)	20–29 years old M (SD)	30–39 years old M (SD)	Over 40 years old M (SD)	F	*p*
Fear	2.33	2.61	2.13	2.23	2.00	0.12
Depression	1.91	1.91	1.89	1.87	0.21	0.78
Anxiety	3.10	3.11	3.11	3.11	2.11	0.10
Anger	3.01	3.09	3.10	2.78	1.11	0.32
N	1170	760	43	131		

actions, the number of new cases has continued to rise in the hardest hit area of the pandemic.

4.3. China's International Image Before and After the Pandemic. According to surveys conducted in 22 countries/regions (excluding China), more and more people in 15 of 21 countries believe that China is positive. China has a better image among the people of the Arab world, Africa, Latin America, and other developing countries, especially Pakistan, Kenya, and Nigeria. About 84%, 85%, and 75% of these three countries are optimistic about China and 61% of Russians also have a positive attitude toward China. Among Western countries, Americans believe that China is the most active country, accounting for 48%. Spain and the United Kingdom are slightly lower, but generally positive. More people in France, Germany, and Japan hold negative views of China than those who hold positive views. The most important reason for China to maintain an overall positive international image is that China's economy continues to grow rapidly, followed by many events, such as the Beijing Olympics and the Shanghai World Expo. More and more people come and visit China and learn about China. In addition, it is China that is gradually assuming more international responsibilities and is committed to solving international problems. This is why China has a better image. The details are shown in Figure 5.

4.4. Overseas Spread of the New Crown Pneumonia Pandemic. The new coronary pneumonia pandemic has been brought under control in China, but its spread abroad is accelerating, and Europe has become a "severe disaster area." After the World Health Organization (WHO) announced the new pneumonia pandemic as "PHEIC" on January 30, local time, on March 12, the WHO further announced that the new coronary heart disease pandemic had become a "global

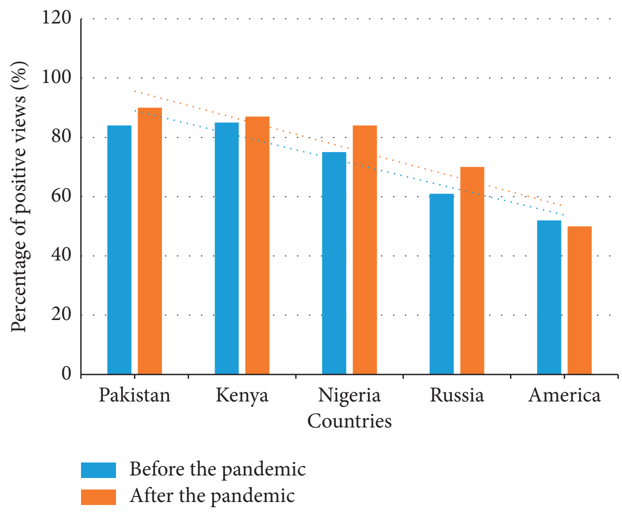

FIGURE 5: Analysis of China's international image before and after the pandemic.

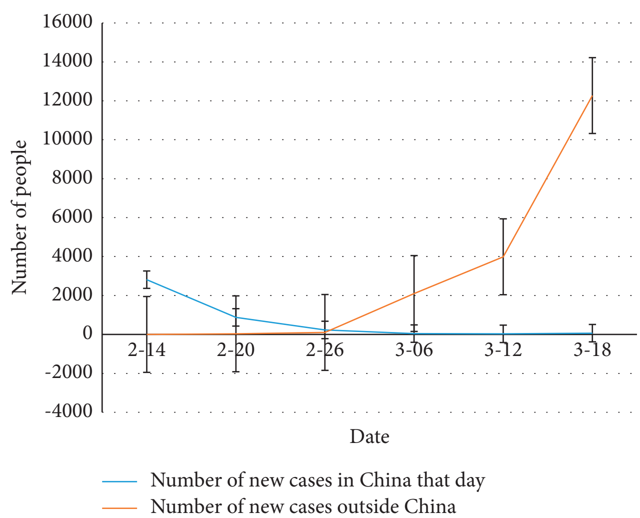

FIGURE 6: Comparison of the number of new cases per day in China and outside China.

pandemic." According to data from the World Health Organization, as of March 19, the new rosette pandemic has spread to more than 150 countries or regions, with a total of 209,839 confirmed cases worldwide, and the number of new confirmed cases outside China far exceeds that in China, 16,498. The situation of pandemic prevention and control abroad is unacceptable. Among them, there are more than 1,000 people infected with the virus in 15 overseas countries. Italy has become the country with the worst pandemic abroad, with 35,713 confirmed cases. Other countries such as Iran, Spain, South Korea, France, Germany, and the United States are also accelerating. The comparison of the number of new cases per day between China and outside China is shown in Figure 6.

4.5. Impact of the New Crown Pneumonia Pandemic on the World Economy. The impact of the pandemic on macroeconomics is mainly reflected in two aspects: first, the spread

FIGURE 7: The world's economy map (This picture is quoted from the Internet).

of panic has led to a reversal of investor confidence, which has disturbed the financial and capital markets; second, the control of quarantine measures has put pressure on the macro economy. Therefore, pressure is exerted on both the consumer and the producer. We will analyze the impact of the pandemic from the spread of the pandemic in the capital market, trade, industrial chain, and cross-border investment. The schematic diagram is shown in Figure 7.

5. Conclusion

In the fight against the novel coronavirus infectious pneumonia pandemic, the Chinese people have demonstrated the style of a big country. First, I have unreservedly passed on my own experience in pandemic prevention and control to all countries in the world, and at the same time, I have unreservedly dedicated my treatment experience to all countries in the world. Second, when the pandemic situation in other countries was severe and medical resources were in short supply, the country dispatched medical teams on time to support countries around the world to fight the pandemic together. Therefore, China has made a selfless dedication to all countries in the world in the fight against the novel coronavirus pneumonia pandemic. Third, provided the world with China's "prescription," Chinese diagnosis and treatment programs are the crystallization of common wisdom and common wisdom between Chinese and Western medicine to fight the pandemic together. In the treatment plan, Chinese medicine has a relatively important position. Traditional Chinese medicine has unique theories and practices in preventing and treating the plague. It is an effective treatment method to give full play to the overall regulation of traditional Chinese medicine, improve immunity, and stimulate one's own disease resistance and rehabilitation capabilities. Fourth, the World Health Organization believes that China has adopted the bravest, most flexible, and most active prevention and control measures in history, which has changed the dangerous course of the rapid spread of the pandemic and reduced the number of people across the country The occurrence of 10,000 cases have won a valuable window for countries around the world to fight the pandemic. Finally, to provide support for the world's fight against the pandemic, China's manufacturing industry can significantly improve its ability to produce medical supplies in a relatively short period of time, and can meet the explosive demand caused by the pandemic. With the gradual improvement of the domestic pandemic, China has taken the initiative to assist other countries that need to protect materials. China is encouraging manufacturers of protective equipment, medical equipment, and therapeutic drugs to meet overseas demand and contribute to the global fight against this pandemic.

Data Availability

The data used to support the findings of this study can be obtained from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflict of interest regarding the publication of this article.

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Retraction

Retracted: Political Will and the Impact Assessment of the New Crown Epidemic on Economic and Social Development and Countermeasures

Journal of Environmental and Public Health

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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https://doi.org/10.1155/2022/8173768

Research Article

Political Will and the Impact Assessment of the New Crown Epidemic on Economic and Social Development and Countermeasures

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Purpose. This paper aimed to study how to analyze and study economic and social development under the new crown epidemic based on the neural network and described the BP neural network. *Methodology.* Economic forecasts are affected by multiple influencing factors, the relationships between these factors are complex, and it is a nonlinear system with a high degree of uncertainty. The use of traditional forecasting methods has many limitations, and neural network methods can overcome these limitations and achieve good nonlinear forecasting. *Research Findings.* Through the analysis and statistics of the impact of the SARS epidemic and the new crown epidemic on the economy, by 2021, the economic contribution of final consumption expenditure, total capital formation, and net exports will be 65.4%, 13.7%, and 20.9%, respectively, and the impact of the current new crown virus epidemic on the economy will be greater than that of the SARS epidemic in 2003. *Research Implications.* The model applied to economic forecasting based on the BP network can achieve good forecasting effect, and scientific and reasonable forecasting methods depend on the in-depth understanding of economic activities and dominance of familiarity with economic theory. *Practical Implications.* Through the analysis of the economy in the context of political will and the new crown epidemic, it will give more reference to more and more complex emergencies in the future.

1. Introduction

At the beginning of the new year, the sudden outbreak of the new crown epidemic in 2019 brought severe challenges to China's economic development. The arrival of the epidemic coincides with the Spring Festival, which has had a huge impact on the service industry and business. However, over the past 40 years of reform and opening up, the Chinese government has accumulated rich experience in responding to emergencies and disasters. The fight against the SARS epidemic in 2003 brought the Chinese economy out of the fog. At present, with the rapid response to the epidemic, rich experience, greater prevention and control efforts, and more effective results, the China's epidemic has been effectively controlled, and the new coronavirus pneumonia virus is currently spreading around the world. China's companies began to restart production. This paper made beneficial improvements on the basis of the standard BP algorithm and analyzed the economic growth level data of SARS and the new crown epidemic, thereby improving the generalization ability of the network. The document showed that China's economic activity has returned to normal as the China's economy prioritizes emerging from the outbreak.

In recent years, with the continuous changes in society, more and more studies have been conducted on economic and social development. De Neve et al. observed that proportions of abstract prosperity were over two times as delicate to negative monetary development as sure financial development. He utilized Gallup World Poll information from in excess of 150 nations, BRFSS information from 2.3

million US respondents, and Eurobarometer information covering over forty years of business cycles [1]. The reason for the Destek Asian review was to research the overall presentation of sustainable and non-environmentally friendly power utilization and financial development in 17 arising economies. To this end, yearly information from 1980 to 2012 was inspected utilizing a directed board causality that considers cross-sectional conditions among nations and country-explicit heterogeneity [2]. Zhang et al. revealed the relationship between electricity consumption and economic growth to achieve the goal of reducing energy consumption while improving the level of economic development. This work showed that the nature of China's relations should and could be explored from a broader perspective, by developing a suitable comprehensive methodological framework [3]. Aneja et al. concentrated on analyzing the connection between energy utilization and financial development in the BRICS nations inside a multivariate board system from 1990 to 2012. At last, a board mistake revision system was applied to uncover the one-way causality from monetary development to inexhaustible and non-environmentally friendly power utilization [4]. Kahia et al. inspected the connection between energy use and financial development by decaying energy use into two kinds of energy, inexhaustible and non-environmentally friendly power use. Exact discoveries gave proof to short- and long-haul bidirectional causal relationships between inexhaustible and non-environmentally friendly power use, which showed substitutability and association between the two energy sources [5]. However, studies that incorporate current developments are only a minority.

As a significant technique for AI, BP neural network has been effectively applied in man-made consciousness, design acknowledgment, picture handling, and different fields. In order to determine the heat transfer coefficient in the range of supercritical water pressure, Ma et al. collected 14 sets of experimental data, and a BP prediction model for determining the heat transfer coefficient of supercritical water was established based on it [6]. Li et al. proposed a new method combining chaotic algorithm and genetic algorithm, aiming at the shortcomings that BP is easy to fall into local minima and slow convergence speed in gesture recognition [7]. Pan et al. proposed a complex input feature importance calculation method based on the BP neural network for multiple input attributes of multiclassification output results according to the correlation and importance issues [8]. Zhang et al. optimized the BP network weights and limited selection process to improve the inversion results and then obtained a better network model, which was used for the inversion of the density interface model [9]. Huichun et al. extracted the total value of the nasal electronic response signal as a characteristic parameter and used a BP neural network to build a prediction model for zearalenone and aflatoxin in different grades of corn mold samples [10]. These algorithms provide solutions to problems in the research field to a certain extent, but the accuracy needs to be further improved.

Through the analysis of the economic impact of the 2003 epidemic and the new crown epidemic, this epidemic will promote technological changes and promote the rapid development of new economies such as e-commerce and smart medical care could be predicted, which will bring a series of important new opportunities for China's industrial restructuring. The innovation of this paper is to combine the economic and social development with BP neural network and introduced the principle and related methods of BP in detail.

2. Economic Forecasting Method Based on Neural Network

2.1. Artificial Neural Networks and Economic Forecasting. Artificial neural network (ANN) is a physical model that simulates and reflects the structure, principle, and function of the human brain neural network. It consists of a large number of neurons in a specific way to form a complex dynamic network, as shown in Figure 1. The main difference between nerve cells and other cells in the body is that nerve cells can generate, process, and transmit signals. It is mathematically proven that artificial neural networks can approximate any function that characterizes the regularity of sample data, no matter what form those functions take. The good nonlinear approximation, fault tolerance, generalization ability, and self-learning characteristics of the artificial neural network make it have a place in various fields such as pattern recognition, speech recognition, and signal processing [11, 12].

The accuracy of economic forecasts depends not only on understanding the history and current situation of the region and the accuracy of the initial data obtained but also on the scientific and advanced nature of forecasting methods. Scientific and reasonable forecasting methods mainly depend on the in-depth understanding of economic activities and the dominance of familiarity with economic theory. By and large, financial gauging strategies can be generally isolated into two classifications: subjective estimating techniques and quantitative determining techniques [13, 14].

The commonly used qualitative methods mainly include AHP, market research, and subjective probability method. Quantitative forecasting methods are mainly based on historical statistics and data, and scientific methods must be used to build specific mathematical models. The analysis and forecasting results of economic phenomena are usually expressed as specific numerical values. At this stage, quantitative analysis is an important method for regional economic forecasting. According to the understanding of the economic growth phenomenon, quantitative forecasting methods can be divided into deterministic model methods and uncertainty model methods. Identify relevant analysis models, including dynamic programming, regression analysis, time series analysis, input-output analysis, and econometric model methods. In general, the relationship between them is difficult to describe by traditional forecasting methods, so the uncertainty forecasting method has its unique advantages in solving forecasting problems, and therefore, it has achieved huge growth in recent years. Some intelligent prediction methods have been developed recently, such as artificial neural networks, gray prediction

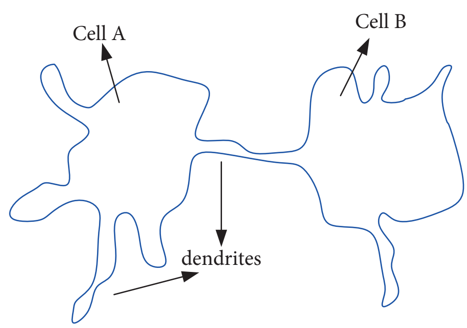

Figure 1: Neuron model.

analysis, and fuzzy analysis [15]. The artificial network method is the main method used in this paper. Common methods of economic forecasting are shown in Figure 2.

2.2. BP Neural Network Algorithm. Economic forecasting is a very important and complex task, which can provide a scientific basis for the government, enterprises, and other relevant departments to understand the future economic operation, evaluate growth opportunities, and formulate development strategies.

The BP algorithm uses the gradient steepest descent method to adjust the connection weights of the hidden layer and the output layer to obtain the smallest error. The specific error indicator generally uses the error mean square value. Usually, after the neural network is calculated in the forward direction, the error will be propagated and used as the input to correct the weight parameter. The whole learning process is that the error is diffused again and the weights of each layer are corrected.

The whole process of forming a BP neural network can be summarized as follows: after the input variables were processed on each layer of neurons, the corresponding output was received at the output stage, which is the forward propagation stage. The output obtained after forward propagation was compared with the expected output to obtain the mean squared value of the error as a variable for inverse correction of the weight factors of the hidden and output layers. The ultimate goal is to bring the mean squared error to the desired minimum value, thereby minimizing the error signal for the entire system [16].

In the forward transmission stage, when the result signal spread to the secret layer and the result layer, the sign strength was enhanced or debilitated by the association loads of each layer, and the contribution of the secret layer is the weighted amount of the association loads of every hub and the info layer. The secret layer standardized the spotless contribution to a scope of sign qualities through an enactment capability as the contribution to the result layer [17]. For the information layer, the section of a hub is the exit of the layer. The construction is displayed in Figure 3.

BPNN has been broadly utilized in different fields, and its precise expectation and straightforward activity make BPNN lean toward by numerous researchers. BPNN has the accompanying attributes:

(1) It can solve the problem of complex internal mechanism. The samples are continuously learned and trained through the guidance of the BPNN, which can continuously improve the learning ability and storage ability.
(2) It has a powerful self-learning function. The network is trained to provide reasonable output to the new dataset, showing a more logical mapping in any scenario.
(3) The pattern can be summarized in the sample. By discovering and solving practical problems, it continuously strengthens its own capabilities, optimizes memory and solving algorithms, and quickly completes nonlinear mapping operations from the input layer to the output layer.
(4) It has the ability to process complex information collaboratively and without interfering with each other. Each neuron part in the BP network has the functions of receiving, processing, and outputting information independently [18]. That is to say, neurons in the same layer can calculate and process information at the same time and then output to the next layer of the network for processing, enhancing the real-time performance of the network.
(5) It has strong fault tolerance. It can also be processed and calculated when the input samples have relatively large errors.

The specific option designed in this paper is a three-level neural network. The three nodes of the output layer are used to control the digital PID controller Z_P, Z_P, Z_D. At the same time, since the parameters cannot be negative, the output layer activation function selects a nonnegative sigmoid function. There is no such requirement for the output of the hidden layer; therefore, the hidden layer activation function selects positive and negative symmetric sigmoid functions [19, 20].

The BP algorithm consists of two processes as follows:

(1) Forward propagation of information: the input vector was sent to the hidden layer through the input layer, and then the output layer outputted, generating the output vector. During the transmission process, the weights of the neural network remained unchanged. If the expected output value was not reached, the weights would be adjusted through error backpropagation.
(2) Backpropagation of the error: the result layer sent the mistake between the genuine result of the organization and the normal result to the secret layer and afterward to the info layer. The blunder input component would constantly change and right the loads of the brain organization and iterated over and again to make the organization yield equivalent to the normal result.

BPNN learning process is shown in Figure 4.

The particular result of the BPNN calculation is a managed learning calculation. The essential logical reason

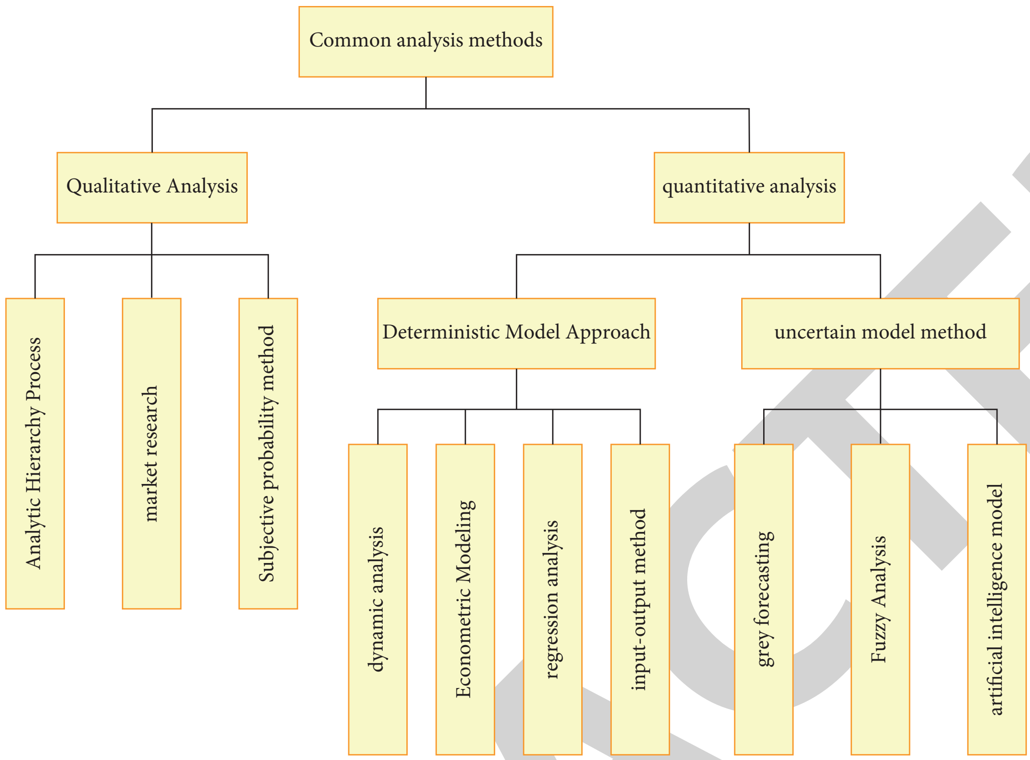

Figure 2: Common methods of economic forecasting.

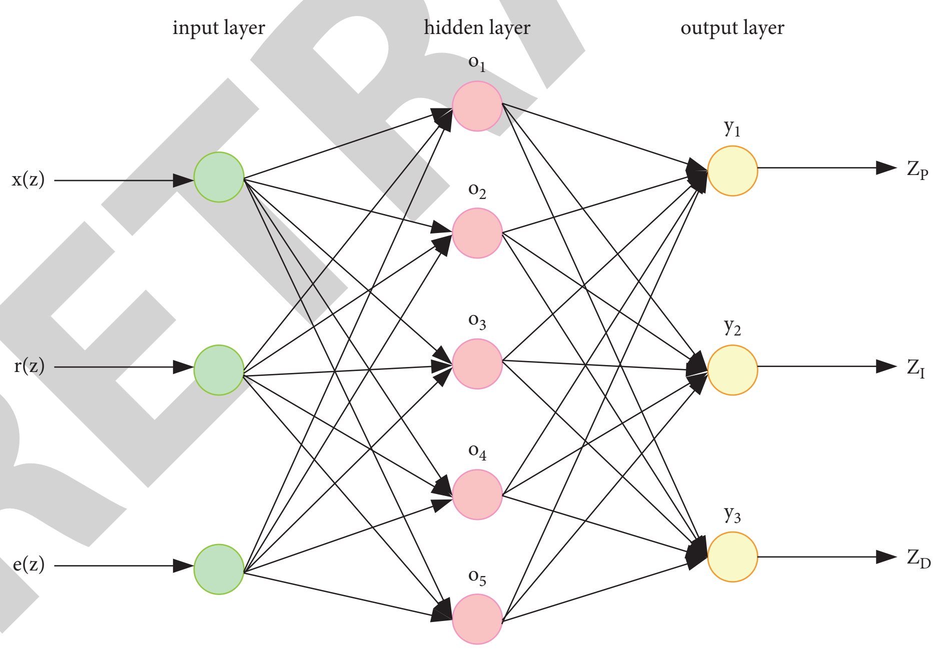

Figure 3: BPNN structure diagram.

for its foundation is the angle plummet technique. The angle plummet strategy expects that the initiation elements of the secret layer and the result layer are ceaseless and scaled down. Simultaneously, the blunder esteem was determined right now of the forward spread stage, and the mean square worth of the mistake got by computing the result and the normal result was utilized as the coefficient for changing the association loads of each layer in the back engendering stage. A definitive objective is to carry the mean squared mistake to the ideal least worth, subsequently limiting the blunder signal for the whole framework.

The gradient descent method was used in the correction of the connection weights, which requires the activation function to have continuous differentiability, and the sigmoid function satisfied this condition. At the same time, the derivative could be obtained by using the original function,

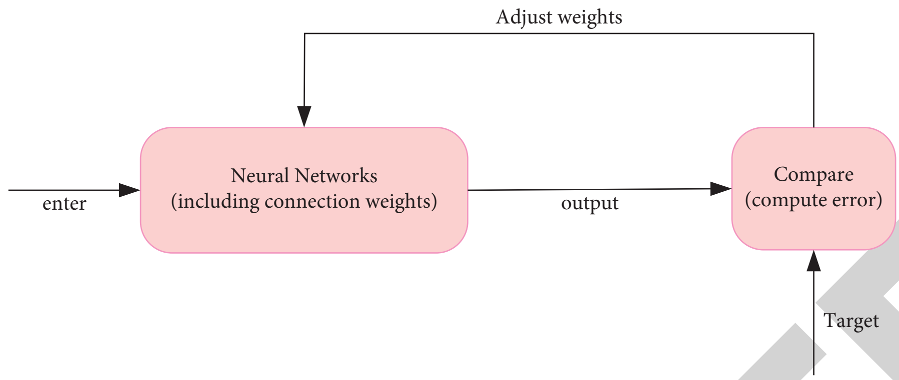

Figure 4: BPNN learning process.

which greatly reduced the difficulty of the operation. The specific function of the sigmoid function is as follows:

$$f(x) = \frac{1}{1 + e^{-x}}. \tag{1}$$

Derive it as follows:

$$f'(x) = \frac{e^{-x}}{1 + e^{-x^2}} = f(x)(1 - f(x)). \tag{2}$$

The extraordinary learning and preparation of BPNN calculation are for the most part separated into three phases: forward propagation stage, backward error propagation stage, and weight update stage. It was assumed that Figure 3 is a three-layer BP organization, including 3 information hubs, 5 secret layer hubs, and 3 result hubs. According to these three stages, the BP algorithm was analyzed concretely.

The result of the organization input layer is as follows:

$$Q_a^{(1)} x(a), \quad a = 1, 2, 3. \tag{3}$$

The information and result calculation of the secret layer of the organization is as follows:

$$\mathrm{net}_b^{(2)} = \sum_{b=1}^{3} v_{ab}^{(2)} Q_a^{(1)}, \tag{4}$$

$$Q_a^{(1)}(a) = \left(\mathrm{net}_b^{(2)}(z)\right), \quad b = 1, 2, \ldots, 5. \tag{5}$$

In formulas (4) and (5), the weight factor of the hidden layer was denoted as $v_{ab}^{(2)}$, and in the superscript, (1) was denoted as the input layer, (2) was denoted as the hidden layer, and (3) was denoted as the output layer. Specifically, $f()$ referred to the function that activates the hidden layer neurons. The input and output of the network output stage are Formula (6) and Formula (7), respectively:

$$\mathrm{net}_i^{(3)} = \sum_{i=1}^{5} v_{ib}^{(3)} Q_b^{(2)}, \tag{6}$$

$$Q_i^{(3)}(z) = g\left(net_i^{(3)}(z)\right), \tag{7}$$

$$Q_1^{(3)}(z) = Z_P, Q_2^{(3)}(z) = Z_I, Q_3^{(3)}(z) = Z_D. \tag{8}$$

In formula (8), the weight factor of the output level was denoted as $v_{ib}^{(3)}$, and the function of the activation output level was denoted as $g()$. Since Z_P, Z_I, Z_D cannot be negative, $g()$ has a nonnegative sigmoid function here.

After the forward propagation phase was completed, the specific error function means square value was calculated as follows:

$$B = \frac{1}{2}[r(z + 1) - y(z + 1)]^2. \tag{9}$$

The blunder back-spread stage is to perform a negative angle remedy on the weight coefficients of the secret layer and the result layer with the mean square worth of the mistake determined above, in order to acquire the addition of the weight coefficients of each layer:

$$v_{ib}^{(3)}(z + 1) = -\mu \frac{\alpha B}{\alpha v_{ib}^{(3)}} + \beta v_{ib}^{(3)}(z). \tag{10}$$

In formula (10), μ is the learning rate, which took a value between 0 and 1, such as $\mu = 0.2 \sim 0.5$; β is the inertia coefficient, which was mainly used to speed up the convergence speed. Usually, a constant between 0 and 1 could be obtained. In BP neural network, the learning speed has a great influence. In the initial stage of neural network training, when the value of β was large, the effect of rapid convergence could be obtained. However, when approaching the optimal point, the value of β must be relatively small to prevent the neural network from entering a nonconvergence state.

After the blunder was back-engendered, the weight coefficients of the result layer and the secret layer would be changed by the mistake, that is to say, the weight coefficients of the secret layer and the result layer would be changed by the negative angle heading, and the targeting ability is the main reason for the completion of the brain organization.

$$v_{ib}^{(3)}(z + 1) = -\mu \frac{\alpha B}{\alpha v_{ib}^{(3)}} = -\mu \frac{\alpha B}{\alpha v_{ib}^{(3)}} Q_b^{(2)}. \tag{11}$$

Definition 1.

$$\varphi_i^3 = -\mu \frac{\alpha B}{\alpha net_{ib}^{(3)}} = e(z + 1) \times Q_i^{(3)} \times \left(1 - Q_i^{(3)}\right). \tag{12}$$

Thereby, the weight coefficient correction amount of the output layer was obtained as follows:

$$\Delta v_{ib}^{(3)}(z+1) = \mu \times e(z+1) \times Q_i^{(3)} \times \left(1 - Q_i^{(3)}\right) \times Q_i^{(2)}. \quad (13)$$

Among them, μ is the learning rate; $Q_i^{(2)}$ represents the output of the hidden layer node; $e(z+1)$ represents the deviation value of the input of the controller at the $z+1$th sampling time; $Q_i^{(3)}$ represents the output of the output layer pole.

Thus, the incremental calculation of the weighted coefficient correction of the output layer could be obtained as follows:

$$v_{ib}^{(3)}(z+1) = v_{ib}^{(3)}(z) = \Delta v_{ib}^{(3)}(z+1). \quad (14)$$

Also, as indicated by the slope strategy, it very well may be realized that the change boundaries of the weight coefficient of the secret layer of the BPNN were as follows:

$$\Delta v_{ib}^{(2)}(z+1) = -\mu \frac{\alpha B}{\alpha v_b^{(2)}} Q_a^{(1)}. \quad (15)$$

Definition 2.

$$\varphi_i^2 = -\frac{\alpha B}{\alpha net_b^{(2)}} = -\frac{\alpha B}{\alpha Q_b^{(2)}} \times Q_b^{(2)} \times \left(1 - Q_b^{(2)}\right). \quad (16)$$

The node output of the hidden layer would directly change the output of all nodes in the output plane connected to it, that is,

$$\begin{aligned}
-\frac{\alpha B}{\alpha Q_b^{(2)}} &= -\sum_{i=1}^{3} \frac{\alpha B}{\alpha net_b^{(3)}} \times \frac{\alpha net_b^{(3)}}{\alpha Q_b^2}, \\
&= -\sum_{i=1}^{3} \frac{\alpha B}{\alpha net_b^{(3)}} \times \frac{\alpha}{\alpha Q_b^2} \left(\sum_{i=1}^{5} v_{ib}^{(3)} Q_b^{(2)} \right), \\
&= -\sum_{i=1}^{3} \left(-\frac{\alpha B}{\alpha net_b^{(3)}} \right) \times v_{ib}^{(3)}, \\
&= -\sum_{i=1}^{3} \left(\varphi_i^3 \right) \times v_{ib}^{(3)}.
\end{aligned} \quad (17)$$

Therefore, the modulation parameters of the hidden layer weight coefficients were obtained as follows:

$$\begin{aligned}
\Delta v_{ab}^{(2)}(z+1) &= \mu \times \varphi_b^2 \times \varphi_i^3, \\
&= \mu \sum_{i=1}^{3} \left(\varphi_b^3 \right) \times v_{ib}^{(3)} \times Q_b^{(2)} \left(1 - Q_b^{(3)} \right).
\end{aligned} \quad (18)$$

The incremental calculation for the weighting coefficient correction of the output layer was as follows:

$$v_{ab}^{(2)}(z+1) = v_{ab}^{(2)}(z) + \Delta v_{ab}^{(2)}(z+1). \quad (19)$$

3. Experiment on the Impact of the New Crown Epidemic on Economic and Social Development

3.1. Impact of the New Crown Epidemic on the Economy Will Exceed That of the SARS Epidemic. In terms of economic structure, the current share of the tertiary industry and consumption is much higher than in 2003, and the epidemic has had a greater impact on the service industry and consumption.

In 2003, the essential, optional, and tertiary ventures represented 12.4%, 45.6%, and 42.0% of GDP at current costs, separately, and their commitment rates to monetary development were 3.1%, 57.9%, and 39.0% separately. The optional business was the foundation of the economy. In 2021, the essential, optional, and tertiary ventures represented 7.3%, 39.4%, and 53.3%, separately. The primary and secondary industries decreased by 5.1 and 6.2 percentage points, respectively, and the tertiary increased by 11.3 percentage units compared with 2003. The commitment paces of definite utilization consumption, gross capital arrangement, and net commodities of labor and products to monetary development were 5.3, 1.1, and 1.7 rate focuses separately, and the financial development rates were 65.4%, 13.7%, and 20.9% individually. The commitment pace of the tertiary business to financial development was 59.4%, an increment of 20.4 rate focuses north of 2003. In 2021, the financial commitment paces of definite utilization use, gross capital arrangement, and net commodities were 65.4%, 13.7%, and 20.9%, separately. The commitment pace of complete capital development was lower than that in 2003, at 52.7%. The economic impact of the current COVID-19 outbreak will be greater than the economic impact of the SARS outbreak in 2003 (see Figure 5), which has a greater impact on services and consumption.

From a national perspective, consumption has been significantly affected. In May 2003, total retail sales of consumer goods grew at an average annual rate of 4.3%, compared with 7.7% in April and 8.3% in June. Investments were not affected. In the whole year of 2003, fixed asset investment did not decline significantly, but increased significantly in April and May (see Table 1). Imports and exports had little impact, which fluctuated only in April 2003. From March to May 2003, the growth rates of exports were 34.7%, 33.3%, and 37.3%, and imports were 45.1%, 34.4%, and 40.9%, respectively (see Table 2).

3.2. China's GDP Growth under the Impact of the Epidemic. The SARS epidemic began in November 2002 and experienced a long incubation period. It did not spread quickly and did not peak until April and May 2003. Therefore, it had no obvious impact on economic growth in the first quarter of 2003. The annual GDP growth rate fell from 11.1% in the first quarter of 2003 to 9.1% in the second quarter, and the monthly growth rate fell from over 12% to 3.5%. The SARS

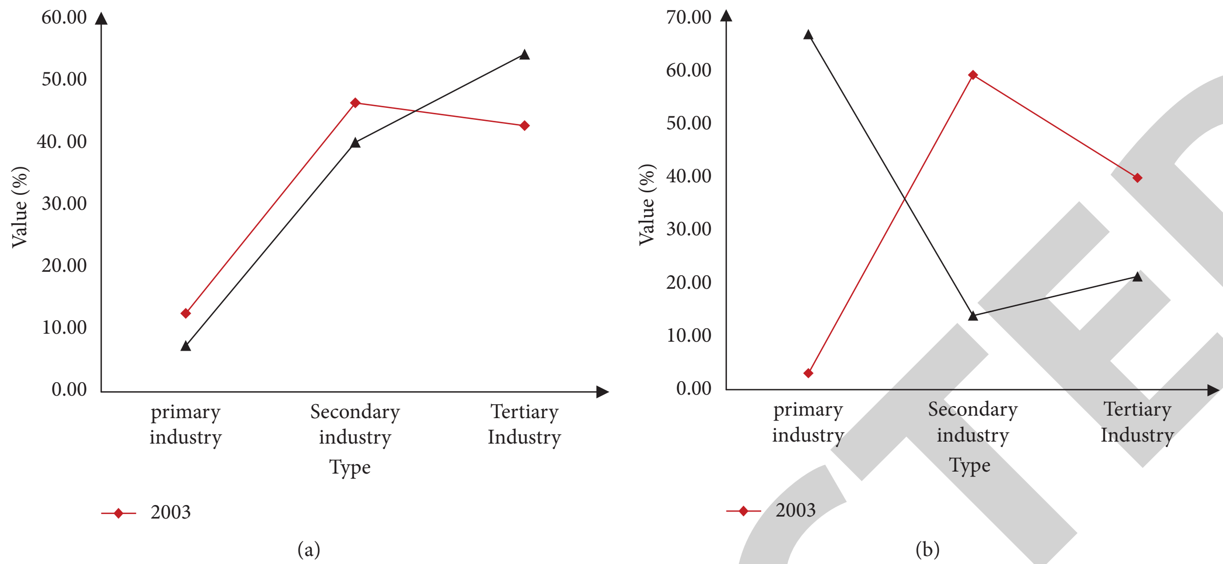

Figure 5: Comparison of 2003 and 2021. (a) GDP comparison (b) Contribution rate comparison of economic growth.

Table 1: Total retail sales of consumer goods.

Year	Month	Total retail sales (%)
2002	2	8.3
	5	8.0
	8	8.6
	11	8.9
2003	2	8.2
	5	4.7
	8	10.2
	11	10.1
2004	2	10.3
	5	18.4
	8	13.9
	11	14.6

Table 2: Import and export growth rate from March to May 2003.

Year	Month	Export growth (%)	Import growth (%)
2003	3	34.7	45.1
	4	33.3	34.4
	5	37.3	40.9

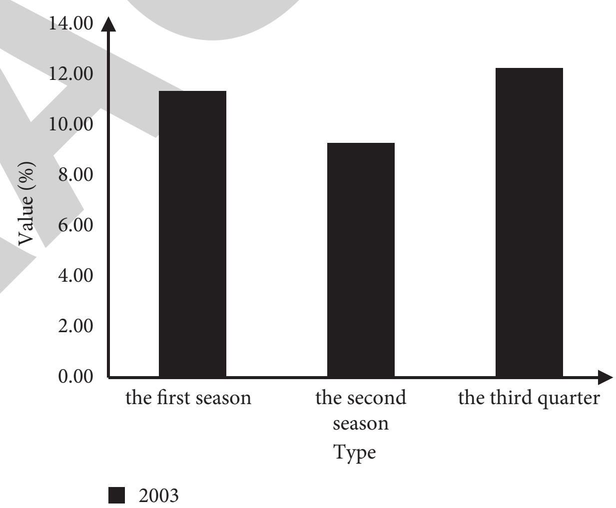

Figure 6: The economic changes in 2003.

epidemic was brought under control in the third quarter, and economic growth gradually recovered to 10% (Figure 6). According to the experience of the SARS epidemic, it took about two months from the rapid outbreak of the epidemic to the control of the epidemic. Likewise, the timing of the economic impact of the coronavirus outbreak is mainly concentrated in the first quarter of 2021.

China's GDP in 2021 reached 114.37 trillion, a year-on-year increase of 8.1%. It was equivalent to 17.73 trillion US dollars, and the per capita GDP was 12, 551 US dollars. It was a stone's throw away from the per capita threshold of US$12, 736 in high-income countries.

In 2021, China's GDP grew by 8.1% year-on-year, which was not only higher than the 6% growth level set by the government work report in March last year but also slightly higher than the 8% growth level predicted by international financial institutions and economic organizations.

At the quarterly level, yearly development was 18.3% in the main quarter, 7.9% in the subsequent quarter, 4.9% in the third quarter from last quarter, and 4.0% in the final quarter. It was clear that in the four quarters of 2021, GDP growth would trend higher towards the end of the year. The situation appeared to be clearer while adding in the growth in the four quarters of 2020 (see Figure 7).

In Figure 7, it very well may be seen that in the primary quarter of 2021, GDP expanded by 18.3% year-on-year, which was excessively quick. The explanation is that the effect of the scourge in 2020 was moderately low, and the quickest year-on-year development was normal. In any case, the descending tension on the large-scale economy has expanded essentially after the second from last quarter of

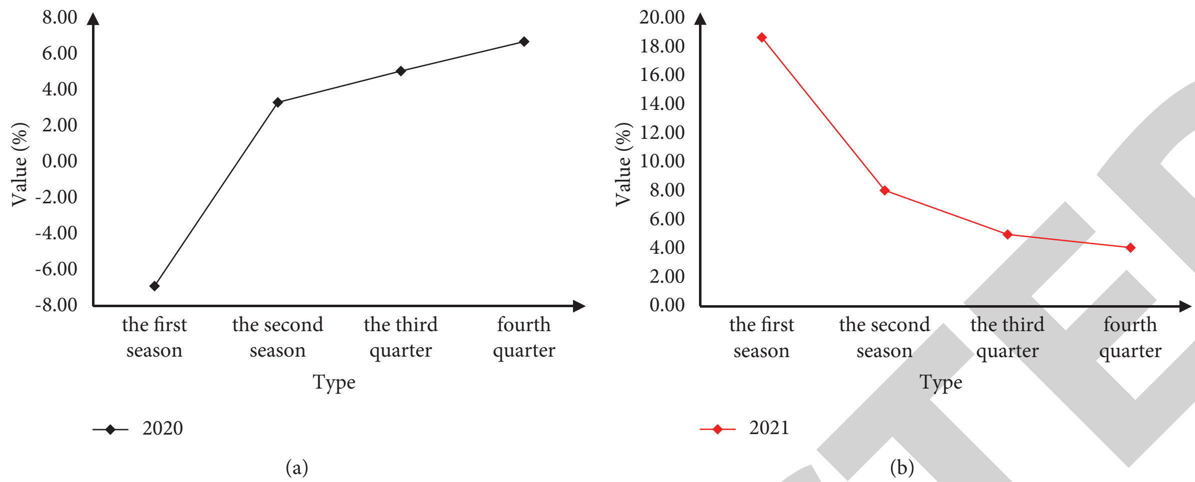

Figure 7: China's GDP growth rate. (a) The year of 2020. (b) The year of 2020.

2021, with a year-on-year increment of 4.9% and 4.0% in the third and fourth quarters. A similar period in 2020 was contrasted, and the development rate has dialed back essentially, which was below the normal development pace of 5.1% in the two years.

The year-on-year development pace of modern added esteem above assigned size and the development pace of all-out retail deals of customer products are displayed in Figure 8(a), and the month-to-month development of all out import and commodity volume is displayed in Figure 8(b).

As can be seen from Figure 8, the 30% year-on-year increase in total import and export volume exceeding expectations was the main contribution to GDP growth in 2021. The growth rate of investment in fixed assets accelerated, the growth rate of industrial output above the designated size accelerated, and the growth rate of total retail sales of consumer goods was slow.

3.3. New Crown Epidemic Brings New Opportunities. There is often a turning point behind a crisis, and the outbreak has also drawn attention to life, health, and smart cities. It will promote technological change, promote the rapid development of new water quality of economies such as e-commerce and smart healthcare, and provide a series of important new opportunities for China's industrial restructuring (see Figure 9).

The first is the accelerated development of the mass health industry. The outbreak of the epidemic has greatly increased people's awareness of life and health and greatly increased the demand for medical equipment such as gas masks and related raw materials.

The second is to further accelerate the construction of smart cities. The SARS epidemic in 2003 led to the rapid development of Alipay and Taobao. There is no doubt that the epidemic will change the way people go from online shopping to online shopping and will deepen the development of industries such as e-commerce, modern logistics, and the new economy.

The third is the rapid rise of the "home economy". Homestay economy is a new concept that emerged with the advent of the Internet, which mainly refers to working from home or engaging in professional work such as online entertainment, e-education, and learning, including using the Internet at home. Office and consumption patterns have changed dramatically, moving offices from one unit to another. The "home economy" was formed spontaneously in the past, but this time, due to the need to prevent and control the epidemic, some provincial and municipal governments have given support and encouragement. The rapid rise of the home economy will promote the development of the Internet celebrity economy, community economy, and platform economy.

The fourth is the green buildings are gradually developing. The rapid construction and live broadcast of Huoshenshan Hospital and Leishenshan Hospital created a miracle in Wuhan, demonstrated the great potential of green buildings and intelligent buildings in Hubei Province, and showed the world the speed and strength of Chinese architecture. Therefore, prefabricated buildings, intelligent buildings, and energy-saving and environmentally friendly buildings will achieve huge growth, and Chinese construction will go overseas.

The fifth is to further develop emergency industrial and military-political integration. In the fight against the epidemic, the People's Liberation Army has provided strong emergency support in various aspects including medical treatment, transportation, and chemical prevention. The newly built Huoshenshan Hospital has been handed over to all the people's soldiers, creating living conditions for military-civilian unity and introducing new associations for the further development of military-political integration.

The new business form and the new model triggered by the epidemic will continue to promote the development of the industry in the direction of green, digital, networked, intelligent, and coordinated development, which is completely consistent with the trend of industrial transformation and upgrading and brings new opportunities to industrial

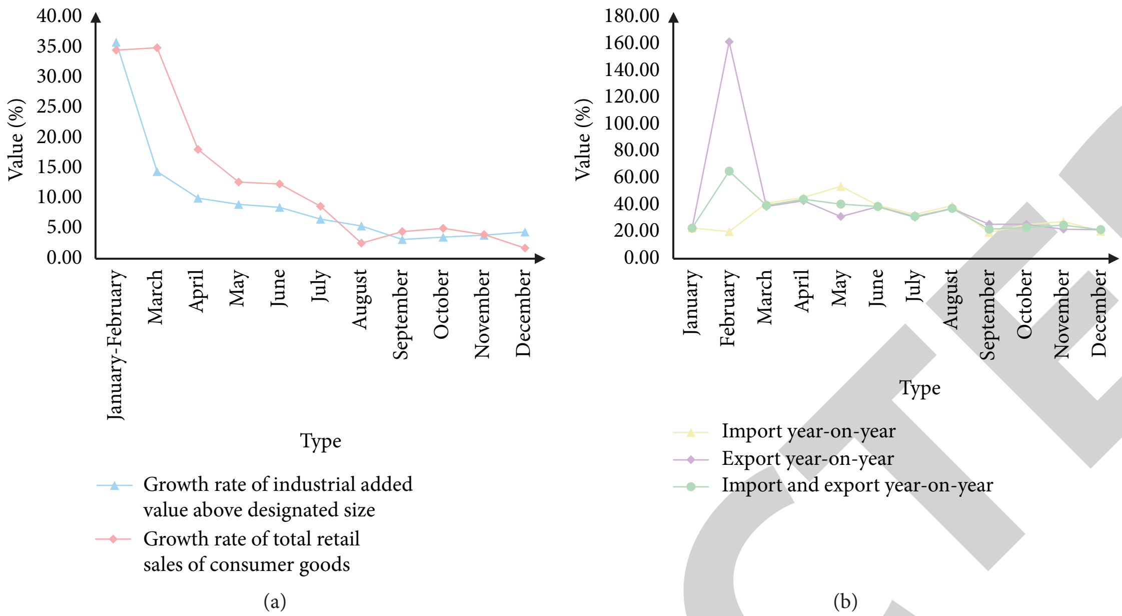

Figure 8: Growth rate. (a) Year-on-year growth rate of industrial added value and growth rate of total retail sales of consumer goods. (b) Monthly growth of total imports and exports.

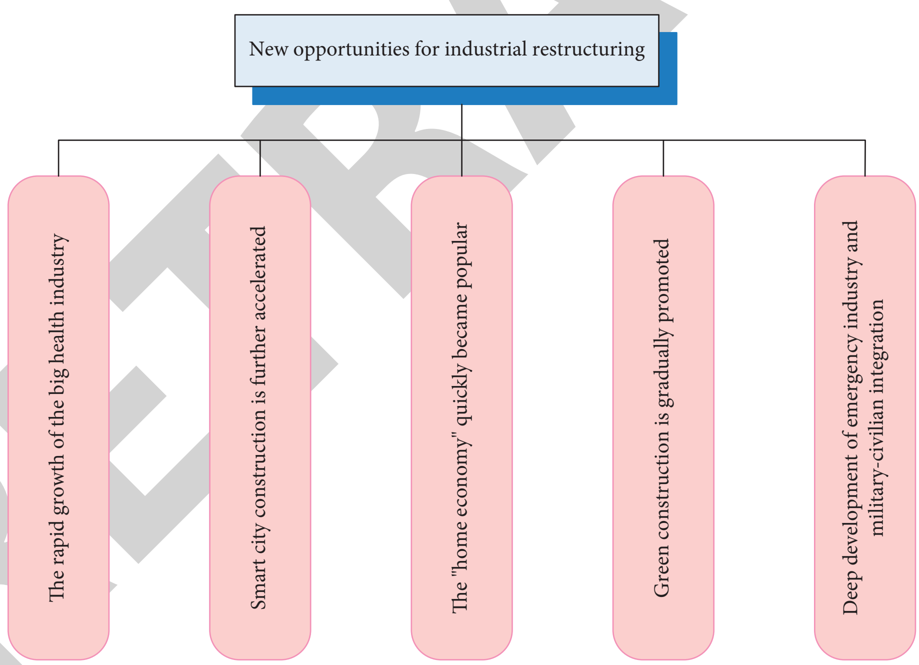

Figure 9: New opportunities for China's industrial restructuring.

development. It will help accelerate the transformation of new and old power, promote high-quality economic growth, and cultivate new economic growth points.

4. Conclusions

2020 is the year of building a moderately prosperous society in an all-around way and the end of the "13th Five-Year Plan". It is crucial to do a good job in economic work. The sudden outbreak of COVID-19 has had significant economic and social impacts across the country, putting even more pressure on the province's economic growth. However, based on experience with relevant events, this effect is short term. The economic and social development should be viewed from a comprehensive, dialectical, and long-term perspective, continuously enhance confidence, and turn pressure into motivation and crisis into opportunity. Governments at all levels must always put the safety and

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Research Article

Marriage, Face, and the Body: Human Body Health and the Body Symbols of Hui'an Woman in Southeastern China

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The body is not only a physical body but also a communicative body which constructs meaning through communication, and the human body health exerts a considerable influence on self-identity and society. The most fundamental power contained in the communicative body of human constitutes our concept and existing culture. Through in-depth interviews, this paper attempts to analyze the daily microphysical practice of Hui'an women of Xuehua Village in Southeastern China and analyze the meaning of symbol which generates from the body of Hui'an women coming and returning between the husbands' and the natal family. Because of the marriage customs of "extended natal residence marriage," how the interaction of the human body health continues this special marriage custom and preserves the face of women in this community is shown.

1. Introduction

1.1. Body as a Medium. From the end of the 20th century to the beginning of the 21st century, a climax of body research emerged in academia, and sociology of body began to become an independent research field. At first, the body was regarded as a physical rather than a social phenomenon. Shilling introduced the body as a "physical object." Naturalistic views of the body have, since the eighteenth century, exerted a considerable influence on how people have perceived the relationship between the body, self-identity, and society [1]. For example, gender inequality is the direct result of damage of human body health. Turner once summarized the three traditions of body research in "The Body and Society," namely, taking the body as a set of social practices, conceptualizing the body as a symbol system, and understanding the body as a symbol system representing and expressing the power relations [2]. No matter what kind of body research tradition, it implies the body as a medium, as a carrier of meaning, and as a symbol system. The body cannot be separated from communication, and communication cannot be separated from the body, so the importance of the body in the field of communication research is self-evident. Wittgenstein once said: "The human body is the best picture of the human soul" [3]. It is impossible for any society and culture to separate the body from the symbol system, because members of society need to communicate through the body. Moreover, important political, economic, and cultural issues must be expressed through the body. The body is not only a symbolic system but also a carrier of power. The body increasingly tends to become the core of modern people's sense of self-identity in the highly modern environment [1]. Apparently, the body is indeed a fascinating and profound problem.

The body is not the same as the physical body. O'Neill distinguishes five kinds of bodies: the world body, the social body, the political body, the consumer body, and the medical body [4]. He believes that the communicative body that we have and are thinking about is the total medium of our world, history, culture, and political economy. The opinion originated from Merleau-Ponty, who wrote the following in "Phenomenology of Perception": "The body is the total medium of the world. Sometimes it is limited to preserve the necessary actions, so it presupposes a biological world around us. And at other times, in the process of clarifying these important actions and developing from their superficial meaning to their metaphorical meaning, the body presents a new core meaning through these actions" [5]. O'Neill also pointed out that we should pay attention to the most basic communicative body as sociologists, which is not only the moral foundation of society but also the moral foundation of any kind of social science practice [4].

While the body has become a hot spot in various philosophical and aesthetic theories, modern communication that starts from the body and eventually ends with the body tends to drive the body out of the territory of human communication. Modern communication technology has not only completely changed the dissemination pattern of human information but also fundamentally changed the function and role of the body in information dissemination [6]. Mass communication tends to ignore the material media in communication, namely, the body. The issue of body is an important field that cannot be avoided after reflecting on the social and historical process of "modernization-modernity." In fact, human beings mainly used the body as a medium to communicate and exchange with themselves, other human beings, and the surrounding world before the emergence of modern media technology [7]. However, the body as a primitive medium has lost its voice in the field of communication research. Under the ritual view of communication, the media is not limited to the mass media. All information carriers can be called media, and the body as a medium is much earlier than any other medium. McLuhan's classic media view that the media is the extension of the human body explains the extension of the body and its influence. He wrote the following in the preface of "Understanding Media": "The writing of this book runs through this belief, the purpose is to explore the contours of man reflected by the extension of man's technology" [8]. On his opinion, roads, clothing, houses, currency, clock, and so forth are all extensions of the human body, and the human body is a comprehensive communication medium. To a great extent, our bodies exist for communication, interaction, and creation and evolve themselves due to communication, interaction, and creation [9]. Culture and information are loaded on the body, which is an active carrier. This article attempts to start with the daily microphysical practice of Hui'an woman in Xuehua Village, Huidong District, Fujian Province, and analyzes the symbolic meaning of the Hui'an woman's body, which returns back frequently to the natal family because of the marriage custom of extended natal residence, to reveal how the interaction of the body constructs the social culture of the ocean fishing village.

1.2. The Extended Natal Residence Marriage of Hui'an Women. The marriage custom of Hui'an women can be attributed to "extended natal residence marriage" or "delayed transfer marriage." Strictly speaking, the extended natal residence marriage covers most regions of Hui'an. Generally speaking, the so-called Hui'an women who live in the natal families after getting married mainly refer to the 7 townships in the southeast of Hui'an, which are Chongwu, Shanxia, Tuzhai, Dongling, Jingfeng, Xiaozuo, and Wangchuan. They are connected into one region, and all belong to the coastal area [10]. It is recorded that the married woman lived with her natal family in Xuehua. From then on, the married man sent relative child or his mother to the wife's home to invite her, to come to the husband's home for celebrating holidays or helping in farmwork only during the busy farming season and some important festivals such as Dragon Boat Festival, Mid-Autumn Festival, Winter Festival, and Spring Festival's Eve. The woman can also refuse to return, but she has to on Spring Festival's Eve. This situation continued until their first child was born [11]. Most of the people of Fujian and Guangdong are now of Han nationality, which is a mixed nation. In ancient times, the aborigines of Fujian and Guangdong were ethnic minorities, and their civilization was later than that of the Huaxia nationality in the north. Therefore, more ancient customs were preserved in Fujian and Guangdong. The custom of "extended natal residence marriage" should also be an ancient custom left over from ancient times. Professor Lin believes that although the "extended natal residence marriage" of the Han nationality has the same origin as the "delayed transfer marriage" of the minority nationality, it has been partially changed due to the influence of the feudal society. It is mainly reflected in the oppression of women in the feudal society. Women's status is low. Even if they live in their parents' home for a long time, they must keep their virginity. The husband can beat and scold his wife. The wife cannot rely on her parents' home permanently and cannot return to her husband's home. Therefore, it contributes to their pessimistic suicide. Women in some areas of Huidong live in their parents' home for a long time after marriage, but they need to strictly observe chastity and eliminate any contact with men, which is quite different from women's sexual freedom in ethnic minorities. It can be seen that the "extended natal residence marriage" in some areas of Huidong has its unique form.

This peculiar marriage custom in Huidong area connects Hui'an women with ethnic minorities, which has attracted many scholars to explore the origin of the extended natal residence marriage. Professor Lin of Xiamen University was the first to explore marriage customs in Huidong area. He believes that this custom occurred during the transition period from matrilineal clan society to patrilineal clan society, based on the information obtained during the agrarian revolution and inquiries about his Hui'an friends, as well as relevant newspaper records and historical archives [12]. Engels explains the transition from matriarchy to patriarchy in the book titled "The Origin of Family, Private Property and the State": "The overthrow of matriarchy is a failure of women with historical significance" [13]. In this way, the extended natal residence marriage, which is the product of institutional changes, can also be seen as the compromised result with a sense of resistance in the process of transition from the matrilineal system to the patrilineal system. Wang holds the same view and believes that no matter what type of extended natal residence marriage, it is mostly related to the matrilineal clan system, and these nationalities also have traces of matrilineal system to varying degrees [14]. Jiang pointed out that the first residents in Huidong area were Minyue people of Baiyue nationality through field investigation and literature review. After mixing with a large number of Han people who immigrated in the Ming Dynasty, they formed the current Huidong residents of Han nationality. This special marriage custom is the product of the combination of the marriage custom of the aboriginal Minyue people and the feudal concept of chastity in the Han culture [15]. Both Han culture and Minyue culture made certain concessions and compromises and experienced a complex process of cultural restructuring: married women lost the social freedom of social contact while living in their parents' home, while men also gave up their husbands' rights for a long time.

However, whether the extended natal residence marriage is part of the Minyue Culture is still unknown. Qiao denies the "relic custom theory" of this marriage custom. From the perspective of function theory, he believes that the marriage custom in each region has its own special causes. The marriage custom in Huidong area is directly related to the local gender division of labor. The extended natal residence marriage enables local women to take into account the interests of their mother's family and husband's family [16]. Wu does not agree with Qiao's negation of the general law of social evolution history. He believes that the extended natal residence marriage not only reflects the system of an extreme patriarchal society but also results from the interaction between the gender division system and the husband's power system [17]. However, in the coastal area near Huidong, the division of labor between men and women is roughly the same; there is no extended natal residence marriage. Guo denies the "relic custom theory" and does not agree with the statement of gender division of labor. Through field investigation and literature review, he points out that Huidong culture has the cultural characteristics of Dan-Min, and the extended natal residence marriage is the product of the intermarriage between Dan-Min and Han people [18]. However, Shi points out that the danists ignored the historical fact that there could not be many Dan-Min in Huidong. In the areas dominated by Huidong people, the extremely rare intermarriage between Dan-Min and Han people could not lead to the extended natal residence marriage [19]. Li, a Taiwanese anthropologist, explains the reasons for the occurrence and existence of the extended natal residence marriage from the perspective of ethnic structure. He believes that, in order to maintain their own traditions, the Huidong people have maintained their own characteristic marriage customs in contrast to the Chongwu people [20].

The later scholars also put forward those opinions such as the theory of combining the extended natal residence marriage from the indigenous Minyue people and the concept of feudal chastity in Han culture, the theory of gender division of labor, and the theory of ethnic interaction. Due to the limited information, those explanations that explain the origin of extended residence marriage in some areas of Huidong cannot be justified completely. After more than 40 years of "transform established habits and social customs," the extended natal residence marriage still existed firmly in Xuehua. There are two reasons for the continuation: First, it is affected by the long-standing feudal consciousness and old customs. Second, the special gender division of labor in Huidong area is an important factor to preserve the extended natal residence marriage [21]. Because men fish outside all year round, women prefer to help their parents work in their familiar home. Most scholars believe that the economic reasons are very important. Girls are still an important labor force in their parents' family. Marrying out too early will cause economic losses to their parents' family. Therefore, keeping the extended natal residence marriage has become a compromise to meet the interests of both parties. This marriage custom is obviously not necessarily related to ethnic composition. It exists in both ethnic minorities and the Han nationality. Obviously, the marriage custom which exists in both ethnic minorities and Han nationalities has no inevitable connection with ethnicity. It was not until the end of the 20th century that the marriage custom gradually disappeared, because the local economy developed rapidly, especially after the booming of the stone carving industry. What role does the body play in the inheritance and disappearance of the marriage custom of "extended natal residence marriage?"

2. Materials and Methods

Xuehua, an assumed name, the field site selected for this study, is a seaside fishing village in southeastern China. It is located between N24°22′~24°54′ north latitude and E113°53′~118°59′ east longitude. It belongs to a subtropical maritime monsoon climate zone. Located at the easternmost end of the Chongwu Peninsula, it protrudes over the Taiwan Strait, surrounded by the sea on three sides. Therefore, it is often windy, with an annual average of 6.9 meters per second. The wind is relatively strong from October to February of the following year. The wind speed, wind direction, and windy days in Xuehua are shown in Table 1. As shown in Table 1, November is the month with the highest average wind velocity and the longest continuous windy days in a year, and the maximum velocity, windy days in average, and windy days in sum of November are all in the forefront of the year. The strong wind obviously caused great damage to human body health, especially the skin. As a result, the local Hui'an women (except those under 30) wear a headscarf to guard against the sea breeze all the year round.

The village is divided into four areas for management, the southeast, southwest, northeast, and northwest; Figure 1 shows the panorama of Xuehua [11]. The idea of cherishing every piece of land that can be planted is rooted in the hearts of Hui'an woman in Xuehua because of the scarce arable land. Therefore, even if there is no separate field for planting, the hostess of every household will not miss any available space; see Figure 2. Now the roads extending in all directions integrate Xuehua into the booming economic network of Fuzhou, Xiamen, and other coastal areas, making it more convenient for Xuehua to connect with the outside world.

Table 1: Wind velocity, wind direction, and windy days.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Average vel. (m/s)	8	8	6.9	5.8	5.6	5.4	5.3	4.9	6.6	8.7	9	8.3
Maximum vel. (m/s)	20	20	20	20	28	18	28	32.6	24	24	24	20
Windy days in average	13.6	12.9	10.1	16.2	3.9	1.5	2.4	3.4	6.3	13.2	15.5	14
Windy days in sum	24	21	19	12	12	7	7	9	13	23	22	22
Maximum number of continuous windy days	11	14	15	7	5	3	6	6	6	17	20	19
Dominant wind direction	NNE	NE	NE	NE	NE	SSW	SSW	SSW	NNE	NNE	NNE	NNE

Figure 1: Panorama of Xuehua Village (photographed by the authors in 2017).

Figure 2: A corner of of Xuehua Village (photographed by the authors in 2017).

During the four-month field investigation, the main work for the first two months was to get familiar with the local customs; the old peoples's club in Xuehua was a key turning point. The researcher got to know the hospitable retired clerk, who has many connections in the village and introduced many famous people to the researcher, including the owners of the stone carving factory, the old captains, retired and current cadres, innkeepers, and stone carvers. The researcher slowly built up personal connections through snowballing. In the next two months, the main purpose was to fully develop the in-depth interview part of the research by snowball sampling. A total of 67 people were interviewed from November 2017 to April 2018, including 34 males and 33 females, covering men and women aged from 20 to 90 years and including the main types of local occupations. The interview questions mainly focus on their body health, such as local marriage customs, occupations, and clothing, as well as other daily practices. The male code is M and the female code is F. The basic information of the interviewees is listed in Table 2.

The marked age in this article is the age of interviewee at the time of the interview.

3. Field Description and Discussion

Goffman absorbs the principles of theatrical performance and developed his theatrical performance theory, using the metaphor of theatrical performance, such as performer, audience, role, script, "patterns of appropriate conduct," front stage, and back stage, to describe the ways we present ourselves in daily life, which vividly portrays the details of symbolic interaction between individuals in daily life. The Xuehua Village also seems to be a big stage of the society where everyone in the community shares the accepted values of society. They restraint each others' behaviors in the front stage and try to maintain or control impressions fostered by their performance in a specific situation through adjusting the most obvious physical signals. Hui'an women in particular consciously express themselves and unintentional communication through their bodies, and others in Xuehua are also accustomed to that. Those embodied practice of Hui'an woman in Xuehua who is refusing to return to the husband's home, concealing her face to show her embarrassment, and getting close to her sisters and alienating herself from her husband, imprinted social values, social relationships, and so forth on individuals, forming a unique mystery and charming culture that distinguished Xuehua from other Han communities.

3.1. The Female Body That Refused to Return to the Husband's Home. Using the body as a medium, the embodied practice of local women expressed their willingness to refuse to return to the husband's home. Before being married and not having a child, the physical moving between the husband's home and the natal home constructed the legality and special meaning of the extended natal residence marriage and formed a set of predetermined modes of action that refused to return to the husband's home, which Goffman called patterns of appropriate conduct. The Hui'an women in Xuehua were very familiar with this script; they purposely expressed themselves through the patterns of appropriate conduct, playing the female roles prescribed by the Xuehua Villagers, in order to maintain the normal evaluation of them by others. In the summer of 1994, when an American scholar who was doing fieldwork in Xuehua visited a local family, she witnessed the scene of a Hui'an woman avoiding her mother-in-law to call her back to her husband's home.

The oldest daughter in the household, Bbingden, was twenty-six at the time and had been married to her fisherman husband for five years. One evening during my visit, Bbingden's mother-in-law suddenly entered the family

Table 2: Basic information of interviewees.

Male code	Age	Occupation	Female code	Age	Occupation
M1	74	Retired cadre	F1	27	Housewife
M2	72	Retired cadre	F2	45	Government staff
M3	38	Self-employed	F3	72	Retired accountant
M4	56	Fishman	F4	46	Self-employed
M5	48	Worker in stone carving factory	F5	22	Teacher
M6	66	Owner of tone carving factory	F6	42	Company employee
M7	73	Retired cadre	F7	40	Company employee
M8	57	Fishman	F8	54	Housewife
M9	68	Ancient architectural painter	F9	42	Teacher
M10	55	Government staff	F10	42	Housewife
M11	50	Teacher	F11	37	Innkeeper
M12	73	Retired loader driver	F12	39	Inn manager
M13	80	Retired cadre	F13	37	Housewife
M14	83	Retired clan chief	F14	60	Housewife
M15	82	Retired cadre	F15	72	Housewife
M16	85	Retired cadre	F16	45	Government staff
M17	93	Retired cadre	F17	38	Housewife
M18	55	Innkeeper	F18	77	Retired cadres
M19	72	Retired veteran	F19	26	Company employee
M20	73	Electrical equipment repairer	F20	50	Housewife
M21	80	Retired cadre	F21	43	Self-employed
M22	76	Retired fishman	F22	68	Housewife
M23	48	Government staff	F23	87	Retired cadre
M24	81	Retired cadre	F24	80	Retired accountant
M25	63	Retired fishman	F25	85	Housewife
M26	62	Retired ship repairer	F26	33	Worker in stone carving factory
M27	62	Retired fishman	F27	45	Worker in stone carving factory
M28	48	Worker in stone carving factory	F28	41	Worker in stone carving factory
M29	29	Manager of stone carving factory	F29	50	Self-employed
M30	49	Worker in stone carving factory	F30	87	Housewife
M31	43	Worker in stone carving factory	F31	84	Housewife
M32	43	Crew	F32	55	Government staff
M33	48	Crew	F33	35	Self-employed
M34	72	Retired teacher			

courtyard, with her sandals churning up dust as the sound of rubber on tile announced her arrival. She had come to ask Bbingden to spend the night with her son. Bbingden's sister turned to me as the older woman walked past and commented, "she'll refuse to go," adding that Bbingden would use me as an excuse to explain why she could not traverse the few village paths that led to her husband's home. Sure enough, Bbingden soon appeared out of the lengthening shadows, her headscarf and headpiece tidily in place and her cropped top neatly buttoned down the side. She grabbed my arm and pulled me through the back door and into the street, walking briskly to escape her mother-in-law [22].

Although such a scene has disappeared nowadays, it still exists vividly in the memories of the locals. Returning to or not coming back to the husband's home seems to be a game between wives and husbands. The game marked by the appearance of the female body often ends in the frustration that the husband's family cannot call back the wife. Although the husband's family is often unable to call back the wife, no one tries to omit this seemingly fruitless movement in the process, because not calling the wife back may mean a break between the two parties, which will start a new round of unfamiliar symbolic interaction. Therefore, the patterns of appropriate conduct of refusing to return to the husband's home which includes the husband's family coming to call back the wife and the wife fleeing to avoid returning to the husband's home have been unanimously approved by the performers, the assisting participants, and the audience. It seems that women have the autonomy to refuse to return to the husband's home, but in fact they are just succumbing to the accepted values of society. Woman's avoidance behavior which changes the body of woman from being present to being absent, to avoid direct face-to-face meetings with the husband's family, is a compromise solution to protect the faces of both parties. Face-saving is actually an action of impression finishing and decorating, which is an act that an individual deliberately shows to others in order to make others have a certain impression of himself or herself [23]. Women in Xuehua deliberately used their physical absence to perform well for this conventional drama; they also added another auxiliary role, which was child.

F2: they always asked the children to call the wife, because the husband would not go. Sometimes it's the mother-in-law to call the wife back, and it was best for the children to do that. There was nothing the mother-in-law can do if the bride refused.

F26: My fourth aunt, she was good at escaping. As long as my little aunt called her, she would disappear, as a result my little aunt could not find her. Sometimes it was not until night that she was able to caught her sister-in-law and bring her home. Anyway, bringing sister-in-law home was the task of the two sisters of my father, they must call her back, otherwise they dared not go home.

The patterns of appropriate conduct allow the female body in Xuehua to be properly arranged in daily interactions, maintaining the dignity of both the natal family and the husband's family. Both parties perform themselves in the interaction, play their respective roles, and express etiquette and show goodwill, but behavior that breaks the rules is not allowed. There are historical and practical reasons for the continuation of the extended natal residence marriage in this fishing village near the sea. There is little contact with the outside world because of the closed geographical environment, and it is difficult to be affected by foreign cultures, resulting in a highly closed state of this traditional culture [15]. The lack of labor at home caused by men perennially fishing outside also highlights the female labor force. Significantly, the gender division of labor of "men do the fishing and women do the farming" provides soil for the continuation of the extended natal residence marriage. Both the husband's family and the natal family have acquiesced to this way of living after marriage. Human body health is closely related to division of labor. On the one hand, the extended natal residence marriage has also adapted to the daily production mode and life rhythm of the fishing village from the perspective of functionalism. On the other hand, the husband's home which is unusually unfamiliar for woman due to the extended natal residence marriage belongs to the front stage that requires a complete set of standard expressive equipment as far as micro daily practice is concerned. Hui'an women have three fears (dare to eat, dare not sleep, and dare not speak). Obviously, the natal family belongs to the back stage where woman feel more free is a more comfortable choice, where they do not need to pay attention to their unintentional gesture.

F32: Because I was the oldest in my family, I had to help my natal family. My husband always went out to work. I lived in my natal home until my son was born and I built my own house before returning to my husband's home.

M34: We preferred boys to girls. Men went fishing, and all the work at home was done by women. If you moved to the husband's home as soon as you got married, your natal family would simply lose a very strong labor force. So (her natal home) would not let her go. It would be equivalent to sending a very strong labor force to other family.

F4: I had lived in my natal home for two years. I would return to my husband's home during some important festivals. I returned at night and left in the early morning. It's more comfortable to live in your natal home, you could eat or sleep freely. If you live in your husband's home and you dare not eat enough, then you dare not do anything, which is very inconvenient. Who likes to live there?

However, Chongwu Town, which also relied on fishing for a living and preferred boys to girls, did not have the extended natal residence marriage. This was related to the fact that the women in Chongwu Town had always bound their feet, but the women in Xuehua who had always unbound their feet were skilled in housework and farmwork. Therefore, the interaction of the body between the husband's home and the natal home constitutes a very important nod; the symbolic meaning of the body was constructed during the interaction, which has three key points. First of all, the person who comes to call the Hui'an woman back to the husband's home on a specific holiday shows a gesture of recognizing the marriage, admitting the daughter-in-law, and hoping that the daughter-in-law will return and help. Secondly, the Hui'an woman needs to release a refusal response to the action of calling her back. Finally, the Hui'an woman controls and modifies her behavior by basing on the interpretation of the behavior in her community, and the meaning is contained in the series of social actions. The female body that travels between her husband's and natal homes contains the symbolic meaning of hardworking, strong, and capable woman, and the female body that shows a rejection gesture expresses the symbolic connotation of female shyness recognized by the community.

3.2. The Female Body Restricted from Returning to the Husband's Home. Women's physical interactions between the two families connect the daily life of the local residents. However, the extended natal residence marriage is a typical representative of feudalism in official context. Although wives and husbands who have experienced the marriage custom complained strongly, they still followed the traditional custom under strong social pressure. For the locals, this was a custom passed down from ancient times.

For the residents of Xuehua Village, the extended residence of the female body in the natal home releases a well-known normal signal. Once someone tries to break the meaning of this symbol, they will be criticized by the other residents who come to defend the meaning of the symbol. As Goffman said, a person's performance in the personal front can be seen as an effort to show someone's image, and his activities in the region maintain and reflect the accepted values of society [24]. These accepted values of society include two aspects: politeness and decorum. The interactions between two families in Xuehua belong to the front stage, so they should use recognized polite behaviors, which include refusing to return to the husband's home, keeping a distance from their husbands, and going to their natal family as soon as possible, to try their best to show the image of shy, solemn, and modest women in Xuehua to maintain their dignity. In fact, it is a universal impulse to show our own idealized appearance to the world, and performances of individuals always tend to embrace and reflect those values that are officially recognized in society [24]. Therefore, although some individuals are not willing to obey the rules of the extended natal residence marriage in the back stage, they will restrain themselves and others in full accordance with the politeness and decorum required by the extended natal residence marriage in the front stage. The existence of this superficial and disguised agreement comes not only from the historical standard behavior in Xuehua but also from the compliments of the standard behavior that individuals have to express after suppressing their own inner thoughts. The latter reinforces the apparent conformity. When revealing information that contradicts with their idealized image in the front stage, such as they go out to play with their husbands before giving birth, they will have to be faced with the failure of their impression management, which means to confront strong social pressure.

Contrary to the power of refusing to return to the husband's home for the female body, the freedom to return to the husband's home is restricted, and the interaction with the husband is also restricted. Therefore, women do not have the autonomy to control their own bodies, fundamentally speaking. This kind of restraint is reflected not only in the number of contacts but also in all aspects of the female body, among which covering the face and refusing to sleep together with the husband are the most prominent parts. Men and women in Xuehua who are now around 70 years old usually experienced arranged marriages introduced by matchmakers. The procedure introduced by matchmakers is called blind dating. Women's faces are covered with headscarves, while men's faces are unobstructed. Therefore, women are usually able to see their blind date clearly, but men are not. The 73-year-old M12 once met his wife by chance in Chongwu Town after blind dating with her, but he did not recognize her. He told me: "The introduction by the matchmakers was arranged by the parents at the time, there was no affection between the young man and woman at all. Moreover, there was no way to fall in love freely then. I had never contact with my wife before getting married, and no chance to develop romantic love. We didn't see each other for one or two year, so we felt strange. If we have mutual affection, we'll miss and want to meet each other. If the situation is opposite, it doesn't matter if we meet or not". Obviously, the headscarf that covers the face of a female poses a considerable obstacle to the establishment of an intimate relationship between husband and wife.

F11: Hui'an woman used to wear broad-rimmed bamboo hat and headscarf during marriage, with her head down and her face basically invisible. I often listened to people here telling jokes, husbands and wives here did not know each other. Sometimes there were disputes when selling fish and vegetables in the market. In fact, the two parties in a quarrel turned out to husband and wife, but they didn't know.

M18: The headscarves they wrapped at the time made the faces look relatively smaller. They came late at night with the tightly wrapped headscarves, then started working as soon as they arrived, carrying water until 11:00 pm or 12:00 pm. They were chatting with their sworn sisters before arriving at the husband's home, so it was very late when they came. Some of the husbands slept already, and the wives left early the next day.

M19: After getting married for one, two, or three years, we would not be able to reconcile our relationship here. My wife all sleep standing up without going to bed, she just stood by the bed until dawn, and I told her to go to bed but she insists on not. She didn't allow me to touch her.

Qichang Zeng, a technician of Xiamen University Museum of Humanity, once said: "When the Hui'an Women return to the husband's home on Spring Festival's Eve, they entered the room at dark and left before dawn, because they spent the day with their sworn sisters. Women wore black elaborate headscarves that hung down to their faces. The husband couldn't see the wife's face, therefore a married couple hadn't known each other for a few years. Once a man had been married for eight years, and one day he was drying grains in Tuzhaipo, but when he met his wife, he didn't recognize her, and they knew each other after being told by others" [12]. The black headscarf mentioned by Qichang Zeng was forcibly banned by the government after China's Liberation and was replaced by the yellow hat and blue headscarf wrapping the women's faces, making them look strange and mysterious. We can use front stage to refer to the space of a particular performance. The standard expressive equipment in this space, as a part of the front stage, is called setting [24]. Yellow hat, blue headscarf, and the bowing head (see Figure 3) constitute the settings that women need when they perform in the front stage at the husband's home. This standard expressive equipment shows their posture of shyness, allowing them to complete specific performances in the front stage. However, the face as a primary medium of expression and communication has moral connotations [25], the concealment of faces makes the husband and wife lose important communication channels, and it also strongly expresses the moral posture of women resisting their husbands. While women stand by their husband's bed until dawn to refuse physical touch, they also use the present body to convey the struggle of unwilling to be present (regardless of whether it is true in the heart); the long-term state of inner depression caused damage to their body health. This standard expressive equipment with a sense of resistance is very likely to further deteriorate the relationship between husband and wife, while it deepens the intimate relationship between institutionalized same-sex and nonkin bonds.

3.3. The Female Body Constrained by the Institutionalized Same-Sex and Nonkin Bonds. Each culture has its own unique structural context, which allows individuals to deal with interpersonal relationships in different ways. The marine production and lifestyle of the Xuehua Village also promote the formation of special institutionalized same-sex and nonkin bonds. Women's refusal to sleep with their husbands is also closely related to the special local companionship between sworn sisters. Friedman defines this special companionship as same-sex, predominantly nonkin, and same-age cohort relationships formed by groups of women and men. They usually originate in childhood (although that is changing more recently) and tend to incorporate peers from one's own village—neighbors, classmates, workmates, and sometimes children of a parent's dui pnua. The institutionalized same-sex and nonkin bonds are normal in the local society, but they are not homosexual [22]. Male groups are brothers and female groups are sisters in Xuehua. However, the mutual restraint is extremely powerful in female groups.

F2: Sworn sisters went out to do farm work together during the day, and when we came back at night we would

Figure 3: The Hui'an women in traditional costumes (photographed by the authors in 2017).

talk together and finally all agreed that when the husbands' side called us back on the fifteenth day of the first month, we refused to return. One took the lead and said not to return, others would agree. We promised that no one would go back, and then no one would. If the husbands' side called we back, we would hide ourselves to prevent from being called back, no matter what method was used.

F32: In the past, sworn sisters always arranged the time to leave (to go to our natal home). If the husband was friendly, the wife could come out early and waited for sworn sisters. Some husbands were not friendly (would not let you go), then the sworn sisters waited for you for a long time and got angry.

The importance of face-saving is particularly emphasized in Chinese traditional culture. Benedict attributed Japanese culture to a shame culture, which is different from the Western guilt culture. Its coercive force comes from the external society rather than inner thoughts of everyone. Caring about other people's views of oneself is a prominent feature of the shame culture, and saving one's face to avoid feeling shame is also one of the main reasons why local women obey the extended natal residence marriage. The perception of the individual from sworn brothers and sworn sisters constitutes the main source of the individual's self-concept. Cooley calls this social self-concept, which is determined by the attitude towards the consciousness of the imaginary others, the self-concept in the mirror [26]. We look at our faces, figures, and clothes in the mirror, because our interest lies in these images that belong to us. Similarly, we learn from our imagination what others think about our appearance, demeanor, purpose, actions, character, friends, and so forth, and we are influenced by these thoughts. Facing with the extended natal residence marriage, once women show a gesture of being close to their husbands, they will be ridiculed or isolated by their sworn sisters. The perception that they are ashamed of being close to their husbands is gradually internalized into women's self-identification. But aberrant behavior will occur when the external pressure is weakened. For example, because F2 was serving as a soldier in the local Hui'an militia post, she kept a certain distance from her sworn sisters, weakening the influence from them. Besides, the society at that time was kind of negative for the requirements of the patterns of appropriate conduct of the extended natal residence marriage. F2 told me: "It was a bit relax at that time. Sometimes my husband came by himself, and we would left together, which was a little more avant-garde." But it could lead to suicide when the external social pressure is too heavy.

The close relationship of sworn sisters is often accused of destroying the intimate relationship between husband and wife. Preliminary Summary of the Implementation of the Marriage Law in Hui'an County from the Fujian Provincial Woman's Federation believes that couple relationships were generally not harmonious, and many couples actually had no relationship because of the arranged marriage and the bad habits of the extended natal residence marriage. Therefore, many women cherish sisterhood and considered it a shame to be closed with their husbands. Friedman's research on sworn sisters in Huidong found that women established an intimate relationship with each other through intimate practices such as eating together, sleeping together, and telling each other secrets. The close relationship between female groups even surpasses the emotional intimacy between husband and wife. On the one hand, it is attributed to the extended natal residence marriage, which gives sworn sisters the space to foster intimacy. On the other hand, the relationships of sworn sisters are more stable to rely on comparison to the unfamiliar husband who has been away all the year round, and this is the same situation in the male groups. In the days when Hui'an woman returned to the husband's home, the sworn sisters walked with each other on the road and promised to go to the natal home as soon as possible; some even promised to keep a distance with their husbands. The back scarves they wore on their heads before liberation were very complicated to take care of. Once they slept with their husbands, they were unable to avoid messy hair, which was easy to be found by sworn sisters when they went to the natal home together. Moreover, the promised time for going to the natal home was only enough for them to do the housework of the husband's family. Therefore the female body is the carrier of relevant information about what they do in the husband's home, revealing information about their psychological and physiological health. They must be cautious of the expression that the body gives off (contextual, nonverbal, presumably unintentional communication).

4. Conclusions

The concretization of human subjectivity is the body: the body is both the carrier and the medium of human [27]. In fact, the body is not only the carrier of physiological thing but also the medium of communication. The embodied practice of Hui'an women in Xuehua who are refusing to return to the husband's home, concealing their faces to show their embarrassment, and getting close to their sisters and alienating themselves from their husbands imprinted social values, social relationships, and so forth on individuals, forming the unique mystery and charming ocean culture in Xuehua, which is different from other Han communities. It also reflects the close relationship between human body health and social interaction.

First of all, the patterns of appropriate conduct, such as the husband's family calling and the woman fleeing to avoid returning to the husband's home, make the body of Hui'an woman be properly arranged in the daily interaction to maintain the face of both the natal family and the husband's family, construct the symbolic meaning of friendly interaction between the two parties, express etiquette, and show goodwill. The interaction of the body between the husband's family and the natal family constitutes a very important nod, and the meaning is contained in the patterns of appropriate conduct of refusing to return to the husband's home. The female body showing the rejection gesture expresses the symbolic meaning of shyness, dignity, and modesty of women recognized by the Xuehua Villagers.

Secondly, the extended residence of the female body in the natal family releases a well-known normal signal. Once someone tries to break this symbol of shyness, dignity, and modesty of women, they will be criticized by the other villagers who come to defend the meaning of the symbol, which represents the face and idealized image of the Hui'an woman. In order to maintain better face, women also need to strengthen their position of safeguarding their faces through embodied practices of covering up their faces and refusing to sleep with their husbands.

Finally, the closed sworn sisters often accompany women when they have to return to the husband's home and promise to go to the natal home as soon as possible, and some even agree to keep a distance from their husbands. The female body is the carrier of relevant information about what they do in the husband's home. They must be careful about the information that their body can reveal to avoid being caught by their sworn sisters. At the same time, they strongly prove their close companionship and reiterate their solemness and innocence through collective suicide.

The body is not only a physical body but also a communicative body which constructs meaning through communication, and the human body health exerts a considerable influence on self-identity and society. The most fundamental power contained in the communicative body of humans constitutes our concept and existing culture. In fact, anthropologists pay more attention to physical issues than sociologists, especially the role of the body in conveying culture and meaning in the ritual process. Through the daily performance of the body and the interaction of symbols, Xuehua Villagers have built a special partner relationship, unique marriage customs, and etiquette of "extended natal residence marriage," as well as the spiritual connotation of women's diligence and courtesy in the marine civilization. As virtual reality, mobile Internet, artificial intelligence, Internet of things, and other new media issues are attracting more and more attention to the communication significance of multiple presence and virtual presence of the body under technical conditions, reexamining the role and significance of human body in the social practice is the logical starting point for returning to the research of the human body in the field of communication. The research on the body in the field of communication needs to be further expanded.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Research Article

Impact of Environmental Fluctuations on Stock Markets: Empirical Evidence from South Asia

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The proportionate use of energy represents economic activity as well as environmental degradation. This study intends to examine the volatility spillover of environmental fluctuations (energy prices) to the stock markets of south Asian countries (i.e., Bangladesh, India, and Pakistan). In this regard, the data have been gathered from the Thomson Reuters DataStream from 2013 to 2021. This study has applied the Granger causality test and ARCH-GARCH (1, 1). It concludes that the bidirectional causality exists between the environmental prices (i.e., energy market) and Bangladesh, Pakistan, and India stock markets (BSE-100, DSE-30, and KSE-100, respectively). The empirical findings of this study show that there are volatility spillovers from the energy to the stock markets of Pakistan and India. On the other hand, no volatility spillover is observed from the energy to the stock market of Bangladesh. Moreover, the study implies that investors should invest in these stock markets to reduce the risk involved with diversification.

1. Introduction

The environment is remarkably considered an essential part of accomplishing a country's economic goals. In the present decade, oil has become the basic necessity to run the economic activities of the countries, especially to stable the economy of the country [1, 2]. The recent demand for oil is 9%, reaching up to 17% in 2040 [3]. Several energy sources are being used, but oil consumption has reached one-third of overall energy consumption [4,5]. Furthermore, Aizenman and Pinto [6] have declared a relationship between the economic crisis and the volatility. This relationship is because the basic phenomenon behind both these factors is identical.

Over the decades, oil has held a pivotal role in environmental fluctuations and economic growth. Especially for oil-importing countries like India, Pakistan, and Bangladesh because the economies of these countries are highly dependent on oil. The dramatic increase in oil prices during the current decade has severely damaged the stock markets of India, Pakistan, and Bangladesh. According to the C.I.A. World Fact Book [7], India was declared the third-largest oil importer, while Pakistan was the thirty-fourth. Moreover, India consumes 4.521 million barrels per day, while Pakistan consumes 557,000 barrels per day. This research investigates the volatility spillovers from the energy market to the stock markets of some selected member countries of South Asia, namely, India, Pakistan, and Bangladesh. The study's research question is to what extent do the volatility spillovers from the oil market to selected south Asia member countries? The reason behind choosing these three countries relies on the fact that these countries import oil in a large quantity in this region. India, Pakistan, and Bangladesh are among the list of developing countries, and they use more oil to maintain their level of growth.

A growing body of literature has discussed the volatility spillover from energy consumption to stock markets in developed and developing countries [8–14]. The primary study in this regard was stepped by Hamilton [15] by focused on the impact of oil prices on the economy of the U.S. and found that sharp fluctuation in oil prices has a significant impact on the economy. Moreover, Basher and Sadorsky [16] identified the role of oil prices on 21 emerging stock markets by applying a multifactor model and found the significant impact of oil prices on these emerging markets. Khalfaoui, Boutahar, and Boubaker [8] have studied the oil volatility spillovers and G7 stock markets by employing multivariate wavelet and GARCH models. The analysis results provide considerable evidence of volatility spillovers from the oil market to the stock markets of G7 countries.

After examining all these studies, a mixed conclusion can be drawn because some studies suggest that the volatility is transmitted from the oil market to the stock markets of different countries; on the other hand, some studies prove that there is no transmittal of volatility from the market of oil to the stock of different countries. The findings vary from country to country and analyzed periods [17–21]. This difference in findings may be due to the methodology, model, time, or data set. This study is an effort to fill the gap in the literature on the subject of volatility transmission from the environmental fluctuations to the stock markets of south Asian countries by using the ARCH–GARCH model to observe the transmittal of instability from oil to the stock markets of south Asian countries, namely, Pakistan, India, and Bangladesh.

Moreover, our study results exhibit significant energy fluctuation spillovers to the stock exchanges of India and Pakistan. Still, there are no volatility spillovers from the oil market to the stock market of Bangladesh. Moreover, the study suggests that there is a need that economists, investors, and policymakers should keep an eye on the international oil market to avoid the risk. Furthermore, the results of this study are fruitful for traders, portfolio makers, policymakers, and investors interested in these emerging markets.

2. Materials and Methods

The data of this study contains daily closing prices of oil West Texas Intermediate (WTI) and stock market indices of selected South Asian countries: Pakistan, India, and Bangladesh. The benchmark indices of Pakistan, India, and Bangladesh stock markets have been utilized in this study since only these three countries in the region have well-developed stock markets and indices data. The benchmark index of the Pakistan Stock Exchange is KSE-100 (Karachi Stock Exchange); for Bangladesh Stock Exchange, it is DSE-30 (Dhaka Stock Exchange); and for the Indian Stock Exchange, it is BSE-100 (Bombay Stock Exchange). Daily stock and oil prices from Jan 30, 2013, to Jun 14, 2021, have been taken to make a better empirical analysis. The daily data was gathered from the Thomson Reuters data stream for analysis. Moreover, the days on which holidays are observed in the stock and oil markets have been excluded from the data stream. The second filtration is that the data of stock and oil prices have been provided in the U.S. dollar.

In this study, the unit root test has been conducted, i.e., the augmented Dickey–Fuller Test (ADF) and the Philips–Perron test (PP), to test whether the time series data is stationary or not nonstationary. The null hypothesis (H0) for ADF Test and PP Test is that there is a unit root in the series or the data is not stationary, while the H_1 demonstrates that the time series data is stationary or there is no unit root in the data. This study applies granger causality and the ARCH-GARCH (1, 1) model to examine the spillover of volatility from oil to the stock markets, namely, the Karachi Stock Exchange, Bombay Stock Exchange, and Dhaka Stock Exchange. GARCH (1.1) represents one ARCH term and one GARCH term. There are two conditions to apply this model, i.e.,

(i) There should be clustering volatility
(ii) There should be an ARCH effect

Here clustering volatility demonstrates that the period of high volatility should be followed by the period of high volatility. The period of low volatility should be followed by a period of low volatility for a long period. The GARCH (1, 1) model determines transmission from the oil market to Pakistan, Bangladesh, and the Indian stock market. There are two equations in this model first one is the mean equation, and the second one is the variance equation. The mean equation for this model is as follows:

$$R_t = \mu + \rho R_{t-1} + \varepsilon_t, \tag{1}$$

where R_t represents the return series from the oil or stock market and ε_t represents the residual series that are normally distributed, having a mean of zero. Now moving toward the conditional variance equation of this model, it is given as follows:

$$H_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}. \tag{2}$$

Note that H_t is the representation of the conditional variance that depends on the level of mean volatility (ω), ε^2_{t-1} represents the effect of news from the previous period, whereas h_{t-1} represents the conditional variance from the previous period. The sum of α and β is measured by how long volatility prevails derived from a shock.

3. Results and Discussion

Table 1 demonstrates the findings of descriptive statistics for stock markets and oil market returns from Jan 30, 2013, to Jun 14, 2021. It represents that the average daily return earned by the oil market is 0.0003 having a standard deviation of 0.034, which is higher in comparison to the stock markets. This shows that the return of the oil market is more volatile compared to the stock markets and the reason behind this is that crude oil is well known and significant in the international market. The standard deviation of Karachi stock returns came out to 0.014, which suggests that the returns of Karachi stocks are less volatile in comparison to the oil market and more volatile in comparison to the returns of the Dhaka stock exchange. Talking about the Bombay stock exchange, the average daily return from 2013 to 2021 is observed to be 0.0007, which is low compared to the Karachi stock exchange and high in comparison to both Dhaka stock exchanges and the crude oil market.

Table 1: Descriptive statistics.

Variables	DSE	KSE	BSE	Oil
Mean	0.0003	0.00082	0.0007	0.0003
S.D	0.011	0.0148	0.013	0.034
Kurtosis	16.460	59.54	37.15	133.80
Skewness	0.190	2.680	1.593	5.128
Maximum	0.102	0.249	0.190	0.710
Minimum	−0.086	−0.097	−0.082	−0.323
Observations	1453	1453	1453	1453

Table 2 shows the results of the augmented Dickey–Fuller Test with the trend and without trend. The purpose of this test is to know about the stationary of the data. This test is applied to examine whether the data is stationary or not. The critical values for without trend at 1%, 5%, and 10% are −2.580, −1.950, and −1.620, respectively, while for with trend it is −3.960, −3.410, and −3.120. The alternative hypothesis will be accepted, and the null hypothesis will be rejected if the test statistic value comes out to be greater than the critical value. Normally we compare test statistics with the 5% critical value. Acceptance of H_1 represents the stationary of data. So from the results of the analysis, we can conclude that our data for stock markets and the oil market is stationary. We do not need to make a difference to make the data stationary. On the whole, results came out that the H_1 is accepted and the H_0 is rejected.

Table 2 represents the analysis done for the ADF and Phillips–Perron test with the trend and without trend to check the stationary of stock and crude oil market. The critical values for without trend at 1%, 5%, and 10% is −2.580, −1.950, and −1.620, respectively, while for with trend it is −3.960, −3.410, and −3.120. The alternative hypothesis will be accepted, and the null hypothesis will be rejected if the test statistic value is higher than the critical value.

As the test statistics value is higher than the critical value, it can be evaluated that the data is stationary. This demonstrates that the H_0 is rejected and the H_1 is accepted. The next step is to implement the GARCH (1, 1) model, and before running this model, it will be checked whether there is clustering volatility or not and whether the data has an arch effect or not. The GARCH model will only be implemented if there is clustering volatility and also if there is a representation of the ARCH effect in the data.

Figure 1 represents the clustering volatility of the residuals, and it can be evaluated from the graph that there is clustering volatility in the data as the period of low volatility is followed by low volatility, and the period of high volatility is followed by a period of high volatility for a prolonged period. This fulfills the one condition to implement the GARCH (1, 1) model. Now we need to check the second condition that whether there is the representation of an ARCH effect in the data or not, and this can be done through the LM test. If the value of probability came out greater than 5 in the LM test, then there will be no ARCG effect, and if the probability is less than 5, there will be an ARCH effect in the data.

Table 3 indicates the Granger causality test for energy and the stock market. The results demonstrate bidirectional causality between the WTI oil market and Bangladesh, Pakistan, and India. These results are similar to Ho and Huang [22] because they also found causality between oil and the Indian stock market. Moreover, bidirectional causality runs between the Bombay stock market and the Bangladeshi stock market. The noteworthy point is that there is no causality between the stock market of Bangladesh and Pakistan.

Table 2: Results of unit root test.

	With trends		Without trends	
Country	ADF	PP test	ADF	PP test
Bangladesh	−45.834	−44.974	−45.415	−44.377
Pakistan	−51.015	−48.941	−50.630	−48.386
India	−46.754	−45.846	−46.610	−45.583
Oil	−50.529	−51.448	−50.496	−51.365

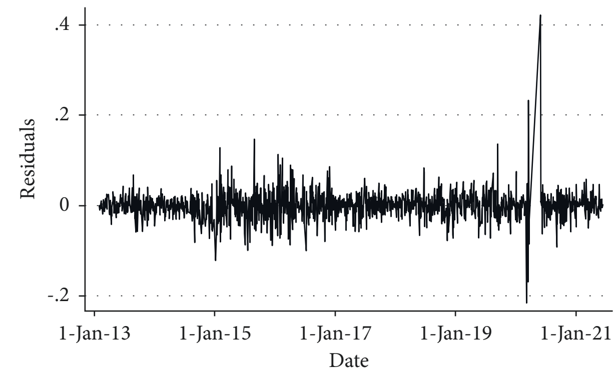

Figure 1: Clustering volatility of the residuals.

Table 4 represents the LM test to verify the condition of the Arch effect, and it represents that the condition of the ARCH effect is fulfilled as it can be seen that the probability is less than 5, so we can accept H1 and reject H0, which is the demonstration of an ARCH effect in the data. Now, on the whole, we can say that the GARCH (1, 1) model can be implemented as there is clustering volatility along with the ARCH effect in the data.

Table 5 represents the transmittal of volatility from the oil market to the stock markets of India, Pakistan, and Bangladesh using the GARCH (1, 1) model. However, the results from the GARCH model came out that there is transmittal of volatility from the oil market to the stock markets of India and Pakistan, and the results for the Bangladesh stock market are not significant means there is no spillover effect in that market. These results are evaluated from the $P > |z|$ value. If the $P > |z|$ value came out to be less than 5%, then there is volatility spillover, and the results are significant. On the other hand, if the $P > |z|$ value came out to be greater than 5%, the results are insignificant, and there is no spillover effect. As the results of this study came out to be smaller than 5%, that is , 0.00 for Pakistan and the Indian stock market, this means that volatility will be transmitted from the oil market to the stock markets of Pakistan and India. On the other hand, the results for the Bangladesh stock market do not come out to be significant as the $P > |z|$ value is greater than 5%, that is, 0.160 in the Bangladesh

Table 3: Summary statistics for granger causality test.

Null hypothesis	$\chi 2$	Lag	p value	Null Hypothesis	$\chi 2$	Lag	p value
B.D. ≠> IND	0.21^{**}	1	0.02	PAK ≠> BD	0.43	1	0.23
BD ≠> PAK	0.41	1	0.41	PAK ≠> IND	0.45^{**}	1	0.01
BD ≠> oil	0.24^{***}	1	0.001	PAK ≠> oil	1.65^{***}	1	0.001
IND ≠> BD	1.24^{**}	1	0.01	Oil ≠> BD	3.45^{**}	1	0.04
IND ≠> PAK	0.43	1	0.21	Oil ≠> IND	0.90^{***}	1	0.001
IND ≠> oil	1.45^{***}	1	0.001	Oil ≠> PAK	3.54^{***}	1	0.001

Notes: "≠>" means "does not Granger-cause." the Schwarz information criterion (SIC) is used. ***, **, and * to indicate a rejection of the null hypothesis.

Table 4: LM test for ARCH effect.

Lags(p)	chi2	Df	Prob > chi2
1	24.672	1	0.0000

Table 5: ARCH family regression.

Sample: 30 Jan 13 to 14 Jun 21 but with gaps				No. of observations = 1453		
Distribution: Gaussian				Prob > chi2 = 0.0000		
OIL WTI	Coef.	Std. Err.	Z	P>|z|	[95% conf. Interval]	
OILWTI			—			
DSE-30	0.062	0.044	1.41	0.160	0.0245	0.1491
KSE-100	0.359	0.042	8.41	0.000	0.2759	0.4438
BSE-100	0.654	0.051	12.72	0.000	0.5533	0.7549
-cons	−0.0004	0.0005	−0.68	0.495	−0.0015	0.0007
ARCH	0.8013	0.046	17.42	0.000	0.711	0.891
L1.						
GARCH						
L1.	0.1056	0.0324	3.26	0.001	0.0421	0.169
−cons	0.0002	0.00002	9.21	0.000	0.0002	0.0003

stock market. From these results, it can be originated that if any disturbance came in the oil market, then that disturbance will also affect the stock markets of Pakistan and India. At the same time, there will be no effect on the stock market of Bangladesh.

4. Conclusions

This paper aims to determine whether there are environmental fluctuations spillover from the energy to stock markets of south Asian countries (Pakistan, India, and Bangladesh). For this purpose, the ARCH-GARCH model and granger causality tests have been applied. The sample era of this study is from the year 2013 to 2021. This study employs the date of daily closing prices for stock prices and crude oil prices from the period starting from Jan 30, 2013, to Jun 4, 2021. The empirical findings of this study indicate that the Karachi stock exchange and Bombay stock exchange are influenced by the oil market, while the results for the Dhaka stock exchange are not the same.

The study concludes that bidirectional causality exists between the WTI oil market and Bangladesh, Pakistan, and India. Moreover, the findings represent that there is no influence of the oil market on the stock market of Dhaka. This means that the result of the study indicates a transmittal of volatility from the oil market to the stock markets of Pakistan and India. Still, there are no spillover effects from the oil market to the Bangladesh stock market. It can be concluded from these results that the reason for this transmittal from the oil market to the stock markets of Pakistan and India may be that these countries import a large amount of oil to fulfill the need of their people. Malik [23] has found that mostly the countries which import oil are affected due to any fluctuation that comes in the crude oil market. Similarly, the stock markets of these oil-importing countries are also affected by crude oil prices because any fluctuation directly influences earnings along with the cash flow streams in the prices of crude oil. This has been discussed above that when the prices of oil increase in the international oil market, the production and input costs increase, reducing the earnings of an organization and the share prices go down. The further reduction in the prices of shares leads to reducing the dividends and profits of an organization, which reduces domestic and foreign investment.

On the other hand, when oil prices decrease, input and production cost decreases, and earnings and investment increase. So, the transmittal of instability from the oil market to the stock markets of Pakistan and India can be observed in this study. At the same time, Bangladesh's results are not significant, meaning there are no spillover effects in the stock market in Bangladesh. The information provided in this paper will provide a ground for policymakers and investors to take more effective and profitable decisions.

This study suggests that there is a need that economists, investors, and policymakers to keep an eye on the information that comes from the international oil market. On the grounds of the results, this study recommends that to balance their budget India and Pakistan should make an effort to balance their import and exports as they cannot reduce their consumption of oil due to the lack of alternatives. As the level of oil consumption is increasing day by day in Pakistan, India, and Bangladesh, the Government of these countries needs to facilitate the transporters for the consumption of fuel. As debated above, a group of studies has investigated the transmission of volatility from the market of oil to the stock markets. Still, a very limited number of studies have observed the spillover effect from the oil market to the stock markets of Pakistan, India, and Bangladesh using the GARCH (1, 1) model.

This study has considered only three countries of South Asia, but in the future study can be done on all the countries of South Asia. Other regions like European Union can also be examined. Similarly, a comparison of volatility spillover can also be done between developed and developing countries. As among all other models, I have used the ARCH-GARCH model for my study in the future; any other methodology like ARMA (1, 1) or any other can be used to observe the transmittal of volatility from the oil market to Pakistan, Bangladesh, and Indian stock markets.

Data Availability

The datasets used and analyzed during the current study are available from the Thomson Rutters eikon DataStream.

Conflicts of Interest

The authors declare no conflicts of interest.

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