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Research Article

Research on Influential Factors of PM2.5 within the Beijing-Tianjin-Hebei Region in China

Jinchao Li,[1,2,3] **Lin Chen**,[1] **Yuwei Xiang**,[1] **and Ming Xu**[2]

[1]*School of Economics and Management, North China Electric Power University, No. 2 Beinong Road, Huilongguan, Changping District, Beijing 102206, China*
[2]*School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109-1041, USA*
[3]*Beijing Key Laboratory of New Energy and Low-Carbon Development, North China Electric Power University, No. 2 Beinong Road, Huilongguan, Changping District, Beijing 102206, China*

Correspondence should be addressed to Jinchao Li; gsyljch@163.com

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Air pollutant emissions are problematic hazards in China, especially in the Beijing-Tianjin-Hebei region. In this paper, we use fishbone method to set up the influential factor set of PM2.5 qualitatively. Then we use Spearman rank correlation test and panel data regression model to analyze the data of Beijing-Tianjin-Hebei region from 2012 to 2015 quantitatively. The results show that population density, energy consumption per unit area, concrete production per unit area, industrial proportion, transportation volume per unit area, new construction areas per unit area, road construction length per unit area, and coal consumption proportion are all positively correlated with PM2.5. The proportion of electricity consumption is negatively correlated with PM2.5. Among them, population density, industrial proportion, transportation volume, energy consumption per unit area, and the proportion of electricity consumption have a pivotal influence on PM2.5. At last, we give some suggestions to solve the hazard of PM2.5 in Beijing-Tianjin-Hebei region.

1. Introduction

Air pollutant emissions represent a large social and environmental problem in China that is due to rapid urbanization and motorization. In the State of the Environment Report of 2015 [1], China's Ministry of Environmental Protection revealed that only 21.6% among the 338 cities monitored by the central government managed to meet official minimum standards for air quality, and only 22.5% of 338 monitored cities met official minimum standards (less than 35 μg/m^3) for fine particle matter (PM2.5). There are 45 cities in which the annual mean concentration of PM2.5 has exceeded 70 μg/m^3. The air pollutant emissions problem is more serious in the Beijing-Tianjin-Hebei region. From November to December in 2015, three extreme conditions of air pollution occurred. During that period, primary and secondary schools and many of the highest polluting industries in the Beijing-Tianjin-Hebei region were temporarily closed, and the use of vehicles was also restricted. However, the mean concentration of PM2.5 in these areas still increased by 9.6% compared to values during 2014 the heating season. To make matters worse, in Beijing, the PM2.5 mean concentration increased by 75.9% in 2015 compared with the same period of 2014. Research has shown that once the concentration of PM2.5 increased by 10 micrograms per cubic meter, the number of emergency patients with hypertension in hospitals increased by 8% [2]. In order to solve the air pollution problems, the Chinese government planned to invest 1840 billion renminbi (RMB) from 2013 to 2017. The direct investment for reducing air pollutant emissions in the Beijing-Tianjin-Hebei region was set at 249.029 billion RMB. An important task for China is to determine the best use of their money in order to achieve the best effect. In 2013, in the State Council Air Pollution Prevention and Control Action Plan [3], the Clean Air Alliance of China pointed out that the industry pollutant emissions in the Beijing-Tianjin-Hebei region should be emphasized for government initiatives. However, this is not specific enough for the huge investment direction in these areas.

As a result of these aforementioned circumstances, teasing out and ranking pollution factors play a vital role in this area of research. This paper aims to solve this problem by exploring the relationships among air pollutant emissions, humans, manufacturing, machines, materials, and energy. We gathered data from the China Statistical Yearbook, Beijing Statistical Yearbook, Tianjin Statistical Yearbook, Hebei Statistical Yearbook, Report on the State of the Environment in China, and relevant government websites. The remainder of the paper is as follows: Section 2 overviews the research literature on analysis of the air pollutant; Section 3 introduces the air quality status of China and the Beijing-Tianjin-Hebei region; Section 4 analyzes and ranks the influence factors of pollution and effects of the air pollutant emissions; Section 5 makes a summary and directs our research for future work.

2. Literature Review

Air pollutant emissions describe the gases and particles that are emitted into the air by various sources. Many studies have shown that air pollutant emissions are related to many diseases [4] (e.g., respiratory system diseases), climate change [5] (e.g., climate warming), and traffic security [6] (e.g., rear-end collisions). Therefore, researching the sources of air pollutant emissions is very important. Considerable researches on air pollution have mentioned some air pollution factors, like human life, industry, energy, transportation, and so on. These published papers are shown in Table 1.

From Table 1, we find that most researchers think air pollutant emissions come from human activities: industry, energy, or traffic. The analysis methods of these papers are mainly from monitoring or calculation. Among the upper fourteen papers, nine articles researched on developed countries' air problem (five articles about Europe, four about USA), and five articles researched on developing countries' air problems (two about China, one about Brazil, one about India, and one about Cuba). Existing researches still need improvement. There is no research on the Beijing-Tianjin-Hebei region, which has exhibited the highest levels of PM2.5 in China.

3. The Air Pollutant Emissions Status of the Beijing-Tianjin-Hebei Region

Located in northeastern China, the Beijing-Tianjin-Hebei (BTH) region consists of the municipalities of Beijing and Tianjin as well as Hebei province. Some information about the BTH region is shown in Table 2 [21].

As shown in Table 2, the areal proportion of the BTH region is only 2.25%, but the GDP, vehicle, and total energy consumption proportions are all over 10%. The data indicates that the BTH region is a major economic region in northern China; besides, Beijing is China's political and cultural center.

Meanwhile, the BTH region also represents three key regions of air pollution control defined by the Twelfth Five-Year Plan on air pollution prevention and control in key regions, which was issued by the Ministry of Environmental Protection, National Development and Reform Commission, and Ministry of Finance in Dec. 2012 [22]. The residents in the BTH region suffer from severe air pollution. Among the cities in the BTH region, there are 11 cities in the top 20 of the worst air pollution in China and 7 cities in the top 10. The average days meeting air quality standards amount to only 37.5% of the whole year. There are 10 cities where more than 50% of days do not meet air standards.

It can be seen from Table 3 that the air quality in Beijing, Tianjin, and Hebei is relatively poor. However, compared with Beijing, the air quality in Tianjin and Hebei is even worse.

As shown in Figure 1, in 2015, annual average concentration range of PM2.5 is 11~125 μg/m^3 in China. From Figure 1, we know that the concentration range of PM2.5 in 13.3% of the 338 cities is over 70 μg/m^3, and the rate of reaching the PM2.5 standard is 22.5%. Differently from PM2.5, the annual average concentration range of PM10 is 24~357 μg/m^3, the cities whose concentration range is over 150 μg/m^3 account for 5.0%, and the rate of reaching the PM10 standard is 34.6%. The annual average concentration range of SO2 is 3~87 μg/m^3, the cities whose concentration range is over 60 μg/m^3 account for 3.3%, and the rate of reaching the SO2 standard is 96.7%. The annual average concentration range of NO2 is 8~63 μg/m^3, the cities whose concentration range is over 60 μg/m^3 account for 0.6%, and the rate of reaching the PM10 standard is 81.7%. The annual average concentration range of O3 is 62~203 μg/m^3, the cities whose concentration range is over 160 μg/m^3 account for 16.0%, and the rate of reaching the PM10 standard is 84.0%. The annual average concentration range of CO is 0.4~6.6 mg/m^3, the cities whose concentration range is over 4.0 mg/m^3 account for 3.3%, and the rate of reaching the PM10 standard is 96.7%. Compared with PM10, SO2, NO2, O3, and CO, this shows that PM2.5 is one of the most serious air pollutant problems in China now. Meanwhile, as shown in Figure 2, the air pollution problem is very serious in the BTH region.

In the above, PM2.5, PM10, NO2, O3, SO2, and CO are all pollutants that affect air quality and do damage to the human health. Among them, PM2.5 particles which are smaller compared with PM10 contain a lot of hazardous substances and stay a long time in the atmosphere; thus PM2.5 has a far greater impact on the health situation of human and environmental quality. In spite of a downward trend from 2013 to 2015 in China, PM2.5 in Beijing went from 89.5 μg/m^3 to 80 μg/m^3, which fell just 9.9 percent. Therefore, the pollution controls of PM2.5 in BTH region have achieved initial results but it is still difficult to achieve the goal of 60 μg/m^3 in 2017. This shows that there are still a lot of difficulties which need to be overcome in PM2.5. By contrast, the concentrations of SO2, NO2, CO, and PM10 have achieved the goal of 2017 in 2015 in Beijing. The O3 pollution is an emerging pollution problem which is not incorporated into the scope of air monitor before 2012 in China. In recent years, photochemical pollution whose main feature is a high concentration of O3 becomes more visible day by day. However, PM2.5 is still the primary air pollutant in BTH region compared with O3. In this paper, we focus on the causes and effects of PM2.5 within the BTH region.

Table 1: Information on influencing factors and analyzing methods in related papers.

Authors	Research subjects	Influencing factors	Correlation analysis method	Geographical area
Dewangan et al. (2016) [7]	PM2.5 and PM10	Cultural ritual	Empirical	Raipur, India
Gilbraith and Powers (2013) [8]	Air pollutant emissions	Residential demand response	Graphical analysis	New York, USA
Amodio et al. (2013) [9]	PM2.5 and PM10	Steel plant	Principal component analysis	Europe
Wang et al. (2006) [10]	SO_2 and total suspended particles (TSP)	Industry	Sensitivity analyses Graphical analysis	Beijing, Dalian, Jinan, Chongqing, Liuzhou, China
Jaramillo and Muller (2016) [11]	Air pollution emissions	Energy production	Pearson's correlation coefficients	USA
Herrera et al. (2013) [12]	Air pollution	Decentralized power generation	Scenario analysis	Santa Clara City, Cuba
Carreras-Sospedra et al. (2010) [13]	Air quality	Central power generation Distributed generation	Scenario analysis	California, USA
Ma et al. (2013) [14]	Air pollutant emissions	Wind power generation	Empirical	Xinjiang, China
Genon et al. (2009) [15]	CO_2, NO_x, SO_x, PM	Small district heating systems	Dispersion model	Italy
Lobscheid et al. (2012) [16]	Air pollutants emitted	On-road vehicles	Graphical analysis	USA
Targino et al. (2016) [17]	Black carbon and PM2.5	Traffic	Graphical analysis	Londrina city, Brazil
Muresan et al. (2015) [18]	Exhaust emissions	Earthwork machines	Graphical analysis	France
Gonzalez-de-Soto et al. (2016) [19]	Air pollution	Hybrid-powered robotic tractors	Graphical analysis	Spain
Megaritis et al. (2014) [20]	PM2.5	Temperature, wind speed, absolute humidity, precipitation and mixing height	Three-dimensional chemical transport model	Europe

Table 2: Some Information about the Beijing-Tianjin-Hebei region in 2014.

	Area (km^2)	Permanent population (thousand men)	GDP (billion RMB)	Vehicle ownership (10000 units)	Total energy consumption (10^4 tce)
Beijing	16410.00	21520.00	2133.10	559.10	6831.23
Tianjin	11946.00	15170.00	1572.70	280.00	8145.06
Hebei	188800.00	73840.00	2942.10	997.00	29320.21
BTH	217156.00	110530.00	6647.90	1836.10	44296.50
China	9634057.00	1368000.00	63591.00	14000.00	439945.90
Proportion	2.25%	8.08%	10.45%	13.12%	10.07%

GDP: gross domestic product; tce: ton coal equivalent.

4. Methodology

4.1. Analysis Process. In this paper, we use the fishbone method [24], the Spearman rank correlation test [25], and a panel data regression model to tease out and rank the influencing factors of PM2.5. The detailed analysis processes are shown in Figure 3.

We first select 15 specialists and gather all aspects of the influencing factors of PM2.5 performed in the form of a fishbone analysis (the result is shown in Figure 4). Based on the fishbone results, we form an initial influencing factors set (the result is shown in Table 4). Next, we collect corresponding data from the BTH region (the result is shown in Table 5) and analyze the relevance of influencing factors and PM2.5 based

Table 3: Environmental status of the BTH region in 2015.

Item	Beijing	Tianjin	Hebei	China average
PM_{10} annual average ($\mu g/m^3$)	101.5	116	136	87
$PM_{2.5}$ annual average ($\mu g/m^3$)	80.6	70	77	50
NO_2 annual average ($\mu g/m^3$)	50	42	46	30
SO_2 annual average ($\mu g/m^3$)	22	29	41	25
O_3 annual average ($\mu g/m^3$)	202.6	142	160	134
CO annual average (mg/m^3)	3.6	3.1	3.7	2.1

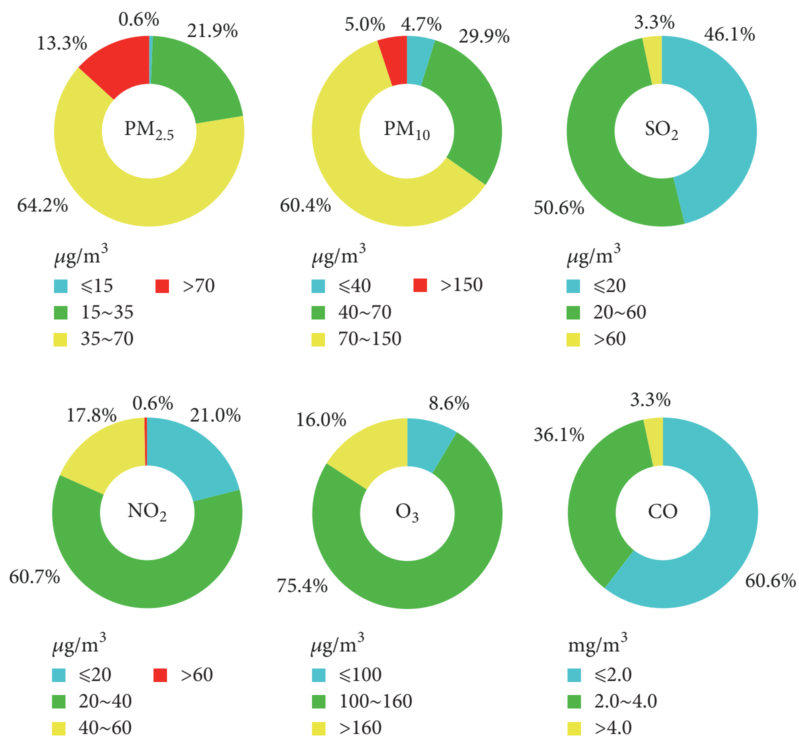

Figure 1: Air quality (or air pollution) variation among 338 monitoring cities in China (source: 2015 State of the China Environment Report [23]).

on the data using the Spearman correlation rank test method. Then, we screen the initial influencing factors set to form the influencing factors set (the result is shown in Table 6). Finally, we rank the influencing factors using a panel data regression model (the result is shown in Table 7).

4.2. Introduction of the Methods

4.2.1. Spearman Rank Correlation Test. Spearman's rank-order correlation is equivalent to Pearson's product-moment correlation coefficient performed on the ranks of the data rather than the raw data, and it is the nonparametric version of the Pearson product-moment correlation. Spearman's correlation coefficient can measure the strength of association between two ranked variables. Its calculation equation is shown in the following formula [26]:

$$r_s = \frac{\sum_{i=1}^{n} \{(x_i - \overline{x})(y_i - \overline{y})\}}{\sqrt{\sum_{i=1}^{n} (x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n} (y_i - \overline{y})^2}}. \quad (1)$$

Here, r_s is Spearman's correlation and $\overline{x}$, $\overline{y}$ are the average values of the two variables x_i and y_i. Spearman's correlation rank will yield a value $-1 \leq r_s \leq 1$. Higher absolute values of r_s correspond to stronger correlations between the two variables. A positive value suggests a positive correlation, while a negative value represents a negative correlation.

4.2.2. Panel Data Regression Model. In short, panel data refers to the combination of time series and cross section data. Its general form is shown below:

$$y_{it} = \sum_{k=1}^{K} \beta_{ki} x_{kit} + u_{it}. \quad (2)$$

In this equation, $i = 1, 2, 3, \ldots, N$, N is the unit in the panel data; $t = 1, 2, 3, \ldots, T$, T is the maximum length in the time series; y_{it} is the observed value of explained variable for unit i at time point t; x_{kit} is the observed value of the kth nonstochastic explanatory variable for unit i at time point t; β_{ki} is a parameter that is solved for; u_{it} is stochastic error term.

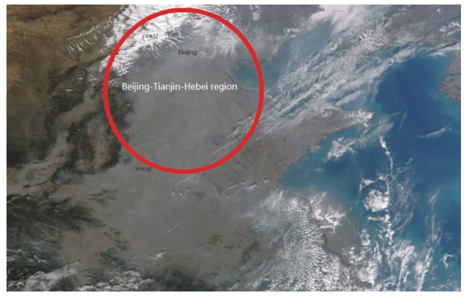

Figure 2: Smog maps of the BTH region in 2014 (sources: NASA).

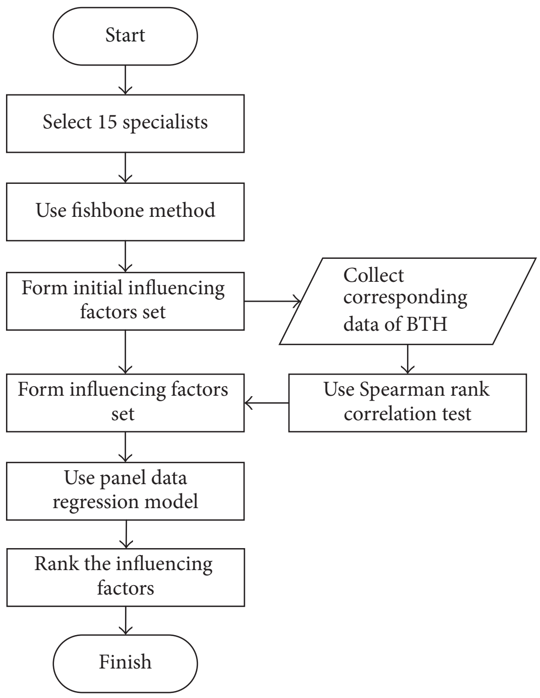

Figure 3: The process of the PM2.5 influential factors analysis.

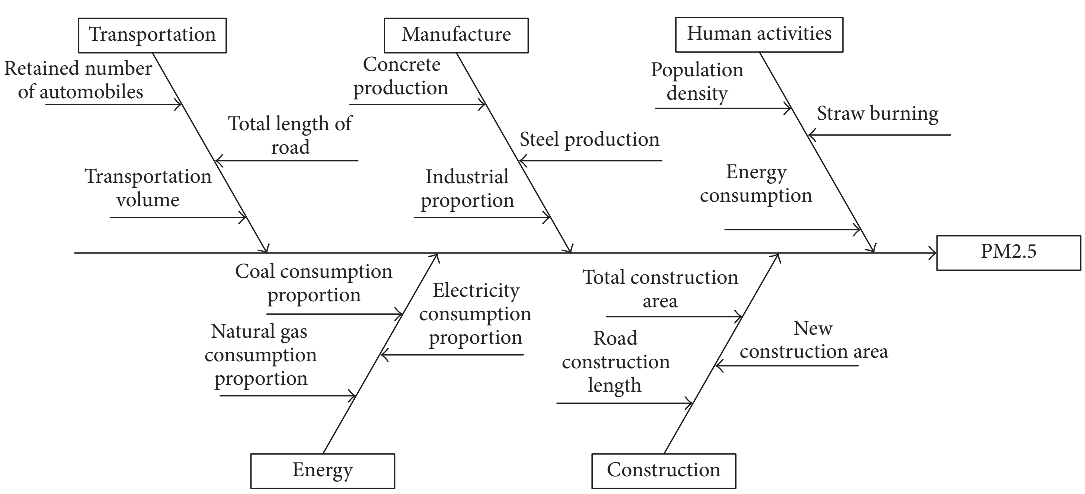

Figure 4: Influencing factors of PM2.5.

Table 4: The codes of the fifteen initial influential factors.

Name	Code
Population density	IF_1
Straw burning amount	IF_2
Energy consumption per unit area	IF_3
Concrete production per unit area	IF_4
Steel production per unit area	IF_5
Industrial proportion	IF_6
Retained number of automobiles per unit area	IF_7
Total length of road per unit area	IF_8
Transportation volume per unit area	IF_9
Total construction areas per unit area	IF_{10}
New construction areas per unit area	IF_{11}
Road construction length per unit area	IF_{12}
Coal consumption proportion	IF_{13}
Natural gas consumption proportion	IF_{14}
Electricity consumption proportion	IF_{15}

During panel data regression, a user should analyze the stationarity of the data first by carrying out a unit root test in order to avoid spurious regression and ensure the validity of the estimated results. If we found that the relationship between variables is the integration of the same order by the result of unit root test, we can carry out a cointegration test. The cointegration test is a method to investigate long-term equilibrium relationship between variables. The so-called cointegration refers to the fact that the sequence is stationary after the linear combination of two or more nonstationary variable sequences. Passing the cointegration test shows that there is long-term stable equilibrium relationship between variables, and the regression residual is also stable. After passing the test, we can select panel data model and conduct a regression analysis.

5. Influencing Factors Analysis of BTH

5.1. Influential Factors Analysis Result Using Fishbone. The influential factors of PM2.5 are shown in Figure 4. The factors come from human activities, manufacturing, transportation, construction, and energy.

Here, human activities mean the activities which have direct effects on PM2.5. This is signified by the excessive concentration, production without order, illegal incineration, and others of human activities.

Manufacture is the activity of obtaining material resources from nature and processing and reprocessing raw materials. Throughout the history of human development, manufacture occasioned a lot of environmental problems. In this article, we analyzed and calculated its impact on PM2.5 by the production of concrete and steel, the industrial proportion.

In transportation, the problems, such as vehicle emissions and flying dust caused by rolling pavements, lead to the high concentration of PM2.5. Thus, we selected car ownership, highway mileage, and freight volume as specific influencing factors.

Many construction activities can cause PM2.5 pollution with the raising of dust concentration, like forcible entry of construction, pipe laying, road work, and so on. Construction is characterized by construction area, the area of new construction, and road lengths.

Various types of energy have obvious differences on tailpipe emissions in the process of consumption. We use the proportion of coal consumption, electric power consumption, and natural gas consumption to reflect the effect on PM2.5 from coal, electricity, and natural gas.

5.2. Quantitative Analysis of the Influencing Factors. The code table of the fifteen initial factors is shown in Table 4.

The fifteen initial influential factors' descriptive statistics of thirteen cities from 2013 to 2015 are shown in Table 5 for Shijiazhuang, Tangshan, Handan, Qinhuangdao, Baoding, Zhangjiakou, Chengde, Langfang, Cangzhou, Hengshui, and Xingtai.

The data are obtained from statistical reviews and reports of Beijing, Tianjin, Shijiazhuang, Tangshan, Qinhuangdao, Handan, Xingtai, Baoding, Zhangjiakou, Chengde, Cangzhou, Langfang, and Hengshui from 2013 to 2016.

The Spearman correlation rank test method is used to analyze the influencing factors of PM2.5. The analysis results are shown in Table 6.

The results show that population density, energy consumption per unit area, concrete production per unit area, industrial proportion, transportation volume per unit area, new construction areas per unit area, road construction length per unit area, and coal consumption proportion are all positively correlated with PM2.5 because their Spearman's correlation coefficients are positive values. Conversely, electricity consumption proportion is negatively correlated with PM2.5 because its Spearman's correlation coefficient is negative.

5.3. Importance Analysis of the Influencing Factors. Panel data regression model is used to calculate the importance of the influential factors of PM2.5. A panel data regression model is generally needed to conduct a panel unit root test and panel cointegration, but as Table 7 shows ($T = 4$, $N = 13$) this table analyzes the data of 13 regions in four years. Because the time span is much less than the number of regions, it makes little sense to conduct the unit root test of panel cointegration, so this article makes panel data regression analysis directly. The analysis results are shown in Table 7.

5.4. Discussion of the Results. From the analysis of the influencing factors, we can see population density, industrial proportion, transportation volume, energy consumption per unit area, and the proportion of electricity consumption have a pivotal influence on PM2.5. From these results, we can provide some discussion of the results from the perspectives of population distribution, industrial structure, transportation system, and energy consumption.

(1) Optimization of Population Distribution. The results show that population density has a significant relationship with

Table 5: Descriptive statistics of the influencing factors.

Variable	Unit	N	Mean	StDev	Min	Max
PM2.5	$\mu g/m^3$	52	98.04	36.73	34.00	186.42
IF_1	Person/km^2	52	615.57	347.56	88.72	1348.14
IF_2	Ton/km^2	52	0.05	0.03	0.00	0.11
IF_3	kgce/person	52	2875.24	2199.52	345.85	7532.65
IF_4	Ton/km^2	52	749.88	737.21	91.89	2855.55
IF_5	Ton/km^2	52	1515.26	2112.26	18.21	8297.95
IF_6	%	52	38.50	8.90	16.12	55.34
IF_7	Unit/km^2	52	114.49	87.43	12.65	349.01
IF_8	km/km^2	52	1.14	0.37	0.49	1.84
IF_9	Ton/km^2	52	16020.78	11903.79	1243.95	44516.16
IF_{10}	m^2/km^2	52	3666.67	3206.75	224.90	13096.12
IF_{11}	m^2/km^2	52	1108.49	1425.79	71.61	7733.04
IF_{12}	km/km^2	52	0.05	0.04	0.01	0.19
IF_{13}	%	52	50.09	14.52	13.70	73.00
IF_{14}	%	52	4.15	6.47	0.02	25.80
IF_{15}	%	52	11.17	5.26	3.93	29.00

In this table, N is the number of the analysis examples. StDev is the standard deviation.

Table 6: Influencing factors quantitative analysis results.

	Correlation	Sig. (two-side)	N
IF_1	0.326^{*}	0.018	52
IF_2	0.143	0.311	52
IF_3	0.375^{**}	0.006	52
IF_4	0.490^{**}	0.000	52
IF_5	0.172	0.224	52
IF_6	0.471^{**}	0.000	52
IF_7	0.220	0.117	52
IF_8	0.164	0.247	52
IF_9	0.396^{**}	0.004	52
IF_{10}	0.227	0.106	52
IF_{11}	0.275^{*}	0.048	52
IF_{12}	0.653^{**}	0.000	52
IF_{13}	0.301^{*}	0.030	52
IF_{14}	−0.233	0.097	52
IF_{15}	-0.279^{*}	0.045	52

$*$ means the confidence level of regression coefficient is above 99%; $**$ means the confidence level of regression coefficient is above 95%.

PM2.5 in the BTH region. PM2.5 emissions are serious hazards in the high population density areas. This is mainly because the increase in population density has caused an increased demand for housing and motor vehicles; the increased demand for housing can lead to an increase of construction of buildings. These engineering constructions can produce environmental pollution; the increases of motor vehicle ownership result in a large number of motor vehicle exhaust emissions that produce large amounts of nitrogen oxide, carbon oxide, sulfur oxides, and volatile organic compounds. Meanwhile, the generation and incineration of household refuse as well as the burning of heating energy have also increased; they can release a large amount of volatile organic compounds, which aggravate PM2.5 emissions. Especially in the BTH region, the days containing haze tend to increase during the winter heating period. In 2014, the number of fog days in the winter accounts for about 27/45 of all haze days. In 2015, they account for 35/42 of all haze days. Human production activities have indirect effects on PM2.5 emissions, so the population density is closely related to the density of PM2.5.

Aiming at the problem of PM2.5 emissions caused by human activities, the government can craft effective human migration policies to mitigate the problem of large population density. This is because there are significant differences in the distribution and concentration variation of PM2.5 between China regions. The differences are caused by the unbalanced economic development. For instance, BTH region is the capital-circle of China and the political and cultural center, but the orient of urban functions of BTH region becomes unclear gradually with the common development of economy and politics. So in order to solve the problem, we can establish new urban zones near BTH region to weaken noncapital functions of Beijing and manage population migration.

(2) Optimization of Industrial Structure. At present, the heavy industry makes up a large proportion in BTH region, especially in Hebei province. The heavy industry, which focuses on raw materials, increased the demand of energy and greatly influenced the environment. In these industries, energy-intensive industries are obvious. As a main district of production of iron and steel, by the end of 2014, crude steel production accounted for 23 percent nationwide (185 million tons) in Hebei. Besides steel, the output values of many industries like electricity, heating power, oil processing, coking, and chemical raw materials make up about a half of the total output value of all industries in Hebei province. These industries commonly have high pollution as well as

Table 7: The importance analysis results.

Variable	Coefficient	Std. error	t-Statistic	Prob.
log(IF1?)	0.558207	0.148701	3.753885	0.0005
log(IF3?)	0.164398	0.100609	1.634033	0.1097
log(IF4?)	0.042059	0.051307	1.819736	0.4170
log(IF6?)	0.463459	0.219537	2.111081	0.0408
log(IF9?)	−0.357751	0.103945	3.441728	0.0013
log(IF11?)	−0.052365	0.059223	1.884206	0.3816
log(IF12?)	0.122102	0.047022	2.596724	0.0129
log(IF13?)	0.045020	0.120676	1.373067	0.7110
log(IF15?)	−0.158461	0.101994	−1.553635	0.1278
C	2.142050	0.955355	2.242151	0.0303
		Weighted statistics		
R-squared	0.867354	Mean dependent var		5.937831
Adjusted R-squared	0.838930	SD dependent var		3.341899
SE of regression	0.235279	Sum squared resid		2.324971
F-statistic	30.51465	Durbin-Watson stat		0.962111
Prob. (F-statistic)	0.000000			
		Unweighted statistics		
R-squared	0.672834	Mean dependent var		4.508054
Sum squared resid	2.865887	Durbin-Watson stat		0.767658

high energy and low efficiency. It is one reason why PM2.5 is serious in Hebei.

For this problem, if we close high energy-consuming and high-polluting enterprises by some restrictions, it can cause severe economic downturn and unemployment. Thus we can improve investment structure by developing green finance to change high-polluting industrial structure. In the past, much of investments flow into high-polluting industries, energy sources, and transportation project because of the bad profit ability of green industries. In order to improve the development of green finance, we can build green finance system to expand financial input for green industries and promote the transitions of investment structure and industrial structure. Detailed measures can be setting up the interest deduction system of green credit, developing guarantee mechanisms for green projects, establishing green industry funds with government involvement, issuing green bonds, and so on.

(3) Optimization of Transportation Systems. For a long time, traditional energy vehicles are still the main part of all vehicles, among traditional energy vehicles; statistics show that the nitrous oxides and PM2.5 from trucks are significantly higher than passenger cars and the largest polluters are heavy trucks [27]. The insufficiency of fuel combustion which caused the pollution of PM2.5 can be solved by improving the technology and adding units for the treatment of tail gas. Next, we can encourage and support the popularity of new energy vehicles. For more and more vehicles in the cities, it is useful to change the behaviour of companies and consumers by a combination of market methods and administration methods, such as levying emissions taxes according to the emission level or collecting congestion charges. Meanwhile, the separation phenomenon between dwelling districts and working areas and the parallel development of economy and politics are common in BTH region especially in Beijing, which caused the high trip rate of motor vehicles. Thus it needs us to plan city structure reasonably and use advanced public transportation systems, in order to reduce the utilization rate of motor vehicles by reasonable traffic diverging.

(4) Optimization of Energy Consumption. From the results, we see that coal consumption proportion affects PM2.5 emissions positively, but natural gas and electricity consumption proportion are negatively correlated with PM2.5. This shows that the reason of serious PM2.5 pollution on the energy side is that coal still occupies a large proportion of energy consumption in China, thus causing the high-carbon energy system which is dominated by coal. The high-carbon energy structure and rapidly rising total energy consumption have led to a rapid growth of greenhouse gas emissions. Although the energy industry scale in China is large, for a long time it has formed a dependence on high-carbon energy and has hindered the optimization of the energy industry; the energy consumption structure in our country must make adjustments. From the results of our analysis, we can change our problem of energy consumption by "electric power replacement." Implementing electric power replacement is an effective measure to control PM2.5. As a secondhand energy, electrical energy in a terminal utilization link does not create pollution, although thermal power generation still needs to burn coal in the production process to exhaust pollutants. By taking many technical measures to make large-scale handling, the emission intensity of pollutants and governance costs are well below traditional combustion modes.

6. Conclusions

In this paper, we analyze the influential factors of PM2.5 in the BTH region of China using the fishbone method, the Spearman rank correlation test, and a panel data regression model. The results show that population density, energy consumption per unit area, concrete production per unit area, industrial proportion, transportation volume per unit area, new construction areas per unit area, road construction length per unit area, and coal consumption proportion are all positively correlated with PM2.5 emissions. Conversely, electricity consumption proportion is negatively correlated with PM2.5. The results also showed that population density, industrial proportion, and transportation volume per unit area are the top three influential factors. Finally, we provided suggestions for optimization of population distribution, industrial structure, transportation system, and energy consumption.

Conflicts of Interest

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

Authors' Contributions

Jinchao Li contributed to the conception, design, and computation. Lin Chen and Yuwei Xiang collected and interpreted the data. Ming Xu performed manuscript review. Ming Xu and Jinchao Li contributed to the article revision. All of the authors drafted and revised the manuscript together and approved its final publication.

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