Retraction

Retracted: Analysis of the Resilience of Balance of Payments Using Comprehensive Evaluation

Journal of Mathematics

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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) Manipulated or compromised peer review

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.

References

[1] S. Fan and Y. Liu, "Analysis of the Resilience of Balance of Payments Using Comprehensive Evaluation," *Journal of Mathematics*, vol. 2022, Article ID 4620492, 13 pages, 2022.

Research Article

Analysis of the Resilience of Balance of Payments Using Comprehensive Evaluation

Shixin Fan and Ying Liu (ID)

School of Statistics, Dongbei University of Finance and Economics, Dalian 116025, Liaoning, China

Correspondence should be addressed to Ying Liu; yingliu2022@outlook.com

Globalization has brought increased attention to the balance of payments situation from a variety of countries. The traditional method of measuring balance of payments may not be applicable in certain situations. This paper draws on the idea of economic resilience, uses the transmission mechanism of balance of payments imbalance, and establishes a system of balance of payments imbalance resilience to provide a complement to the traditional measure. In this article, we establish a system of balance of payments resilience and ensure its reasonableness and effectiveness. The main conclusions are as follows: (1) balance of payments resilience score can be used as a reference and early warning indicator of a country's balance of payments situation and improves the measurement of balance of payments. (2) Improving the country's unemployment rate and boosting adjusted net savings will significantly upgrade the balance of payments situation. Improving foreign capital adequacy and foreign exchange market conditions is more beneficial for improving the country's rank of resilience score.

1. Introduction

Politics, economy, and culture of countries around the globe are becoming increasingly intertwined through globalization and international trade. In such a situation, various countries use the balance of payments (BOP) to measure their gains and losses in international trade. A stable BOP gives a country a competitive edge in international transactions and vice versa. It is common to use the current account balance for the purpose of measuring the BOP internationally [1], and the bounds of the imbalance were set at 5% of GDP [2]. This type of BOP measurement method, however, has some negative aspects. The BOP closely relates to the level of economic development in a country. Having a moderate and stable current account surplus is conducive to a country's economic development, whereas a deficit, especially a large deficit, is strongly unfavorable. We examine the latest data from some countries and find that it conflicts with the above.

2. Literature Review

The literature review of this paper is divided into three parts: (1) we briefly describe the BOP theory and traditional methods of measuring the imbalance. (2) We describe the idea of economic resilience. This article uses this to establish an index system. (3) The rationale for the selection of the BOP imbalance resilience indicators is introduced using the foundation for the selection of the indicators, which is the core portion of the literature review.

2.1. Balance of Payments Theory and Traditional Imbalance Measurement Methods. It should be noted that the BOP does not emphasize the accounts in which the deficit is incurred. According to the sixth edition of *Balance of Payments and International Investment Position Manual* (BPM6) [3], autonomous transactions are recorded in the

current account and capital account, whereas financial accounts have both records, and it is not easy to distinguish between them within the account. As a result, current and capital account deficits should be given greater attention when correcting BOP imbalances. Measures of imbalances have focussed on current accounts and relative deficits in recent years. The most popular method of calculating BOP balance is to utilize the current account balance [1]. The current account is more indicative of the supply and demand situation in the foreign currency market than the capital account [4], and recent Western research has concentrated on current account imbalances [5]. A BOP imbalance exists in industrial nations with a current account balance to GDP ratio of higher than 5%. [2]. As a boundary of imbalance, many international organizations and summits use 5%.

To sum up, the current BOP measure is based on the ratio of current account balance to GDP with 5% as the alert line for imbalance. We consider the use of a single indicator and a fixed alert line to be inappropriate and not helpful in explaining some economic phenomena. Thus, this article constructs an indicator system for the resilience of BOP imbalances, thereby supplementing the existing imbalance measurement methods.

2.2. Economic Resilience. Economic resilience is a relatively new field that involves disciplines such as development economics and regional economics. Holling [6] first proposed the concept of resilience to describe the ability of ecosystems to recover after trauma. Through decades of development, resilience has gradually included ecology, engineering, and economics. In this paper, we adopt the concept of economic resilience in macroeconomics, which describes a country's ability to recover after an external shock to its economy [7]. Briguglio et al. [8] succeeded in developing a system of indicators for estimating economic resilience by looking at four areas: macroeconomic stability, micro market efficiency, better economic governance, and social development. Those areas reflect not only the ability of an economy to resist external shocks, but also the severity of an economic recession resulting from external shocks. As a result, the indicators selected should satisfy two requirements in this paper: (1) This indicator can be used to judge a country's capacity to resist BOP imbalances and its economic strength. (2) Indices will change when a country's BOP imbalances are unbearably high, reflecting the loss and vulnerability of its economy.

2.3. Literature on Unbalanced Resilience System Construction Indicators. In this section, we discuss the criteria that are relevant to resilience indicators selection. Indicators should meet both requirements of Section 2.2 and have literature support. We have finally generated a path of BOP imbalances transmission, containing indicators of resilience.

2.3.1. The Impact of BOP Imbalances on the Domestic Economy. BOP changes may directly impact a country's foreign currency exchange market [9]. The foreign currency

reserves, the foreign investment, the exchange rate, and the BOP all interact, according to Lu [10]. The BOP will have an influence on international commerce and investment in addition to foreign money. Foreign direct investment is linked to foreign currency reserves, which in turn is linked to the BOP [11]. Sun [1] and Chen [12] determined that a country's BOP situation is linked to its international trade competitiveness and that the terms of trade index may be used to quantify that competitiveness. As a result, we may deduce that BOP variations have a first-order impact on the foreign exchange and international trade markets and that the BOP limited growth model serves as a link to the domestic economy.

The BOP constrained growth model argues that BOP affects the growth of the domestic economy, especially GDP, through foreign trade and foreign exchange markets. This model, first proposed by Thirlwall [13], considers the impact of BOP on economic growth (GDP). Thirlwall concluded that failure to achieve BOP equilibrium inhibited a country's economic growth, and Thirlwall and Hussain [14] optimized the model to require fewer constraints. Kvedaras et al. [15] analyze new empirical data to demonstrate the current applicability of the model, which means that it is reasonable to apply the model theory in this paper. Scholars have also applied the model to various countries, concluding that the terms of trade index, real interest rate, exchange rate, and other indicators can be affected by the BOP, and using the model to limit GDP growth.

In addition to affecting GDP growth, foreign exchange reserves and exchange rate movements also have an impact on inflation [16]. Li and Ren [17] found that BOP can affect the quality of economic growth by affecting domestic macroeconomic stability; that is, BOP affects macroeconomic stability indicators, such as inflation and employment. The BOP can also reach deep within the macroeconomy and have an impact on fiscal conditions, real interest rates, and economic growth rates [18].

Thus, we can conclude that the BOP affects the foreign exchange rate, foreign trade, domestic economic growth, macroeconomic stability, and other macroeconomic indicators. Some indicators, such as fiscal policy and exchange rate, also affect the BOP.

2.3.2. BOP and Quality of Economic Growth. As clarified above (according to Section 2.3.1), BOP can influence the quality of economic development by affecting the foreign exchange market and the foreign trade market. The quality of economic development itself can be a measure of the economic strength and the ability to resist imbalances, which is precisely what indicators need.

Liu et al. [19] concluded that BOP is conducive to improving the quality of a country's economic growth. Kong et al. [20] conducted research on the relationship between the foreign openness and the quality of economic growth in a changing exchange rate environment from 1994 to 2018 and established a system for measuring the quality of economic growth, the indicators of which could be used to select indicators to construct resilience of BOP. Long and Ji [21] studied the GPI of Chinese provinces and optimized the measure of GPI. The GPI is highly sensitive to the welfare of

people and can be used to complement quality of economic growth.

Thus, we can conclude that indicators such as industrialization level, technical efficiency, TFP growth rates, research expenditures, environmental depletion, and poverty measure will also be added to the system of BOP imbalances resilience indicators.

2.3.3. BOP Crisis Theory and Events.

The BOP crisis is a special case of imbalance. By studying the theoretical model of the BOP crisis and the economic variables affected by the crisis, we can choose resilience indicators from another perspective.

Krugman [22] proposed the first generation of BOP crisis model, arguing that when a country's money supply exceeds its money demand for a long period of time, foreign exchange reserves will continue to fall and currency speculators will attack at some point to disintegrate the fixed exchange rate system, causing the country's currency to devalue and the economy to collapse. Obstfeld [23] proposed a second-generation model of BOP crises, noting that when domestic macroeconomics is weak, currency speculation leads governments to abandon fixed exchange rate regimes on their own initiative, which triggers a chain reaction. Third-generation BOP crisis models are more inclined to examine the financial sector, which is called "capital item crisis theory."

Sen [24] optimizes the first generation of the BOP model to make the model's predicted timing of BOP crises more reasonable. Wang [25] examined the third-generation BOP crisis model and concluded that the crisis would result in a significant currency depreciation, which would have a negative impact on macroeconomic stability, and a sharp drop in real investment, which would have a negative impact on the real economy. According to Yin and Li [11], the crisis will result in a massive fiscal deficit. Wang [25] explores the causes of contagions associated with the three BOP crises that have occurred, such as inflation and fiscal conditions.

Studies of this type generally confirm the transmission path of the BOP imbalances derived from Sections 2.3.1 and 2.3.2 from a different angle. As a result, the transmission path obtained in this article will be more reliable.

The paper ultimately briefly describes this component as the transmission path of BOP imbalances, as described below. BOP imbalances will impact the foreign exchange market, resulting in changes in exchange rates, foreign exchange reserves, and foreign investment. As a result of the above-mentioned market changes, the imbalance will further affect domestic macroeconomic growth and stability, as well as inflation, unemployment, and GDP growth rate, which can affect quality of economic growth. Table 1 shows the final results of the election of the BOP imbalance resilience system indicators.

2.4. Summary of the Literature Review.

Globally, the ratio of current account deficits to GDP is commonly used rather than large deficits in BOP theory. Using a fixed value as a warning line for imbalances is internationally common, but it also has some disadvantages. Thus, this paper draws on the idea of economic resilience in the macroeconomic field and summarizes two requirements for the selection of imbalance resilience indicators, on the basis of which the transmission path of BOP imbalance is derived to provide reference for the establishment of the resilience system in the next section.

3. Methodology and Data Resources

3.1. Indicator System Construction Method.

This article's index system will calculate the BOP resilience score and weighting factors between the basic indicator and resilience score. Thus, the chosen method can express the resilience system in a formula, and the weight coefficients also have economic significance. The gray box-based model cannot give the weight coefficient, so this article does not use this type. Thus, this paper constructs the resilience system using the two-stage weighting evaluation method based on minimum variance. The method first calculates objective weights to the indicators and calculates a resilience score for each year, followed by a time weighting to obtain the total score.

3.2. Data Description.

This section introduces the countries, period of time, indicators, and sources of the data.

We began the analysis with Russian Federation's establishment in 1992 and ended it in 2019, making a 28-year-period total. Among them, 2010 is the base year for the relative indicators, so 27 years of data are included in the analysis.

The article aims to analyze as many countries as possible, but for the reliability of the results, the countries included in the analysis must meet the data requirements. The missing value boundary is set at 10%; if a country has more than 3 missing values for an indicator, the country is not selected for analysis, and if only a few countries meet the missing value boundary for an indicator, the indicator is discarded. Table 1 shows the BOP imbalance resilience indicators selected in this article. Table 2 and Figure 1 show the countries that participated in the analysis.

As shown in Figure 1, many African countries did not participate in the analysis, mainly due to data acquisition limitations.

4. Resilience System Results and Reasonableness Analysis and Improvement

4.1. BOP Resilience Results.

In this part, the initial weights are first obtained from the entropy value method, the panel data of the resilience scores for each year are obtained using the initial weights, the initial values of the secondary weights are obtained, and the secondary weights are further obtained. Next, the panel score data are weighted by the secondary weights to obtain the final total score of each country, and the initial indicator weights are weighted to obtain the reference weights of the indicators.

4.1.1. Resilience Scores for Each Country by Year.

In this paper, we calculated panel data of resilience scores for 37 countries between 1992 and 2019 by entropy method and also calculated the indicators weights for each year. Figures 2 and 3 show the results of the resilience scores and the indicator weights, respectively.

TABLE 1: Resilience system construction indicators.

Type	Abbreviation	Name	Positive/negative	Data source
	reer	Real effective exchange rate	Positive	IMF
	tti	Terms of trade index	Positive	IMF
Direct economic impact	fera	Foreign exchange reserve adequacy	Positive	IMF
	ftd	Foreign trade dependency	Positive	WB
	fdin/gdp	Foreign direct investment to GDP ratio	Positive	WB
Economic development level	dr	Deficit rate	Positive	IMF
	ti/gdp	Total investment to GDP	Positive	IMF
	irc	Inflation rate of change	Negative	IMF
Economic stability	ir	Inflation rate	Negative	IMF
	u	Unemployment	Negative	IMF
	gdpc	GDP growth rate	Positive	IMF
	ans	Adjusted net savings	Positive	WB
	iav/gdp	Industrial value added to GDP	Positive	WB
Quality of economic growth	nipc	National income per capita	Positive	WB
	tfpc	Total factor productivity of change	Positive	PWT
	wtfpc	Welfare-related total factor productivity of change	Positive	PWT

Direct economic impact refers to the direct impact of the bop on foreign exchange and foreign capital markets. IMF: International Monetary Fund. WB: World Bank. PWT: Penn World Table.

TABLE 2: Countries participating in the analysis.

Geographic continents	Country code	Country name	Geographic continents	Country code	Country name
	CHE	Switzerland		CHN	China
	CYP	Cyprus		JPN	Japan
	DEU	Germany		MYS	Malaysia
	DNK	Denmark	Asia	PHL	Philippines
	ESP	Spain		SGP	Singapore
	FIN	Finland		IND	India
	FRA	France		CHL	Chile
	GBR	United Kingdom		COL	Colombia
	GRC	Greece		CRI	Costa Rica
Europe	HUN	Hungary	America	DOM	Dominican Republic
	ITA	Italy		MEX	Mexico
	NLD	Netherlands		PRY	Paraguay
	NOR	Norway		CAN	Canada
	POL	Poland		USA	United States
	PRT	Portugal		MAR	Morocco
	ROU	Romania	Africa	TUN	Tunisia
	SVK	Slovak Republic		ZAF	South Africa
	SWE	Sweden		AUS	Australia
	RUS	Russian Federation	Oceania		

As shown in Figure 2, F refers to the resilience score; Figures 2(a), 2(c), and 2(e) show the resilience scores by scatter plots, where the size of the scatter points shows the level of resilience; and Figures 2(b), 2(d), and 2(e) are the kernel density distribution of resilience scores, which is another way of showing the score more visually. We can see visually that countries such as Switzerland (CHE), China (CHN), and Singapore (SGP) have significantly higher resilience scores than other countries, whereas countries like the United States and the United Kingdom are not performing so well.

Figure 3 shows the kernel density distribution of the weights of each indicator, from which it can be seen that most of the indicator weights are relatively concentrated, but the distribution of fdin/gdp is more dispersed, and its change over 27 years is large. *fdin/gdp*, *fera*, and *ftd*, which have

relatively large weights, will make the resilience score more differentiated.

4.1.2. Time Weights and Final Total Score. Calculate the initial and final weights at first. In this paper, we present multiple nondimensionalization methods for weight distance data, and the obtained clustering and separation years were all 2001 and 2018. Table 3 shows the time weights of the initial and final weights.

Then, using time weighting, reweigh the panel data of resilience scores for each year and calculate the final score. Figure 4 shows the final resilience score, where the F refers to the resilience score (the F in Figures 5–7 also refers to the resilience score). The resilience score of each country has now been calculated.
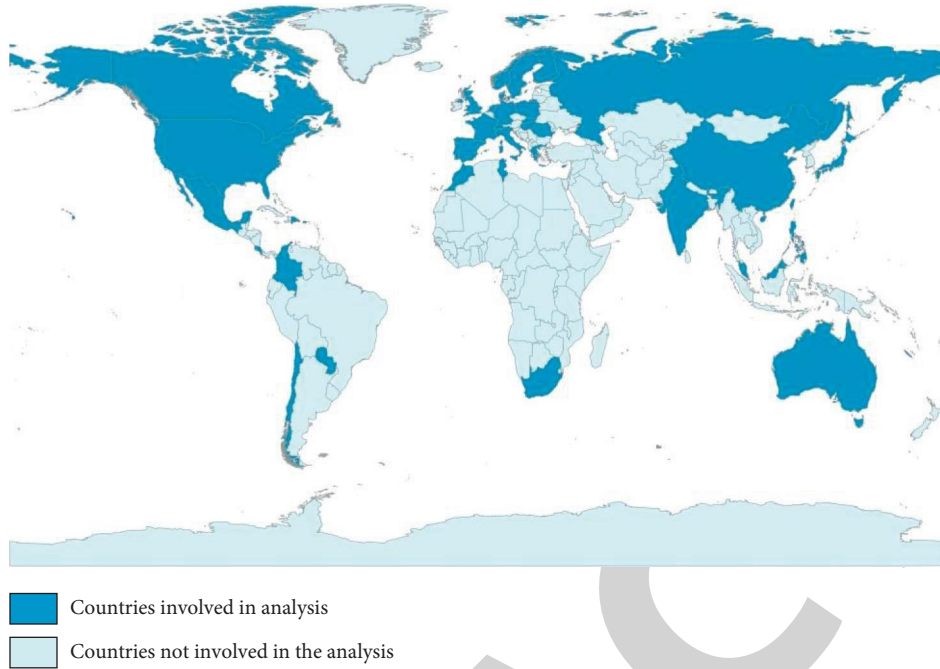
Countries involved in analysis

Countries not involved in the analysis

FIGURE 1: Geographical distribution of participating countries.

4.2. Reasonableness Analysis for Resilience. In this section, we consider the reasonableness of BOP resilience indicators system in three ways: (1) The indicators selected meet the theoretical requirements of the resilience system. (2) There should be a correlation between resilience score and BOP. (3) The resilience score at key points needs to be consistent with history.

4.2.1. The Reasonableness of Indicators Selection. The indicators underlying the construction of the resilience system are all involved in the transmission path of BOP imbalance and meet the two requirements for the selection of indicators (according to Section 2.3). Additionally, the indicator data are obtained from the international organization database after a strict evaluation of missing values and outliers is performed. Countries and indicators with inadequate data are excluded.

4.2.2. Resilience Score and BOP Correlation. The BOP imbalance resilience score should be correlated with the ratio of current account balance to GDP. This is because a country with low resilience will face greater difficulty recovering from a severe shock to its BOP. Similarly, the larger the deficit in a country's current account balance to GDP ratio is, the more the economy suffers, leading to a lower resilience score. In this article, we use the Granger causality test of panel data to see whether the above relationship exists.

The method was proposed by Clive Granger in 1969 and is based on the following idea: if x is a cause of y, but y is not a cause of x, then past values of x can help predict future values of y, but past values of y cannot help predict future values of x. Consider the time series model below:

$$y_t = \gamma + \sum_{m=1}^{p} \alpha_m y_{t-m} + \sum_{m=1}^{p} \beta_m x_{t-m} + \varepsilon_t. \tag{1}$$

In (1), p is the lag order, and the null hypothesis tested is

$$H_0: \beta_1 = \beta_2 = \ldots = \beta_p = 0. \tag{2}$$

The null hypothesis indicates that the past value of x does not predict the future value of y. If the H_0 is rejected, then x becomes the "Granger factor" of y. Changing x and y in (2), we can test whether y is a Granger factor of x. The following models can be applied to panel data:

$$y_{it} = \gamma + \sum_{m=1}^{p} \alpha_m y_{i,t-m} + \sum_{m=1}^{p} \beta_m x_{i,t-m} + u_i + \varepsilon_{it}. \tag{3}$$

In (3), u_i is the heterogeneity of individual i. For dynamic panel models, differenced GMM and system GMM are used for estimation. There are two assumptions when estimating the model. The first is that the cross-section coefficients are the same. The panel data is regarded as stacked data, and a Granger causality test is conducted similarly to that performed on time series data. The second is that coefficients of cross sections are different, and each section member is subjected to the Granger causality test. In this paper, causality tests of up to 6th order were conducted for both assumptions.

The Granger causality test requires that the panel data are stationary. Table 4 demonstrates the results of the panel unit root test.

The results of all four tests are significant, and it can be concluded that the panel data do not have unit roots. Table 5 shows the results of Granger causality tests under two assumptions.
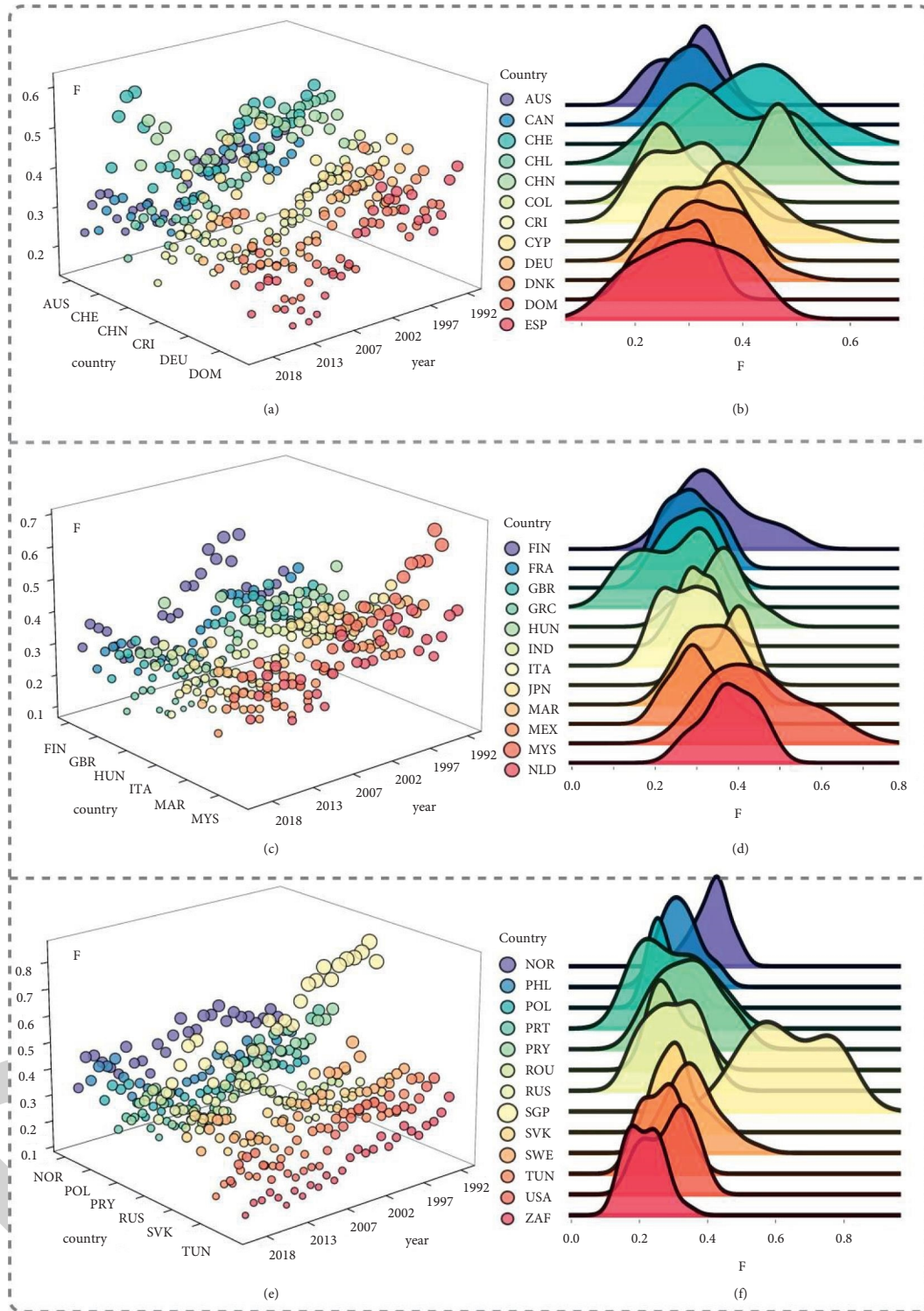
Figure 2: Resilience scores by country by year.

In Table 5, CA refers to the ratio of BOP current account balance to GDP ratio, and F is the resilience score. There is significant evidence that BOP current account balance to GDP ratio and resilience score are causally correlated in the fixed coefficient model. The resilience scores of orders 1, 2, and 4 in the variable coefficient model are the cause of BOP current account balance. Based on the results, it can be

shown that the two are causal and that the resilience score correlates with theoretical expectation.

4.2.3. Historical Consistency of Time Points. At the time of the event, BOP imbalance resilience score calculated in this article should fluctuate and trend accordingly. This section
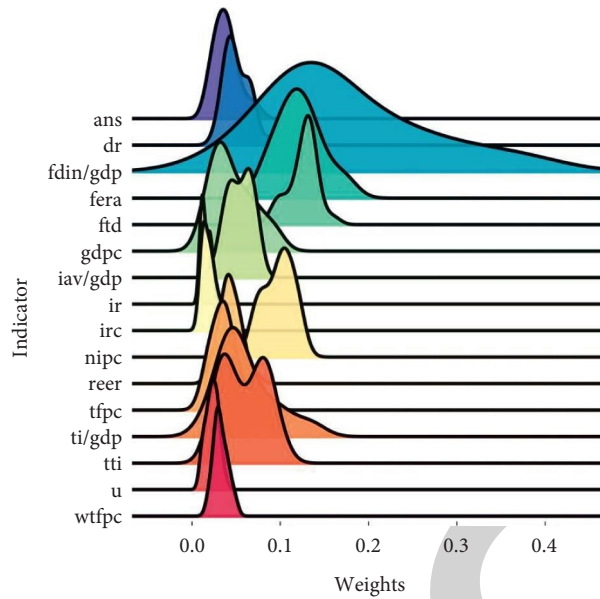
FIGURE 3: Distribution of indicator weights.

TABLE 3: Time weights.

year	Initial weights	Final weights	Year	Initial weights	Final weights
1992	0.035783	0	2006	0.032883	0.040212
1993	0.036586	0	2007	0.032281	0.043386
1994	0.038372	0.002116	2008	0.032362	0.046561
1995	0.039552	0.005291	2009	0.036253	0.049735
1996	0.041762	0.008466	2011	0.034754	0.05291
1997	0.041649	0.01164	2012	0.038164	0.056085
1998	0.042268	0.014815	2013	0.039484	0.059259
1999	0.046003	0.017989	2014	0.035973	0.062434
2000	0.050484	0.021164	2015	0.038808	0.065609
2001	0.059982	0.024339	2016	0.031467	0.068783
2002	0.050823	0.027513	2017	0.028217	0.071958
2003	0.04105	0.030688	2018	0	0.075132
2004	0.033153	0.033862	2019	0.027062	0.078307
2005	0.034825	0.037037			

analyzes BOP crisis events, financial crisis events (the financial crisis will damage the country's economy [26, 27], which will affect BOP resilience), and individual country cases.

First is the BOP crisis event. There was the European Monetary System Crisis in 1994–95, the Latin American Debt Crisis in 1995–97, and the 1997 Asian Financial Crisis (actually BOP crisis) during the period covered by this article. These crises relate to the countries involved in the study of this paper as shown in Table 6. Germany and Russia are among the countries affected by the Asian Financial Crisis, so they are also included in the analysis.

Figure 5 illustrates the resilience scores of the countries involved in the crisis events.

In Figure 5, the green shading in Figure 5(a) is the time period of the European Monetary System Crisis, the orange shading is the time period of the Asian Financial Crisis, and Figures 5(b) and 5(c) show their scores specifically, respectively. The countries involved in the European Monetary

System Crisis underwent a significant decline in resilience scores starting in 1992, bottoming out in 1994 or 1995 before slowly recovering. Mexico, which is in the midst of a Latin American Debt Crisis, had the same trend. In the Asian Financial Crisis, Russia and Malaysia also experienced a decline in their resilience scores in 1997. Thus, the reflection of the resilience score at BOP crisis is in line with realistic expectations.

The next step is to analyze the resilience score during the financial crisis.

The research period of this paper starts from 1992, so this section examines the international financial crisis in 2007–2011. At the end of our study time period, the high foreign exchange reserves of China and Switzerland may have financial crisis risk [28]. However, this phenomenon is not universal, so it will not be analyzed further.

The crisis (2007–2011) was not prompted by BOP imbalances, but the outburst of the crisis has resulted in huge
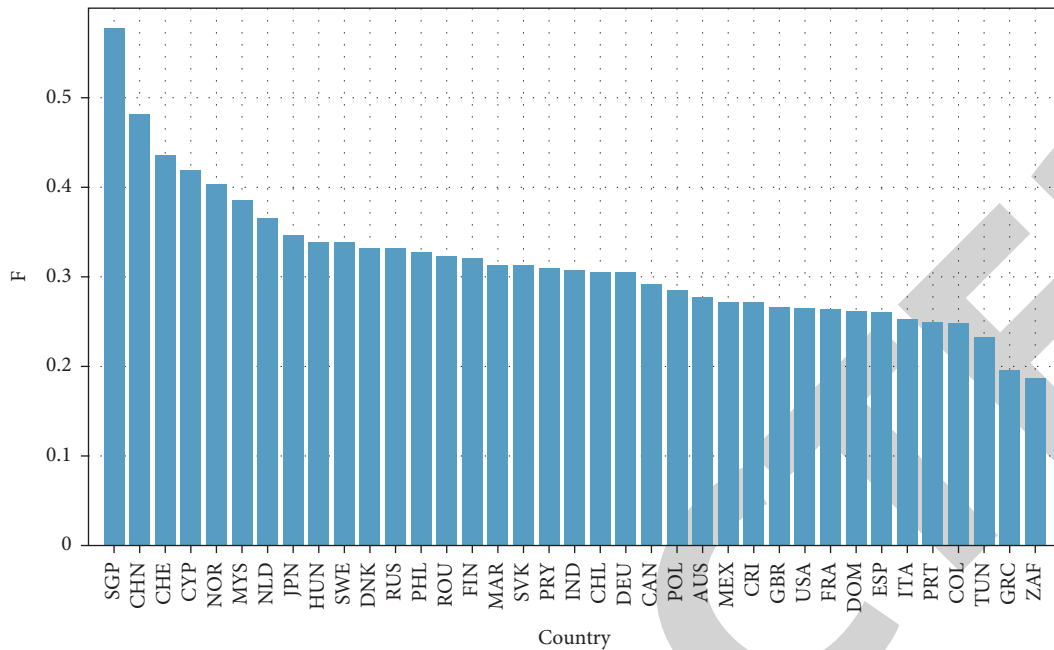
FIGURE 4: Final resilience scores for each country.

losses, and thus the resilience score should also trend in the same direction. Figure 6 illustrates the change in resilience scores during the financial crisis.

Based on the scores, we can see that most countries had their lowest scores in 2007 and 2009, respectively. Such a score result is consistent with the perception of reality.

Finally, we assess China's and America's BOP resilience separately. Figure 7 shows the resilience scores of the two countries.

In the aftermath of the international financial crisis, the resilience scores of both China and the US trended sharply downward and then upward, with the difference that China's resilience score eventually remained the same as it was before 2007, while the US rarely returned to its previous level. The above scores are consistent with the US focus on its BOP deficit in recent years.

4.3. Improvement of Resilience System. As a result of the limitation of the method for establishing a system, in this paper we propose to use a more appropriate method for determining the importance of resilience system construction indicators.

4.3.1. Limitations in the Construction of the Resilience System. Min–max normalization is particularly sensitive to outliers; if one indicator has a very minor outlier, all other nations' indicators will be near to 0.99. As a result, the indicator's range of fluctuation will be limited. As a consequence, the indicator's weight in the entropy approach will be quite minimal. However, the outlier, not the indication, is to blame for this outcome. The meaning of the indicator weights derived by the entropy technique, in addition to data sensitivity, is "distinctness," which does not entirely match "importance." With a greater weight, the difference between nations in this indicator widens, whereas a lower weight

narrows the gap between countries, implying that countries get similar (rather than lower) ratings in this indicator. As a result, the indicator's weight can merely mean that it is more distinct, not that it is more significant or useful in a BOP context. As a result, we choose to utilize the random forest approach to assess the relevance of the indicators and interpret them in conjunction with the weights in this study.

The following is a brief description of the random forest importance score. Random forest method is one of the ensemble methods of decision trees. A decision tree is essentially a collection of judgments, and the input samples are judged layer by layer to form one node of the tree, through which the input space is divided into different regions, and the child nodes continue to divide the regions to get many subregions. The same layer's input and output (leaf nodes) do not overlap, and the final leaf nodes correspond to the areas, so the input and output (leaf nodes) are the same. Ensemble trees are created by combining the outcomes of numerous smaller decision trees and then voting on each class's findings (classification issue) or calculating the mean (regression problem). Although each tree makes errors, making judgments as a group increases accuracy while avoiding the issue of out-of-sample prediction. Each decision tree is given a feature importance score, i.e., the importance of the input variable in making a decision in the tree, with a value between 0 and 1, where 0 means that the variable does not contribute to the decision and 1 indicates a perfect prediction of the target value. In this paper, feature importance is used as a complement to the indicator weights.
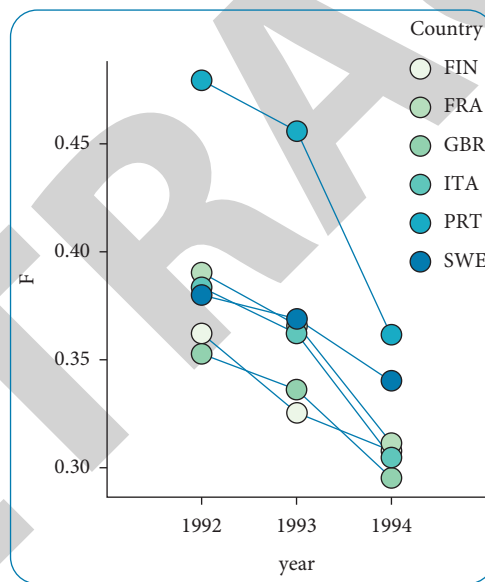
Figure 8 shows the results of the indicator importance scores. The time-adjusted importance is the result of weighting the importance scores using the weights above (Table 3).

It can be seen that the importance of the annual average does not change much from the time-adjusted importance,
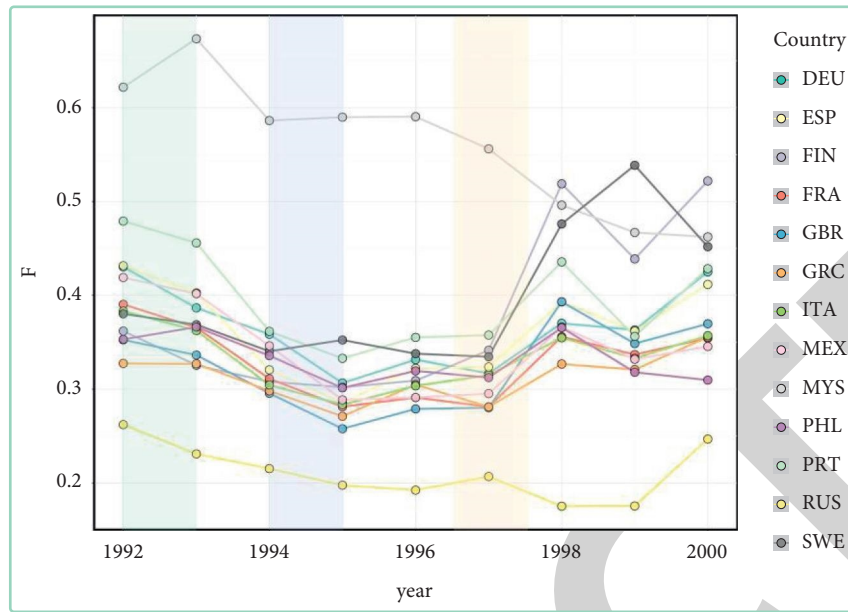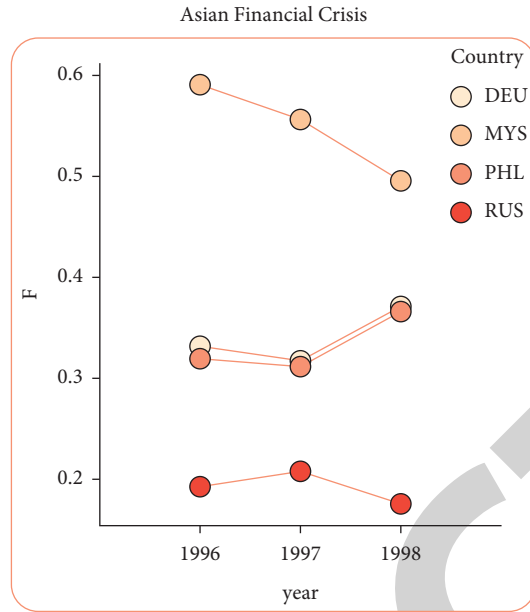
(a)

European Monetary System Crisis

(b)

Figure 5: Continued.
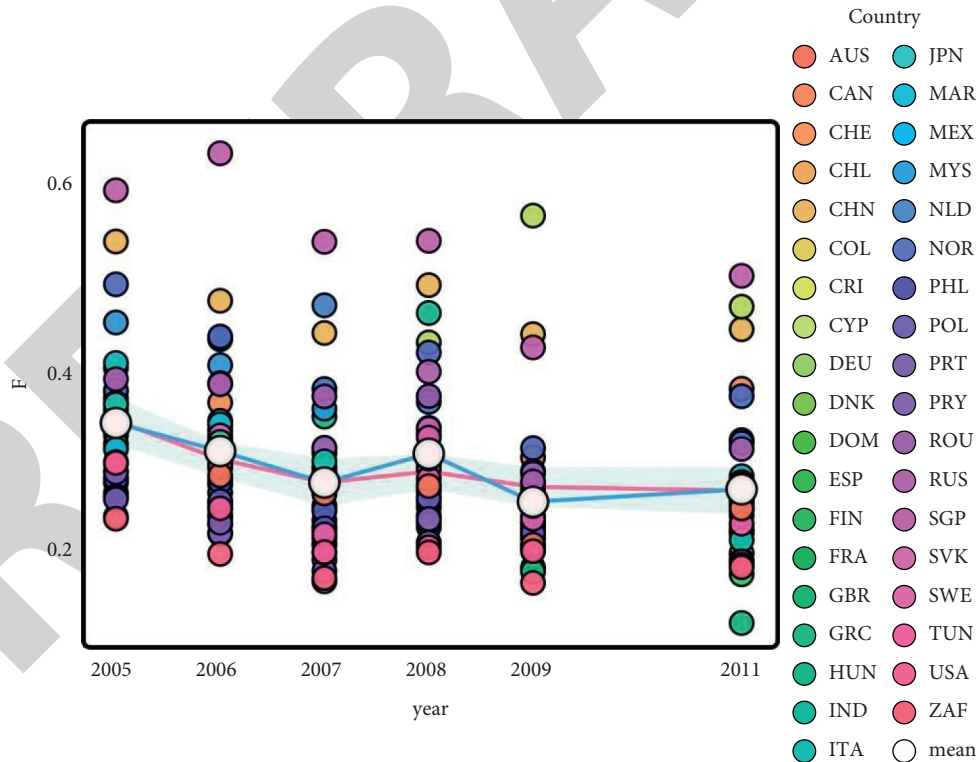
Figure 5: Resilience scores in BOP crisis.

Figure 6: Country resilience scores during the financial crisis.

which means that the importance of the indicators is more stable across years compared to the indicator weights, which has a complementary effect. We can conclude that the unemployment rate and adjusted net savings are more important, while net foreign direct investment to GDP ratio, foreign reserve adequacy, and foreign trade dependence are better at distinguishing between countries' resilience scores.
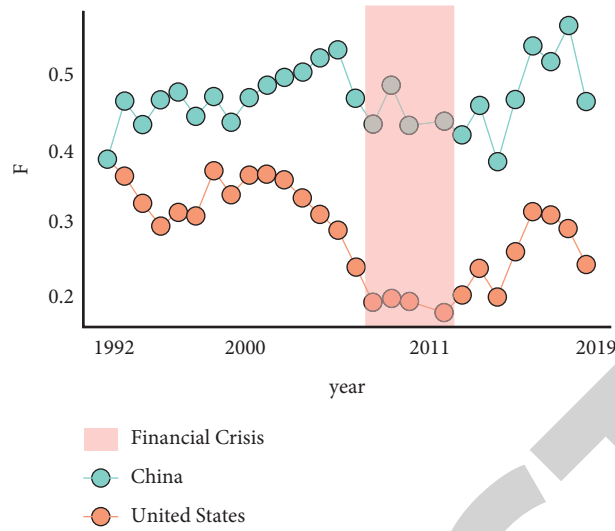
FIGURE 7: China and US resilience score.

TABLE 4: Panel unit root test results.

Method	Statistic	Prob.**	Cross sections	Obs
Null: unit root (assumes common unit root process)				
Levin, Lin & Chu t*	−3.26146	0.0006	37	956
Null: unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	−4.15204	0.0000	37	956
ADF—Fisher Chi-square	119.654	0.0006	37	956
PP—Fisher Chi-square	115.808	0.0014	37	962

Two asterisks mean that the results are significant at the 0.05 significance level.

TABLE 5: Results of Granger's causality test.

Lag order	Null hypothesis	W-stat.	Zbar-stat.	Prob.
	Fixed coefficient			
1	CA does not Granger cause F		25.5178	$5.00E-07$
	F does not Granger cause CA		18.3578	0.00002
2	CA does not Granger cause F		11.5310	0.00001
	F does not Granger cause CA		9.32977	0.0001
3	CA does not Granger cause F		7.09366	0.0001
	F does not Granger cause CA		6.35504	0.0003
4	CA does not Granger cause F		4.54826	0.0012
	F does not Granger cause CA		4.82955	0.0007
5	CA does not Granger cause F		4.10409	0.0011
	F does not Granger cause CA		4.03856	0.0013
6	CA does not Granger cause F		3.91646	0.0007
	F does not Granger cause CA		3.70241	0.0012
	Unfixed *coefficient*			
	Null hypothesis	W-stat.	Zbar-stat.	Prob.
1	CA does not homogeneously cause F	1.49194	1.44778	0.1477
	F does not homogeneously cause CA	2.21510	4.08701	0.00004
2	CA does not homogeneously cause F	2.78540	1.37882	0.168
	F does not homogeneously cause CA	3.28474	2.60133	0.0093
3	CA does not homogeneously cause F	3.99853	1.11452	0.2651
	F does not homogeneously cause CA	4.13998	1.37792	0.1682
4	CA does not homogeneously cause F	5.74697	1.57432	0.1154
	F does not homogeneously cause CA	5.89868	1.79541	0.0726
5	CA does not homogeneously cause F	7.10803	1.10941	0.2673
	F does not homogeneously cause CA	7.01405	1.00483	0.315
6	CA does not homogeneously cause F	9.01583	0.77239	0.4399
	F does not homogeneously cause CA	9.12442	0.85495	0.3926

TABLE 6: Countries involved in BOP crisis.

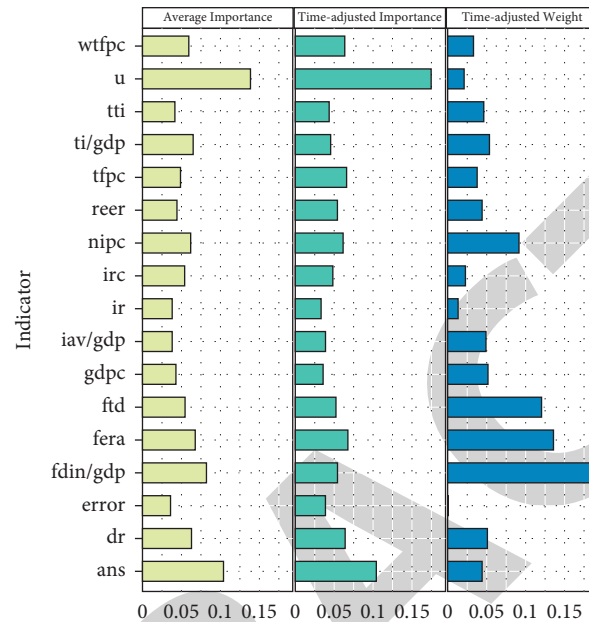|	Year	Country
European Monetary System Crisis	1992-1993	Germany, Spain, Finland, France, UK, Greece, Italy, Portugal, Sweden
Latin American Debt Crisis	1994-1995	Mexico
Asian Financial Crisis	1997	Germany, Malaysia, Philippines, Russian Federation

FIGURE 8: Importance of indicators.

5. Conclusion

5.1. Establishing a System for BOP Imbalance Resilience.
This paper draws on the idea of economic resilience and establishes a BOP imbalance resilience score system based on the transmission mechanism of BOP imbalance to measure a country's ability to tolerate BOP imbalance.

The indicator system has been proven to be reasonable in the selection of indicators and the relevance of the result data, and its changes are consistent with historical events and can provide a complement to the traditional measure of BOP imbalance.

5.2. Adjustment of the Balance of Payments.
The analysis in this paper concludes that a country that wants to change its disadvantaged BOP position should improve unemployment and increase adjusted net savings, and if it wants to change its resilience ranking among the countries researched, it should improve the net foreign direct investment to GDP ratio, foreign exchange reserve adequacy, and foreign trade dependence.

5.3. The Complementary Effect of Resilience.
BOP resilience can provide complementary analysis for countries with surpluses and deficits and can be used as a reference and early warning indicator for BOP position. When the surplus or deficit performance and the resilience score are both good, it is more reliable to conclude that the country is in a positive BOP position.

Introducing categorical variables for further analysis, Asia and Africa have slightly higher resilience scores than Europe and America, and high-development countries perform better than very high-development countries. Asia and Africa are more sensitive to whether they are reserve currency issuers, while in Europe and America, whether they are capital exporters has a greater impact on the score.

Data Availability

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

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

References

[1] G. Sun, "Current account surplus and capital account deficit—options for the evolution of China's balance of payments pattern under the overall balance objective," Studies of International Finance, no. 330, pp. 10–22, 2014.

[2] C. Freund, "Current account adjustment in industrial countries," *Journal of International Money and Finance*, vol. 24, no. 8, pp. 1278–1298, 2005.

[3] International Monetary Fund, *Balance of Payments and International Investment Position Manual*, International Monetary Fund, Washington, DC, USA, 6th edition, 2009.

[4] X. Hu, "Continuous improvement of the managed floating exchange rate system," *China Financialyst*, no. 15, pp. 8–11, 2010.

[5] X. Zhou, *Several Observations and Analyses on the Savings Rate Issue*, China Finance, Beijing, China, 2009.

[6] C. S. Holling, "Resilience and stability of ecological systems," *Annual Review of Ecology and Systematics*, vol. 4, no. 1, pp. 1–23, 1973.

[7] H. Su, "Advances in research on economic resilience," *Economic Perspectives*, vol. 654, no. 8, pp. 144–151, 2015.

[8] L. Briguglio, G. Cordina, N. Farrugia, and S. Vella, "Economic vulnerability and resilience: concepts and measurements," *Oxford Development Studies*, vol. 37, pp. 229–247, 2008.

[9] N. A. Müller-Plantenberg, "Balance of payments accounting and exchange rate dynamics," *International Review of Economics & Finance*, vol. 19, no. 1, pp. 46–63, 2010.

[10] F. Lu, "A study of China's double balance of payments surplus phenomenon: theoretical reflections on China's foreign exchange reserves surpassing trillion dollars," *The Journal of World Economy*, no. 11, 95 pages, 2006.

[11] Z. Yin and Y. Li, "Analysis of the real causes of the paradox of a balance-of-payments crisis model," *Contemporary Finance & Economics*, no. 3, pp. 63–66, 2005.

[12] W. Chen, J. Liang, and R. Fan, "Understanding China's economic growth model from balance of payments changes and international comparisons," *Studies of International Finance*, no. 383, pp. 13–23, 2019.

[13] A. P. Thirlwall, "The balance of payments constraint as an explanation of international growth rate differences," *BNL Quarterly Review*, vol. 32, pp. 45–53, 1979.

[14] A. P. Thirlwall and M. N. Hussain, "The balance of payments constraint, capital flows and growth rate differences between developing countries," *Oxford Economic Papers*, vol. 34, no. 3, pp. 498–510, 1982.

[15] V. Kvedaras, C. Garcimartín, and J. Astudillo, "Balance-of-payments constrained growth dynamics: an empirical investigation," *Economic Modelling*, vol. 89, pp. 232–244, 2020.

[16] Z. Gao, "The influence of China's foreign exchange reserves, exchange rate changes on inflation—analysis based on balance of payments perspective," *Studies of International Finance*, no. 283, pp. 4–10, 2010.

[17] J. Li and B. Ren, "Imbalance of international payments, economic fluctuations and quality of China's economic growth," *Contemporary Finance & Economics*, no. 338, pp. 23–31, 2013.

[18] W. Fang, "A comparative study of balance-of-payments crisis contagion," *The Journal of World Economy*, no. 6, pp. 13–21, 2000.

[19] Y. Liu, L. An, and T. Jin, "Quality of economic growth of China under the background imbalanced economic structure," *The Journal of Quantitative & Technical Economics*, no. 31, pp. 20–35, 2014.

[20] Q. Kong, D. Peng, Y. Ni, X. Jiang, and Z. Wang, "Trade openness and economic growth quality of China: empirical analysis using ARDL model," *Finance Research Letters*, vol. 38, 2020.

[21] X. Long and X. Ji, "Economic growth quality, environmental sustainability, and social welfare in China—provincial assessment based on genuine progress indicator (GPI)," *Ecological Economics*, vol. 159, pp. 157–176, 2019.

[22] P. Krugman, "A model of balance-of-payments crises," *Journal of Money, Credit, and Banking*, vol. 11, no. 3, pp. 311–325, 1979.

[23] M. Obstfeld, "Rational and self-fulfilling balance-of-payments crises," 1486, National Bureau of Economic Research, Cambridge, MA, USA, National Bureau of Economic Research, 1984 .

[24] P. Sen, "The impossible trinity and Krugman's balance of payments crisis model," *International Economics*, vol. 139, pp. 174–181, 2014.

[25] Y. Wang, "Capital account balance of payments crisis and southeast Asian financial crisis," *Studies of International Finance*, pp. 10–15, 2001.

[26] J. Dovern and C. Zuber, "How economic crises damage potential output—evidence from the great recession," *Journal of Macroeconomics*, vol. 65, Article ID 103239, 2020.

[27] D. Furceri and A. Mourougane, "The effect of financial crises on potential output: new empirical evidence from OECD countries," *Journal of Macroeconomics*, vol. 34, no. 3, pp. 822–832, 2012.

[28] M. Kumhof and I. Yan, "Balance-of-payments anti-crises," *Journal of Macroeconomics*, vol. 48, pp. 186–202, 2016.