

Spatio-temporal Evolution of China's Economic Power Based on Asymmetric Theory

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Abstract: In the 21st century, economic interdependence between countries has gradually become an important source of state power. Globalization and the rise of China's economy have had a significant impact on other economies around the world. China's economic influence is becoming more and more important. On the basis of the sensitivity dependence and vulnerability dependence of asymmetric interdependence theory, the economic spillover between countries is selected to construct a quantitative model to measure economic power. This paper analyzes the evolution of China's economic power both in time and space from 2000 to 2014. Four conclusions were drawn from the study: 1) The spatial spillover effect of China's economy on other countries has been continuously growing since the beginning of the 21st century, which has brought about the rapid increase in China's economic power; 2) China's economic power has been significantly strengthened both in intensity and scope, having expanded from the surrounding countries to the whole world. In 2014, China had a high amount of economic power over 18 countries from the 41 main countries in the world, compared to 2 in 2000; 3) China's power in terms of sensitivity dependence takes on an evolutionary trend from point distribution to flaky growth, and it shows a process 'from point to line' from the aspect of spatial diffusion. Furthermore, China's power in terms of vulnerability dependence shows a trend that extends from the surrounding countries to European and South American countries; 4) comprehensively, China's power in terms of vulnerability dependence is higher than that of sensitivity dependence, and the spatial distribution pattern demonstrates a process from centralization to decentralization from 2000 to 2014.

Keywords: spatial spillover; economic power; spatiotemporal evolution; China

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1 Introduction

Since China's introduction into the WTO (World Trade Organization), China's economy has maintained a trend of rapid growth and has forged closer economic ties with the rest of the world. Consequently, it has become

an important contributor and influencer in terms of global economic growth (Feldkircher and Korhonen, 2014). Since 2006, China's contribution to world economic growth has ranked first. It became the world's second largest economy in 2010, and the largest trading country in 2013. With the great development of China's

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economy, China's influence on the global economy has been increasing (Ducruet and Wang, 2018; Che and Zhu, 2019), and the scope of China's economic power continues to expand. At present, China is the largest trading partner of more than 120 countries and economies, and thus has constructed an economic power network all over the world (Chen et al., 2019).

In the field of politics, power refers to the ability to exert influence and control over other people's thoughts and actions (Morgenthau and Thompson, 1997). Power between States is formed according to mutual connections and influence, which reflects the asymmetry of interaction among state actors in terms of politics, military power, and economics. After the end of the cold war, international relations tended to ease. Peace and development became the main characteristics of the international community, and competition among countries also shifted from military power to economic strength (Cooper, 1968). Therefore, economic impact has replaced force as the main means of national foreign policy (Luttwak, 1990). In order to maintain and strengthen dominance in bilateral relations, major powers gradually introduce economic mechanisms into inter-state relations, thus enhancing their attractiveness to other countries through foreign trade and investment (Rio and Lores, 2017), and thereby influencing and controlling other countries' decision-making (Hu et al., 2019). Therefore, in contemporary international relations, economic power is manifested in the ability of a country to use its own economic strength to force other countries to change their will in the process of bilateral economic exchange activities (Kappel, 2010). Economic power comes from the economic influence of a country relative to other countries, and it mainly depends on the asymmetric importance of the economic relationship between the two countries relative to their own domestic economy (Yang and Liu, 2015).

Economic power comes from the economic interdependence among actors. In reality, the most common and influential relationship among actors is asymmetric interdependence (Gilpin, 1987). Because of asymmetric economic interdependence, one party with a low degree of dependence has the economic power to influence and control the behavior of another party in bilateral relations (Keohane and Nye, 1977), thus asymmetric economic interdependence has increasingly become an important means for countries to exert strategic influence

over others (O'Loughlin and Anselin, 1996). In empirical research, Barbieri (1995) and Oneal and Russett (1997) first used bilateral trade data to study asymmetric interdependence between countries, using both the proportion of bilateral trade in a country's total foreign trade and GDP separately as indicators to measure the sensitivity and vulnerability of one country. Thereafter, scholars performed further analyses on asymmetric interdependence from the perspectives of foreign investment, finance, and exchange rate (O'Loughlin and Anselin, 1996; Lim, 2010; Fei, 2017). In recent years, there have been two main researches on China's economic power (Lu and Du, 2013; Du et al., 2016b). The first uses trade data to study the bilateral asymmetric relations between China and other countries or regions, including the United States (Yang et al., 2017), the EU (Grosse, 2014), Japan (Wang, 2009), Southeast Asian Countries (Zong and Zeng, 2017), and others (Yu and Wu, 2019; Liang et al., 2019). The second constructs a comprehensive index of economic power evaluation based on the theory of compound interdependence, which studies the evolutionary trend and spatial pattern of China's economic power (Du et al., 2016a; Yang et al., 2017).

After reviewing the existing literature, we found that although many studies have expanded the field in terms of the object and methods of study since Barbieri (1995) and Oneal and Russett (1997) proposed the method of analyzing the economic interdependence from the perspective of trade, they have not abandoned the basic analysis based on data of bilateral trade. However, the international trade structure has undergone tremendous changes in the past 20 years, and new models of international specialization, such as fragmentation production and production segmentation, have integrated countries into the global value chain (Koopman et al., 2010). The proportion that intermediate trade accounts for total trade has been rising. Take China as an example, according to the world input-output tables (<http://www.wiod.org/home>), intermediate goods accounted for 49.98% of China's total exports and 74.59% of total imports in 2014. With the deepening of the global value chain, the volume of trade based on customs statistics can only reflect the current situation of commodity flows in the two countries; however, it fails to reflect the value source and final flow of trading goods (De Backer and Miroudot, 2013). Therefore, the bilateral trade

volume between two countries can not reflect the true degree of interconnection between two countries in the global value chain, therefore, the asymmetric interdependence calculated by the trade data can not reflect the accurate economic power.

In view of this, we use the inter-regional input-output model to measure the spatial spillover effect between China and other countries. An economic power evaluation model is constructed based on inter-regional spillover effect, and then be used to explore how China's economic power on 41 major countries had been changed during 2000 and 2014.

2 Methodology and Data

2.1 Spatial spillover effect

Miller (1966) first applied input-output analysis technology to the study of inter-regional economic impact. He proposed a method to measure the economic feedback effect in a two-region input-output model, but did not explicitly put forward the concept and measurement of the spillover effect. Later, scholars dissected the spillover effect and feedback effect between regions, and studied the internal relationship between them and the intraregional multiplier effect (Sonis and Hewings, 1999; Miller and Blair, 2009), going on to apply them to empirical analysis.

According to the row balance in input-output tables, the total output is equal to the sum of the intermediate products and final products. In a three-region input-output model,

$$\begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} = \begin{bmatrix} Z^{11} & Z^{12} & Z^{13} \\ Z^{21} & Z^{22} & Z^{23} \\ Z^{31} & Z^{32} & Z^{33} \end{bmatrix} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} + \begin{bmatrix} A^{11} & A^{12} & A^{13} \\ A^{21} & A^{22} & A^{23} \\ A^{31} & A^{32} & A^{33} \end{bmatrix} \begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} + \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} \tag{1}$$

where X and Y stand for the total output column vector and the final product column vector, separately. Z stands for intermediate products, and A is the corresponding direct consumption coefficient matrix. Note that Eq. (1) can be rewritten as

$$\begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} = \left(\begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \end{bmatrix} - \begin{bmatrix} A^{11} & A^{12} & A^{13} \\ A^{21} & A^{22} & A^{23} \\ A^{31} & A^{32} & A^{33} \end{bmatrix} \right)^{-1} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} = \begin{bmatrix} B^{11} & B^{12} & B^{13} \\ B^{21} & B^{22} & B^{23} \\ B^{31} & B^{32} & B^{33} \end{bmatrix} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} \tag{2}$$

where I is the identity matrix and has the same order as

matrix A . B is the inter-regional Leontief inverse matrix. According to the inter-regional input-output model, the inter-regional Leontief inverse matrix can be decomposed into

$$\begin{bmatrix} B^{11} & B^{12} & B^{13} \\ B^{21} & B^{22} & B^{23} \\ B^{31} & B^{32} & B^{33} \end{bmatrix} = \begin{bmatrix} B^{11} & 0 & 0 \\ 0 & B^{22} & 0 \\ 0 & 0 & B^{33} \end{bmatrix} + \begin{bmatrix} 0 & B^{12} & B^{13} \\ B^{21} & 0 & B^{23} \\ B^{31} & B^{32} & 0 \end{bmatrix} \tag{3}$$

By introducing Eq. (3) into Eq. (2), we can get the total output of the three regions.

$$\begin{bmatrix} X^1 \\ X^2 \\ X^3 \end{bmatrix} = \begin{bmatrix} B^{11} & 0 & 0 \\ 0 & B^{22} & 0 \\ 0 & 0 & B^{33} \end{bmatrix} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} + \begin{bmatrix} 0 & B^{12} & B^{13} \\ B^{21} & 0 & B^{23} \\ B^{31} & B^{32} & 0 \end{bmatrix} \begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} \tag{4}$$

For any of these three regions, we can get its output by Eq. (4). Take Region 1 as an example, there is

$$X^1 = B^{11}Y^1 + B^{12}Y^2 + B^{13}Y^3 \tag{5}$$

Eq. (5) shows that the total output of Region 1 consists of two parts. One is the total product produced to meet the local final needs (the first item after the equal sign). The other is the total product produced to meet the final needs of both Region 2 and Region 3 (the last two items), and the later part is the spillover effect of the other regions on the total output of Region 1.

By extending the three-region input-output model to the world input-output model including n countries with m sectors, country r 's total output equals

$$X^r = B^{rr}Y^r + \sum_{s, s \neq r} B^{rs}Y^s \quad (r, s = 1, 2, \dots, n) \tag{6}$$

Thus, the spillover effect of country s to r is

$$SO^{rs} = B^{rs}Y^s = (SO_i^{rs})_{m \times 1} \tag{7}$$

SO is a column vector, and its i th item represents the total output of country r 's i industry caused by country s 's final demand. Suppose $e' = (1, 1, \dots, 1)_{1 \times m}$ is a summation operator, and $v^r = (v_j^r)_{1 \times m}$ is the row vector of value added rate of country r 's m sectors, then,

the total spillover effect of country s to r is $e'SO^{rs}$ (8)

the total spillover value added of country s to r is $v^r SO^{rs}$ (9)

2.2 Economic power evaluation model

According to the theory of interdependence, asymmetric interdependence can produce two types of dependency: sensitivity interdependence and vulnerability interdependence (Keohane, 1977). Sensitivity refers to the extent to which a policy framework responds, i.e., how fast one country's policy changes lead to a costly change in another country, and how much this costs. While vulnerability refers to the extent to which vulnerable actors suffer losses due to the costs imposed by external events, i.e., the costs incurred by vulnerable countries when adjusting to external changes. Sensitivity and vulnerability represent a country's relative position in bilateral relations, with the more sensitive and vulnerable party being at a disadvantage due to a lack of bargaining power.

In the era of globalization, each country has become a part of the global value chain by participating in the international specialization. Therefore, all countries have a stake in each other's economic activities. The final consumption of a country will not only drive its own production, but also produce economic spillovers into other countries through the global value chain (Liu et al., 2017). Therefore, the asymmetric economic interdependence between two countries can be measured by the sensitivity and vulnerability of spatial economic spillovers between them. On the basis of the economic spillover effect in the previous section, this paper calculates the sensitivity dependence (SD) and vulnerability dependence (VD) between China and the major countries in the world, and constructs an economic power evaluation model to analyze the spatial pattern and evolution of China's economic power.

According to the theory of asymmetric interdependence, the SD of country r to s is defined as

$$SD^{rs} = \frac{e^r SO^{rs}}{\sum_s e^s SO^{rs}} - \frac{e^s SO^{sr}}{\sum_r e^r SO^{sr}} \quad (10)$$

The denominator in Eq. (10) stands for the total economic spillover of a country in the global value chain. Therefore, the two items on the right side of the equals sign respectively measure the importance of the spillover effect of the two countries on each other. A SD greater than zero indicates that country r is sensitive to

s , and otherwise, country s is sensitive to r . The greater the value of SD , the higher the sensitivity dependence of country r to s .

The VD of country r to s is given as

$$VD^{rs} = \frac{v^r SO^{rs}}{GDP^r} - \frac{v^s SO^{sr}}{GDP^s} \quad (11)$$

where GDP stands for the gross domestic product of country r or s . Therefore, the two items on the right side of the equals sign respectively measure the contribution of the value-added of the spillover effect between the two countries to their GDP. A VD greater than zero indicates that country r is vulnerable to s , and otherwise, country s is vulnerable to r . The greater the value of VD , the higher the vulnerability dependence of country r to s .

By integrating Eq. (10) and Eq. (11), the economic power of country s to r is as follows:

$$EP^{sr} = w_1 \cdot SD^{rs} + w_2 \cdot VD^{rs} \quad (12)$$

where EP^{sr} is the economic power of country s over country r , and is the weighted sum of SD and VD . w_1 and w_2 are the weights of SD and VD , respectively, and they are determined by the information entropy method (Dong et al., 2019). We first separately calculate three weight values from the data of 2000, 2008, and 2014. Then, the average value of the three weight values is taken as the final weight of these two indicators. They are 0.45 and 0.55, respectively.

Based on the size of EP , SD , and VD , and for the convenience of future research, China's relation to other countries can be divided into four types. The classification criteria are shown in Table 1.

2.3 Data

Inter-country input-output tables are usually used to estimate the economic spillover effect between countries. The most commonly used inter-country input-output tables are the World Input-Output Tables (WIOTs) financed by the Seventh Framework Plan of the European

Table 1 Classification criteria of economic power (EP), sensitivity dependence (SD), and vulnerability dependence (VD)

Indicators	Above 1%	(0.5%, 1%]	(0, 0.5%]	Bellow 0
EP	High EP Zone	Middle EP Zone	Low EP Zone	Negative EP Zone
SD	High SD Zone	Middle SD Zone	Low SD Zone	Negative SD Zone
VD	High VD Zone	Middle VD Zone	Low VD Zone	Negative VD Zone

Commission (Timmer et al., 2015). The 2016 edition of WIOTs covers 56 industries in 28 EU countries and 15 other major countries or regions (including China), with data from 2000 to 2014. Compared with other inter-country input-output tables, WIOTs cover the major countries in the world which accounted for more than 84% of the world's total GDP in 2014, and merge the remaining countries into one economy (Rest of World—RoW). Thus, it constructs an economic system reflecting the production and use of the global economy, and clearly presents the input-output relationship of products among industries in different countries. On the basis of WIOTs, we can calculate the economic spillover effect of China on other countries or regions. The 41 countries are divided into four regions (Taiwan being merged into RoW) (Table 2).

3 Results

3.1 Sequential characteristics of China's economic spatial spillover

The spatial spillover effect of China's economy from 2000 to 2014 is highly correlated with the changes in China's foreign trade. According to the growth rate of China's economic spatial spillover and the changes in the ratio of China's GDP (Fig. 1), this period can be divided into two stages:

(1) The rapid growth stage: 2000–2008. With China's accession to the WTO, China's foreign trade had been growing rapidly and had developed closer economic ties with other countries. During this period, China's economic spatial spillovers maintained an average annual growth rate of 23%, and its proportion of global space spillovers increased constantly from 4.3% to 8.4%. In 2008, China's economic spatial spillover was US\$ 1.7 trillion, which was 5.12 times more than it was in 2000. In the same period, the ratio of spatial spillovers in China's GDP maintained a slow upward trend, indicat-

ing that China's development contributed more to other countries than China's own GDP after China's accession to the WTO.

(2) The slow adjustment stage: 2009–2014. Affected by the global financial crisis and the rise of trade protectionism, the global economy declined in the whole and the process of economic globalization slowed down. Although economic ties between China and other countries were strengthening, the growth rate obviously slowed down. During this period, the average growth rate of China's economic spatial spillovers was only 14.3%; it even became negative in 2014, resulting in spatial spillovers increasing only 87% in five years. As a result of the deceleration of the globalization process, the growth rate of China's spatial spillovers was lower than that of China's GDP in the same period, leading to the ratio of space spillovers to GDP falling from 5.5% in 2008 to 4.5% in 2014. Although the spatial spillover of China's economy stepped into a stage of slow growth, China's growth rate was still higher than the global average. During this period, China's proportion of global spatial spillovers increased by 2.4%, and only declined in 2014.

3.2 The overall evaluation of China's economic power

The index of China's economic power over 41 major countries from 2000 to 2014 was obtained by using Eq. (12). Judging from the average value (Fig. 2), China's economic power took on a phased feature with its spillovers, with a trend of growth. In 2000, China's economic power was at its lowest, with a value of 0.21. In 2014, it reached 1.07, which was 4.17 times higher than in 2000. In terms of different stages, from 2000 to 2008, China's economic power was in a period of low level but rapid growth. Joining the WTO opened the door to the world for China's economic development. Through cooperation regarding international trade, foreign

Table 2 Classification of the 41 major countries

Region	Countries
East Asia & Oceania (EAO)	Australia (AUS), Indonesia (IDN), India (IND), Japan (JPN), Republic of Korea (KOR)
America (Ame)	Brazil (BRA), Canada (CAN), Mexico (MEX), United States (USA)
Central-east Europe & West Asia (CEWA)	Bulgaria (BGR), Cyprus (CYP), Czech (CZE), Estonia (EST), Croatia (HRV), Hungary (HUN), Lithuania (LTU), Latvia (LVA), Poland (POL), Romania (ROU), Russian (RUS), Slovakia (SVK), Slovenia (SVN), Turkey (TUR), Austria (AUT), Belgium (BEL), Switzerland (CHE), Germany (DEU), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), the UK (GBR), Greece (GRC), Ireland (IRL), Italy (ITA), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Norway (NOR), Portugal (PRT), Sweden (SWE)

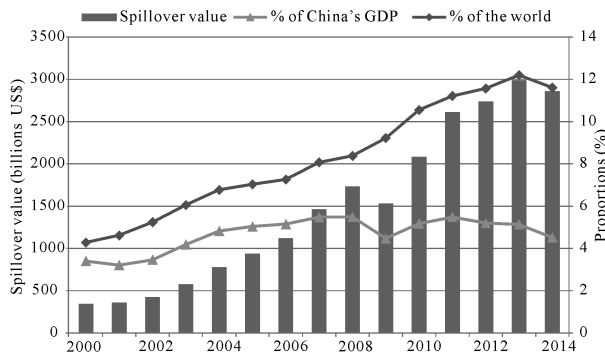


Fig. 1 Changes of China's economic spillover effect 2000–2014

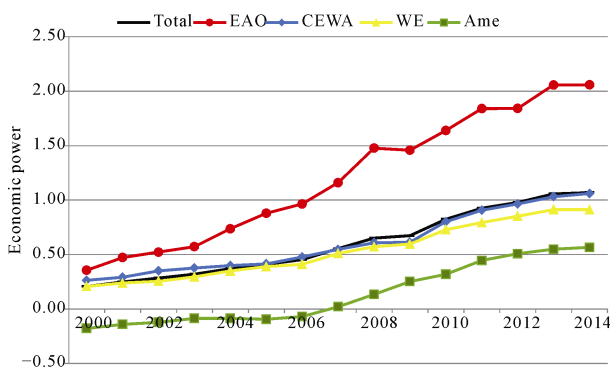


Fig. 2 Changes in China's economic power in four regions 2000–2014. EAO, CEWA, WE, Ame represent east Asia & Oceania, central-east Europe & west Asia, west Europe, America, separately

investment, service and technology transfer, *etc.*, China established closer economic ties with other countries. China is gradually becoming the world's leading exporter of manufactured goods, whilst also being the world's biggest industrial products importer and consumer market at the same time. Thus China got closer and closer economic ties with the world, and became more important for other countries. China's economic spatial spillover brings a rapid increase in economic power. At the beginning of this period, China had just boarded the express train of economic globalization. Its level of economic power was low, but the growth rate was very fast, with an average annual growth rate of 15.4%. From 2008 to 2014, China's economic power was in a period of high-level and steady increase. The global financial crisis in 2008 had a severe impact on the global economy, making the global economic growth rate slow down and trade protectionism rise, which resulted in a lack of growth in global trade. China's economic and trade cooperation with the world's major countries was hit heavily and the speed at which its economic power increased slowed down, with

an average annual growth rate of only 8.6%, far below the first stage. In this stage, China's economic power rose from 0.65 to 1.07.

From the point of view of regions, China's economic power varied widely between the four of them. Among them, China had the highest economic power and the fastest growth rate in the EAO region, as it is close to China both in terms of geography and economic cooperation. China's economic power over the EAO region reached 2.06 in 2014, 4.8 times more than in 2000. China's economic power over the CEWA and WE regions was intermediate, slightly below the average, and the trend of change was basically consistent with the average of all other countries. China had the lowest economic power in the Americas, and the value was about a quarter of that in Asia. Before 2007, China's economic power in this region was less than 0, indicating that it was a zone of no economic power. However, after stepping into the second phase, China's economic power in the region rose rapidly, reaching 0.57 in 2014, with an average annual growth rate of more than 27%.

3.3 Spatiotemporal characteristics of China's economic power

According to the spatial expansion process of China's economic power in Fig. 3, it can be seen that China's scope of economic power expanded from its periphery to the whole world, and penetrated into developed countries. In 2000, China's economic power spread to all of the major countries in the world, but the degree of power was generally small. Most countries belonged to the low EP zone, which did not constitute the range of China's economic power. Only Indonesia and Luxembourg were in the high EP zone, and the middle EP zone was mainly distributed in neighboring countries, such as Russia and Australia. The US, Japan, Germany, Britain, and France, which are the most developed countries, were in the negative EP zone. In 2008, more than half of the countries were in the ranges of the middle or high EP zone. Among them, the number of middle-EP-zone countries increased rapidly, with about 15 more than in 2000 (Table 3). The only negative-EP-zone country was the United States. In 2014, the scope of China's economic power expanded further, and only three countries were in the low or negative EP zone, while the number of countries in the high EP zone increased to 18, representing more than 40% of the total number of countries.

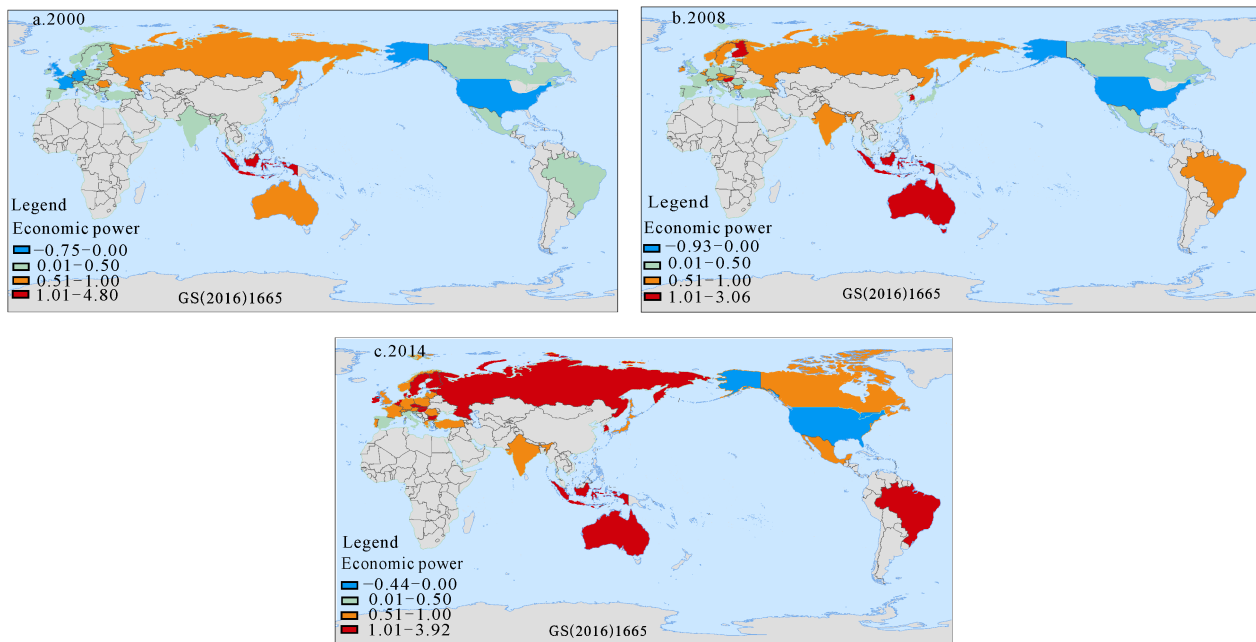


Fig. 3 Expansion of China's economic power in 2000, 2008, and 2014

From the evolution of China's economic power, it can be seen that the scope of China's economic power expanded greatly, from neighboring areas to the global scale. In terms of the number of different EP-zone countries, the number of high EP zone countries increased from 2 to 18, and the number of low and negative EP zone countries decreased from 35 to 3. This indicates the rapid global expansion of China's economic power. In terms of the spatial pattern of expansion, it took on an evolving trend of expansion from the EAO region, to the CEWA and WE regions, and the Americas. In 2014, China's high EP zone expanded to Europe and the Americas. Many

developed countries in the west Europe, including the Netherlands, Belgium, Denmark, and Sweden, had become the high-EP-zone countries. However, the veteran capitalist countries represented by the G7 countries were still in the low or middle EP zone of China's economic power, and China's economic power on the United States had always been negative. Although China's economic spatial spillover to these countries had increased rapidly since its introduction to the WTO, there was not much room for China's economic power in them to rise according to Eq. (12), as a result of their strong economic strength and increasing economic influence on China.

Table 3 Number and distribution of different types of China's economic power in 2000, 2008, and 2014

Type	2000		2008		2014	
	Number	Region or country	Number	Region or country	Number	Region or country
High EP Zone	2	EAO (1), WE (1)	5	EAO (3), WE (1), CEWA (1)	18	EAO (3), WE (8), CEWA (6), Ame (1)
Middle EP Zone	4	EAO (2), CEWA (2)	19	EAO (1), WE (10), CEWA (7), Ame (1)	20	EAO (2), WE (8), CEWA (8), Ame (2)
Low EP Zone	30	EAO (1), WE (14), CEWA (12), Ame (3)	16	EAO (1), WE (7), CEWA (6), Ame (2)	2	WE (2)
Neg. EP Zone	5	US, JPN, WE (3)	1	US	1	US

Note: please refer to Table 2 for abbreviations in the table

3.4 Dimensional evolution characteristics of China's economic power

(1) From 2000 to 2014, the SD power of China's economic spillover showed an evolutionary trend of growth from a point-like dispersion to contiguous growth, showing a 'point to line' development process in space (Figs. 4a, 4b, 4c).

In 2000, most of the countries that were sensitive to China's economic spillovers were in the low SD zone, and were distributed in four regions. Luxembourg, Indonesia, and Malta were the only three countries that belonged to the middle or high SD zone, which were dispersed in different regions. The US, Britain, Germany, Japan, France, and Russia were in the negative SD zone. It showed that before China's accession to the WTO, only very little countries were sensitive to China's economic spillovers and the SD power was very weak. By 2008, the SD power on all countries had im-

proved, and China's SD power extended to the periphery of the three countries in 2000, forming a belt connecting southeastern Asia, South Asia, Europe, South Korea, and Mexico. The number of high SD countries increased to seven, and the number of medium SD countries increased to 18, accounting for more than half of the total countries. At this time, the low negative SD countries were mainly distributed in the west Europe and the regions in America. By 2014, the SD power in all countries was further enhanced, with 40 countries (with the exception of the US) entering the high or medium SD zone. Among them, 19 countries were in the high SD zone and 21 countries in the medium SD zone. Japan and Germany also stepped up from the negative SD zone into the medium SD zone, while most countries in the belt area in 2008 stepped up into the high SD zone. The spatial pattern of China's SD power was strengthened and enhanced.

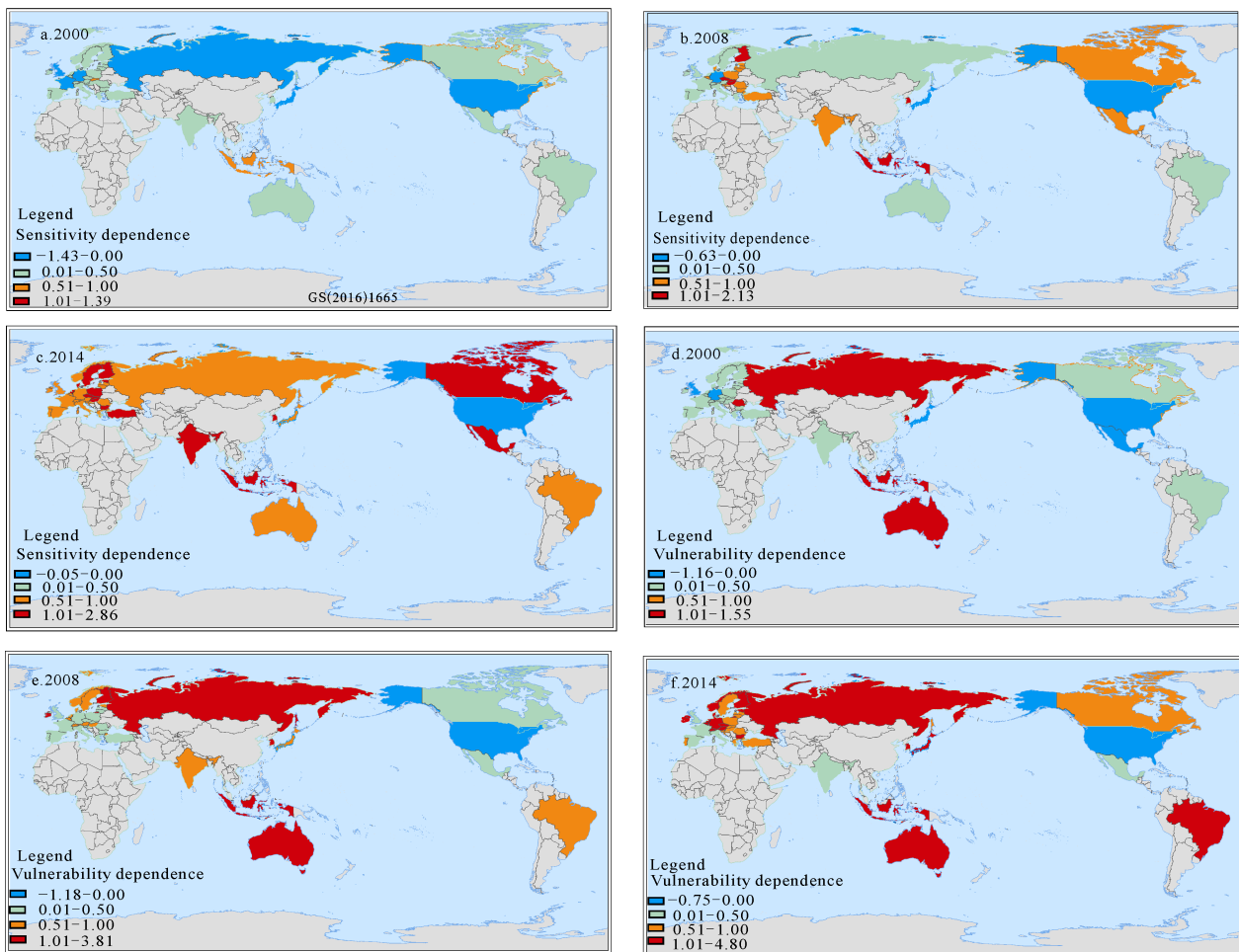


Fig. 4 Expansion of China's sensitivity dependence (SD) power and vulnerability dependence (VD) power in 2000, 2008, and 2014

(2) From 2000 to 2014, the VD power of China's economic spillover presented a trend of gradual advance from Asia to Europe and South America, which was spatially manifested as a radiation process from near to far (Figs. 4d, 4e, 4f).

In 2000, most of the countries that were vulnerable to China's economy spillover were distributed around the EAO and CEWA regions. Among them, only five countries were highly dependent on China: Indonesia, South Korea, Russia, Romania, and Australia. Most European and American countries were located in the low or negative VD zones, e.g., the US, Japan, Germany, Britain, and Mexico. In 2008, the VD power of China's economic spillover expanded in Western Europe. Nine WE countries became dependent to a medium extent on China, which was seven more than that in 2000. China's VD power on Ireland and Luxembourg exceeded 1%, and the two countries entered into the high VD zone. However, in the CEWA region and the Americas, the VD power of China's economic spillovers remained weak. About 11 countries in the CEWA region, and the US, Mexico, and Canada were in the low or negative VD zone. From 2008 to 2014, China's VD power further extended to Europe and the Americas, and 34 countries were in the high or medium VD zone in 2014. Among them, there were 18 countries in the high VD zone, including nine WE countries and three CEWA countries, and 17 countries in the medium VD zone, including 5 west European countries and 11 CEWA countries. In the EAO region, 4 countries (with the exception of India) were located in the high VD zone. However, in the Americas, China only had high VD power in Brazil.

(3) Generally speaking, the VD power of China's economic spillover is higher than the SD power, and the

spatial pattern expanded from centralization to decentralization (Fig. 5).

According to the combination of SD power and VD power, and taking whether the dependence index exceeds 1% as a standard, the 41 countries that were dependent on China's economy can be divided into four areas: Dual high (I), high SD and low VD (II), high VD and low SD (III), Dual low (IV). In 2000, almost all countries were in either area III or IV, which indicates China's SD power in these countries was very low, with Luxembourg being the only exception. Among them, the EAO countries (with the exception of Japan) and two CEWA countries were concentrated in area III, and most of the European countries and America countries were concentrated in area IV. In 2014, the distribution of all countries changed as China's SD power and VD power improved, with most countries moving into areas I, II, and III, and the amount of countries in area IV further reducing. The distribution of the spatial pattern was more dispersed than in 2000. Among the 41 countries, the CEWA countries were mainly distributed in areas II and IV, showing that the vulnerability dependence of these countries on China's economy was generally low. The WE countries were distributed around the origin and spread over the four areas (Fig. 3), indicating that both the sensitivity and vulnerability dependence of WE countries to China's economy were relatively balanced. The distribution of the five EAO countries was very scattered. South Korea, Indonesia, and Australia were located in area I, and South Korea's sensitivity and vulnerability dependence to China was more than 4% and 2%, respectively. Japan and India were located in areas II and III, respectively. The four American countries were scattered in areas II, III, and IV.

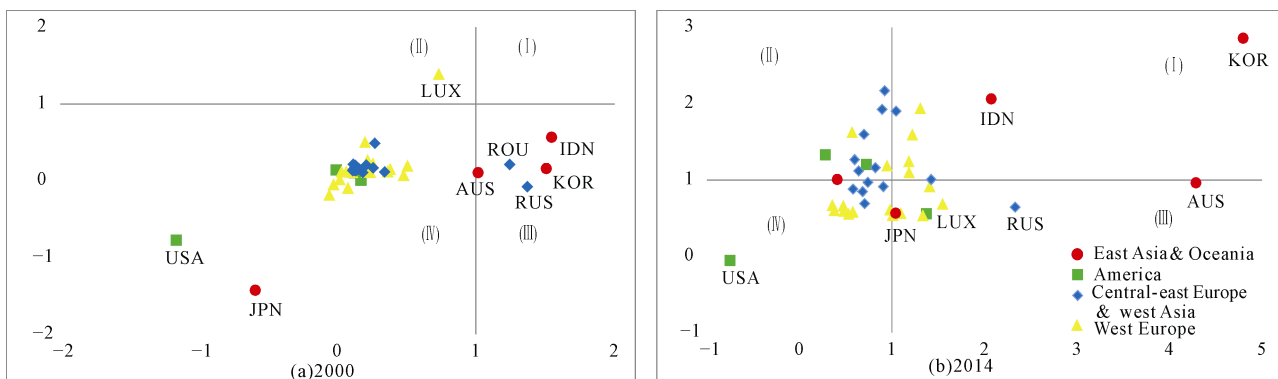


Fig. 5 Comprehensive pattern of China's sensitivity dependence power and vulnerability dependence power in 2000 and 2014. The longitudinal axis shows sensitivity dependence power, the horizontal axis shows vulnerability dependence power

4 Conclusions

The inter-regional input-output model was used to calculate the spatial spillover effect of China on major countries around the world, it was then applied to the economic power analysis of China in relation to other countries. This paper analyzes the spatiotemporal characteristics and overall level of China's economic power, as well as the evolution of the sensitivity dependence and vulnerability dependence in relation to other countries around the world. The following conclusions were drawn: 1) With the rapid development of the economy and the deepening of economic ties from the beginning of the 21st century, the spatial spillover effect of China's economy has been increasingly strengthened, which has brought about the rapid increase of China's economic power. From 2000 to 2008, China's economic power was low but grew fast. From 2008 to 2014, China's economic power was high but the growth rate was slow; 2) the evolution of the spatial pattern shows that the intensity and scope of China's economic power have strengthened significantly, and its economic power expanded from the surrounding areas to the whole world, penetrating all of the major countries in the world; 3) China's SD power takes on a trend from point distribution to flaky growth, and it shows a process 'from point to line' from the aspect of spatial diffusion. The VD power has a trend that extends from the surrounding EAO countries to Europe and the South American countries. Comprehensively, China's VD power is higher than its SD power, and the spatial distribution pattern shows an evolutionary process from centralization to decentralization.

Based on the theory of asymmetric interdependence, this article measures the economic power from the impact of economic spatial spillover on the economy of two countries, highlighting the importance of the economic correlation between countries compared to national economic power. However, the size of the economic power is not only reflected in the absolute value of economic spatial spillovers between countries, but also reflected in the structure of economic spatial spillovers. Especially under the trend of RMB accelerating internationalization and anti-globalization, there would be significant changes in the meaning and evaluation of economic power, which of course also brings opportunities and challenges to relative academic research. At the

same time, this paper focuses only on revealing the spatio-temporal evolution of China's economic power, but does not further explaining 'why'. In future studies, more aspects such as currency integration, FDI, the quality of economic spatial spillovers should be considered to help build a comprehensive evaluation model of economic power. And more attention should be paid to the formation mechanism of economic power.

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