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The Impact of Inter-provincial Economic Spillover on Economic Growth from the Perspective of Integration

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Abstract

In the context of globalization and integration, the inter-regional spillover effect has an important impact on China's economic development. The economic growth of the province is deeply influenced by the economic spillover effects from other provinces. This paper first reviews the theories of economic spillovers in development economics and new economic geography. Then, panel data from 1999 to 2019 of 31 provinces in China except Hong Kong, Macao and Taiwan were used to analyze the spatial econometric model. It is found that over the past two decades, the marginal contribution rate of economic spillover represented by market potential to economic growth exceeds that of capital, labor and other factors input. And as time goes on, the marginal contribution of market potential increases. In addition, in the analysis of the three major economic zones divided by provinces in China, it is found that the contribution of market potential to economic growth varies in different regions.

Keywords

Spillover Effect; Economic Growth; Spatial Econometric Model.

1. Introduction

With the economic development and technological progress, the barriers between regions are gradually broken down, and the economic interaction between provinces and cities fully indicates that the boundaries between regions are gradually blurred.

From the perspective of domestic development, economic spillovers between regions promote economic development. In the initial stage of reform and opening up, our policy idea is to let some people and some regions get rich first, and bring about prosperity later, and ultimately achieve common prosperity. The inter-regional prosperity can be realized through the inter-regional economic spillover effect. Inter-regional trade and resource factor flow are increasingly frequent, and inter-regional spillover effect on regional economic growth is also increasing. Theoretically, the spillover effect can achieve the goal of getting rich first and getting rich later, coordinate unbalanced regional development, and narrow the regional development gap. Over the past four decades of reform and opening-up, China has made remarkable achievements in economic development, with an expanded economy, stronger resilience and steady growth. There are many reasons for this success in China, which has a large population and a vast territory. The market barriers and factor barriers between different regions have been gradually eliminated in the reform of the socialist market economy system, the flow of factors in different regions has become freer, and the efficiency of resource allocation has been optimized, so that the development of some regions can drive the surrounding areas. In addition, opening up to the outside world to introduce foreign advanced technology and management experience, thus increasing exports, also promoted economic growth (Pan Wenqing, 2012a).

The domestic economic situation fully shows that it is of great significance to study the economic spillover effect from the perspective of economic integration.First, it confirms the

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correctness of the theory of economic spillover in development economics and new economic geography. In the 1950s and 1960s, development economists who studied the theory of unbalanced growth between regions first noticed the spillover effect. The classic theories include Peru's growth pole theory, Muirdahl's cumulative circular causality theory, and Herchman's "core-edge" theory. Then, the new economic geography school included spatial factors into the analysis scope, analyzed the internal driving factors of economic activity agglomeration, and explored the correlation between regional growth and spatial agglomeration, expanding and enriching the traditional theory. However, these two theories were only analyzed at the theoretical level at the beginning, and later scholars verified the correctness and fallibility of the theories with different research objects, different indicators and models. In this paper, the study of regional economic spillover effect and transmission mechanism is also confirmed by the latest data.

In addition, as China's economy enters a new stage of development, it is of profound significance to study the spillover effect of China's regional economic development for promoting high-quality development. First, we need to help narrow the regional income gap and promote common prosperity. China's unbalanced and inadequate problem is still prominent, urban and rural regional development and income distribution gap. And the economic spillover effect is helpful to realize the first rich, then rich, and finally achieve common prosperity. The size of regional spillover effect, the heterogeneity of regional spillover effect and the contribution of regional spillover effect to economic growth are of great significance for exploring the path to achieve common prosperity. Second, to help build a rational industrial layout and promote coordinated development. China has shifted from high-speed development to high-quality development, and industrial transformation and upgrading are underway. It is of great significance to measure the spillover effect of such an industrial pattern where the growth is concentrated in the innovation research and development sector and the standard production sector is concentrated in other regions. Third, we need to help remove barriers to factor flow and promote market optimization. To achieve regional integrated development, the primary task is to remove the barriers to the flow of production factors between regions. Whether the internal factor barriers are broken down and the level of market integration can also be concluded from the economic spillover effect.

This paper is divided into five parts.The first part is the introduction, which mainly introduces the background and research significance of the topic, and discusses the correlation between economic growth and economic space spillover effect. The second part is literature review. First of all, according to development economics and new economic geography, the economic spillover effect mechanism is analyzed at the theoretical level, and the different mechanisms of spillover effect are clarified to lay the theoretical foundation for this topic. Then, by combing the empirical studies related to this topic at home and abroad, appropriate samples and model methods are selected for research. The third part is about the model setting and empirical method of the relationship between spillover effect and economic growth, and specifically introduces how to set the model and how to choose the estimation method. The fourth part is the empirical part. Firstly, Moran's I index is used to test the spatial correlation of the whole country, and the local Moran scatter plot is attached to show the spatial agglomeration of the provinces. Secondly, the data of the whole country are estimated by basic panel model and spatial econometric model respectively. Finally, estimates are made by region and by period. The fifth part is conclusions and suggestions, summarizing the above theoretical and empirical conclusions on the impact of economic spillover on economic growth, and putting forward relevant suggestions according to the conclusions.

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2. Terature Review

2.1. Ted Theories on Economic Spillover Effect

Since the 1950s, western economists have put forward different theories on regional economic growth, which constitute the related theories of economic spillover effect of early development economics. The theory of growth poles, proposed by French economist Francois Perroux (1950), is mainly an abstract definition of the first place in a region by analogy to the concept of "magnetic poles" in physics. The "poles of growth" in this theory are based on the interrelated economic relations between economic elements in the abstract digital space. Later, Boudeville (1966) concretized Peroux's growth pole theory. As a "growth pole", advanced sectors can promote the development of themselves and other economic sectors through scientific and technological innovation and technological progress, and can also use their advantages to attract production factors and other behaviors similar to monopoly manufacturers to produce restrictive effects on other economic sectors. The circular accumulation causality theory proposed by Swedish economist Myrdal (1957) is an effective supplement to the "growth pole" theory. He believes that social and economic development is a dynamic process in which various economic factors interact and cause and effect each other. The "return effect" enlarges the regional development gap, while the "diffusion effect" Narrows the regional economic development gap. However, because the "return effect" dominates, the differentiation degree of regional economic development eventually increases. Hirschman's (1958) "core-periphery" theory is similar to the "circular accumulation causality" theory, in that the "trickle-down effect" is a positive effect and the "polarization effect" is a negative effect. But in contrast, Herchmann believes that in the long run, the "trickle-down effect" is greater than the "polarization effect", and eventually the development gap between regions will narrow. Williamson (1965) revealed the "inverted U-shaped relationship" between the level of national economic development and regional imbalance based on empirical analysis, that is, with the development of national economy, the degree of regional imbalance increases first and then decreases. Friedmann (1972) proposed the "center-periphery" model, believing that regional development is a process of social, political, economic and other factors, and that the powerful innovation ability of the "center" can spread to the "periphery".

In addition, the new economic geography school incorporates spatial factors into the analysis framework, forming two major economic behavior research topics: spatial aggregation and spatial spillover. The most essential cause of economic agglomeration is "increasing returns". Under the accidental impact, economic activities first gather in a region. When the cost between regions is not large enough to separate the market, economic activities may gather due to the increasing returns of economic forces. In addition, vertical industrial linkages and division of labor also contribute to economic agglomeration. The cause of spatial spillover is agglomeration uneconomy. When spatial agglomeration fails to produce economic benefits within the region, economic spillover occurs under the action of "centrifugal force".

The above theories of development economics and new economic geography provide a theoretical basis for the study of economic space spillover. Later generations, on the basis of these theories, continue to enrich and improve the study of economic spillover effect.

2.2. Omic Spillover Effects Affect Regional Economic Growth through Different Transmission Mechanisms

The classical growth theory and the new growth theory have different views on the influencing factors of economic growth. The classical growth theory holds that the economic development of a region mainly benefits from the input of capital, labor and other factors, while the new growth theory holds that the technological progress implied by fixed capital investment (Romer,1986) and the accumulation of human capital over time (Lucas,1988) contribute to the

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spillover effect of economic growth. Spillover effects can be transmitted through the flow of factors of production between regions. Lateral transmission is the economic interaction between the growth pole and its surrounding areas, that is, between the growth pole and its neighboring areas. The size of spillover effect decreases with the increase of geographical distance. Vertical transmission is mainly concentrated between upstream and downstream enterprises in the industrial chain, and can also be regarded as between the demand side and the supply side. According to the market potential theory proposed by Krugman(1991), when a region's economy develops rapidly, its economic volume is often large, so it has a large demand for products and services in the surrounding region and creates a large market scale for the surrounding region, which means that the region can drive the development of the surrounding region.

According to different transmission modes, Zhao Kui et al. (2021) divided the transmission mechanism into learning mechanism and division mechanism. The learning mechanism refers to the local urban enterprises learn the advanced technology, experience and knowledge of the provincial capital enterprises to improve their own productivity, and the division of labor mechanism refers to the technical exchange between different functional departments within the enterprise. The division of labor mechanism has changed the industrial structure of the city, the innovation and research and development department is mainly concentrated in the capital city, the standardized production department is mainly concentrated in the local city, and the connection between the enterprise departments drives the development of the local city. The results of Zhao Kui et al. (2021) show that learning mechanisms play a leading role in economic spillovers.

According to the different spillover contents, it can be divided into knowledge space spillover, infrastructure space spillover, industrial transfer space spillover, and industrial chain space spillover (Yan Qianqian, 2015; Zeng Yang, 2019). The size of knowledge spillover effect depends on the knowledge acceptance ability and the type of enterprises in the region, and the spillover effect of technology-intensive enterprises is larger than that of labor-intensive enterprises. The spatial spillover effect of infrastructure promotes the free flow of labor, reduces the transportation cost of enterprises, improves the efficiency of regional resource allocation and promotes the refinement of division of labor at the macro level. The spillover effect of industrial transfer alleviates the employment pressure in less developed areas and accelerates the optimization of industrial structure; The spillover effect of the industrial chain drives the development of surrounding industries and upstream and downstream industries in the horizontal and vertical complementarity between industries.

According to the different factors of flow production, it can be divided into material flow, capital flow, talent flow, technology flow and information flow (Zhou Zhenhua, 2002). At different stages of development, the dominant flow factors are different. In the early stage of economic development, material flow is dominant. In the mature stage of economic development, capital flow or talent flow is dominant. It is these factors of production that constantly circulate between regions, gather, reorganize, integrate and collaborate within the region, and the scale of factor flow continues to expand, while the economic scale of the region also expands.

2.3. Methods for Measuring Economic Spillover Effects

For the study of regional economic spillover, predecessors have used a variety of methods, which can be roughly divided into econometric analysis and input-output analysis. Because of the simplicity and flexibility of the econometric analysis method, most scholars use this method in the study of regional spillover effect. According to whether the spatial factor is considered, the models used by predecessors can be divided into VAR model and spatial metrology model. Groenewold, Lee and Chen(2007; 2008) China is divided into three regions: East, middle and west, and six economic zones: southeast, Yangtze River basin, Yellow River Basin, Northeast,

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Northwest and Southwest, respectively, using VAR model to study the influence between regions. Guo Xiaohui (2018) believed that the size and direction of the spillover effect would change with time, while most scholars paid little attention to the time-varying characteristics of the spillover effect when studying the economic spillover effect, so he used the TVP-VAR model to analyze the size and direction of the economic spillover between Beijing, Tianjin and Hebei with the quarterly data of 13 years. The research shows that the coordinated development of Beijing-Tianjin-Hebei does promote the increase of spillover effects among the three regions, but the spillover effects between them have not undergone structural and fundamental changes. As the core city of the three regions, Beijing has not fully played a leading role in the two regions.

Spatial econometric models are further divided into spatial error model (SEM), spatial autoregressive model (SAR), spatial autocorrelation model (SAC) and spatial Durbin model (SDM). Pan Wenqing (2012a) used SEM model to investigate the spatial spillover effects of provincial economic development in China during 1988-2009. The results show that the direct spillover effect represented by the market potential plays a significant role in the economic growth of China's provinces. The indirect spatial spillover effect represented by the error term reveals that the factors that affect the economic growth of a region will also have an impact on the surrounding region. Zhu Daocai et al. (2016) also used SEM model to study spatial and temporal differences of spatial spillover effects of 40 central cities along the Yangtze River Economic Belt from 2000 to 2013, and the results showed that a "center-periphery" model had been formed between the Yangtze River Economic Belt and neighboring regions. Among them, 21 cities in Shanghai, Jiangsu, Anhui and Zhejiang provinces seize development opportunities and take advantage of location advantages to fully develop themselves and drive the development of neighboring cities. 19 cities in Jiangxi, Hubei, Hunan, Chongqing, Sichuan and Yunnan provinces have negative spillover effect due to strong agglomeration effect. In addition, the overall spillover effect of the Yangtze River Economic Belt fluctuates during the sample period. Cheng Mingwang et al. (2019) used SAR model to estimate the contribution rates of spillover effect, capital and labor to economic growth from 1978 to 2015, effectively responding to "Krugman's doubt". The results show that China's growth was driven by large-scale capital accumulation and intensive labor input at the beginning of reform and opening up. With the passage of time, the inter-regional spillover effect, the improvement of total factor productivity and human capital play an increasingly important role in economic growth. There are knowledge progress and technological innovation in China's economic growth.

However, Pan Wenqing et al. (2007) argued that although econometric analysis methods are very flexible, different conclusions are often obtained due to the different models established by scholars using econometric analysis methods and the different indicators selected, and the econometric analysis technology cannot analyze the feedback impact between regions. Therefore, input-output table analysis is used to analyze economic spillover effects. Pan Wenqing et al. (2007) analyzed the regional spillover and feedback effects between China's coastal and inland regions by using the input-output table of China's eight regions in 2000, and concluded that, contrary to people's expectations, the coastal regions did not play a sufficient role in driving inland regions, and the spillover effect of inland regions on coastal regions was greater than that of coastal regions on inland regions. Pan Wenqing et al. (2008) used the input-output table of 2000 again to study the spillover effects of the three growth poles around the Bohai Sea, the Yangtze River Delta and the Pearl River Delta on China's inland areas. On the whole, the three growth poles had limited effects on the inland areas. Among them, the spillover effect of the central region is stronger, while the spillover effect of the northeast, northwest and southwest regions is weaker. Pan Wenqing (2015) made a comparative analysis of the changes of spillover effects in China's eight major economic regions based on the input-output tables of 1997 and 2007, and the results showed that the links between the regions became closer, and

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the development of regional economy gradually shifted from relying on its own development to relying more on external market. The removal of market barriers and factor barriers has brought strong growth drivers to all regions.

3. Empirical Model Setting

3.1. Establishment of Spatial Weight Matrix

The "first law of geography" states that as the distance between regions increases, the degree of correlation between regions decreases. The degree of correlation can be measured by the N-order symmetric spatial weight matrix. Spatial weight matrix is one of the features of spatial econometrics that is different from traditional econometrics (Zhang Xueliang, 2012). The results of spatial correlation test and the estimation results of spatial metrology model will be different with different spatial weight matrices. In order to make spatial correlation test and spatial econometric model estimation more reliable, the following two commonly used spatial weight matrices will be used for spatial econometric analysis.

The first is the binary 0-1 space weight matrix W_{01}, also known as the adjacency matrix, which is set up according to the proximity relationship between regions. If two regions are adjacent, that is, have a common boundary or a common vertex, then the corresponding weight element is set to 1; Conversely, if two regions are not adjacent to each other, the corresponding weight element is set to 0. W_{01} fter normalization, the sum of the elements in each row is 1. The expression for the elements of the 0-1 matrix is as follows:

$$w_{ij}=\begin{cases}1, Area\ i\ is\ adjacent\ to\ j\\0, Region\ i\ is\ not\ adjacent\ to\ j\ or\ "i=j"\end{cases}\tag{1}$$

Secondly, the anti-geographical distance matrix W_d is set up according to the geographical distance between regions. If the geographical distance between two regions is close, a larger weight is assigned, and if the geographical distance between two regions is far, a smaller weight is assigned. Compared with 0-1 matrix, the inverse geographical distance matrix can more accurately reflect the distance relationship between regions, and its weight setting method is as follows:

$$w_{ij}=\frac{1}{d_{ij}}\tag{2}$$

$$W_d=\begin{bmatrix}0 & \frac{1}{d_{12}} & \cdots & \frac{1}{d_{1n}}\\ \frac{1}{d_{21}} & 0 & \cdots & \frac{1}{d_{2n}}\\ \vdots & \vdots & \ddots & \vdots\\ \frac{1}{\mathrm{d}_{\mathrm{n}1}} & \frac{1}{\mathrm{d}_{\mathrm{n}2}} & \cdots & 0\end{bmatrix}\tag{3}$$

Where d_{ij} is the geographical distance between region i and j, and the geographical distance between the two provinces in this paper is calculated according to the longitude and latitude of the capital city. The longitude and latitude of the provincial capital city are chosen to calculate

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the distance between the two provinces, because the provincial capital city is often the economic center of a province and has great influence.

3.2. Spatial Autocorrelation Test

In this paper, the most commonly used Moran index will be used to test the global spatial correlation of GDP in China's provinces. The calculation formula is as follows:

$$I=\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}\left(Y_i-\bar{Y}\right)\left(Y_j-\bar{Y}\right)}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n}w_{ij}} \tag{4}$$

$$S^2=\frac{1}{n}\sum_{i=1}^{n}\left(Y_i-\bar{Y}\right)^2 \quad , \bar{Y}=\frac{1}{n}\sum_{i=1}^{n}Y_i \tag{5}$$

In the formula, n is the number of observation areas, w_{ij} is the weight element of the spatial weight matrix, and Y_i is the GDP value of region i. The value of the Moran index is $[-1,1]$, where $[-1,0)$ indicates a negative spatial correlation, 0,1 indicates a positive spatial correlation, and 0 indicates no spatial correlation.

Of course, if there is a global spatial correlation, it does not mean that there is also a local spatial correlation. Therefore, in order to further explore the inter-provincial spatial agglomeration, this paper will also use the Moran scatter plot for an intuitive presentation. The measured value of both global and local Moreland index depends on the establishment of spatial weight matrix to some extent, so this paper will also use the two different weight matrices established in the above paper to test the spatial correlation.

3.3. Establishment of Spatial Metrology Model

Based on the analysis of existing literature, regional correlation is one of the important factors affecting regional economic growth. The development of spatial econometric models has made it possible to study more multidimensional interactions between economies. The basic OLS regression cannot accurately measure the spatial spillover effect between variables, which leads to bias in the estimation of model coefficients. Therefore, the spatial econometric model can be used to investigate the spatial relationship of inter-regional economic growth and make corresponding decomposition of economic spillovers. There are four main types of spatial metrology models: (1) Spatial autoregressive (SAR) model with spatial lag term of dependent variable; (2) Spatial error (SEM) model with spatial error term; (3) Spatial autocorrelation (SAC) model containing both spatial lag term and spatial error term of dependent variable; (4) Spatial Durbin (SDM) model containing both spatial lag terms of dependent variables and spatial lag terms of independent variables. On the basis of the above model, the time lag term of dependent variable and time lag term of independent variable can be added, and a more complex spatial measurement model can be constructed.

However, the spatial transmission mechanisms set by different spatial metrology models are different, and the economic meanings they represent are also different (Bai Junhong et al., 2017). The SAR model assumes that the dependent variable will affect the dependent variable in other regions through the spatial interaction, which is reflected as the spatial lag term of the dependent variable in the model. The SEM model assumes that the overflow of independent variables is the result of random shock, which is reflected in the model as the spatial lag term of the error term. SAC model also considers the spillover effect of dependent variable and error term, which is reflected in the spatial cross term of dependent variable and the spatial lag term of error. SDM considers the spillover effect of dependent variable and independent variable at the same time, which is reflected in the spatial lag term of dependent variable and independent variable.

In this paper, the methods of Bai Junhong et al. (2017) and Sun Hongjun (2019) are used for the optimal selection of models. The following sets up the spatial metrology model represented by formula (6)-(10), in which formula (6) and formula (7) are SDM model and SAC model respectively. (8)-(10) are SAR models, SEM models and OLS models obtained by attaching restrictions to SDM models and SAC models.

$$lnGDP_{it} = \alpha + \rho WlnGDP_{it} + \beta_1 lnMP_{it} + \beta_2 X_{con} + \theta_1 WlnMP_{it} + \theta_2 WX_{con} + \varepsilon_{it} \quad (6)$$

$$\begin{aligned} lnGDP_{it} &= \alpha + \rho W \ln GDP_{it} + \beta_1 \ln MP_{it} + \beta_2 X_{con} + \mu_{it} \\ \mu_{it} &= \lambda W \mu_t + \varepsilon_{it} \end{aligned} \quad (7)$$

If the spatial lag term of the SDM model independent variable does not exist, that is, when $\theta_i = 0 (i = 1,2)$, or the spatial error term coefficient of SAC model $\lambda = 0$, the above two models can become SAR models:

$$lnGDP_{it} = \alpha + \rho WlnGDP_{it} + \beta_1 lnMP_{it} + \beta_2 X_{con} + \varepsilon_{it} \quad (8)$$

If $\theta_i = -\rho\beta_i$ is satisfied between the spatial lag term coefficient $\theta_i (i = 1,2)$ of the independent variable of SDM model, the spatial lag term coefficient ρ of the dependent variable and the regression coefficient $\beta_i (i = 1,2)$, or the spatial lag term coefficient ρ of the SAC model meets $\rho = 0$, the model will be transformed into an SEM model:

$$\begin{aligned} lnGDP_{it} &= \alpha + \beta_1 \ln MP_{it} + \beta_2 X_{con} + \mu_{it} \\ \mu_{it} &= \lambda W \mu_t + \varepsilon_{it} \end{aligned} \quad (9)$$

The basic OLS model does not add regional spatial factors, in other words, the coefficients of all the above models with W terms are 0, and the model can become a basic OLS model:

$$lnGDP_{it} = \alpha + \beta_1 lnMP_{it} + \beta_2 X_{con} + \varepsilon_{it} \quad (10)$$

Among the above types, GDP_{it} and MP_{it} are the GDP market potential of Province i in year t respectively, and X_{con} is a series of selected control variables, including capital stock K, labor input L, innovation level PAT, education level EDU and industrial structure INS. The absolute quantity is included in the equation in logarithmic form, and the ratio data is included in the equation in original value. The specific treatment of each variable is described below. μ_{it} is the residual term. $W \ln GDP_{it}$, $W \ln MP_{it}$, WX_{con} , $\lambda W \mu_{it}$ are respectively the spatial lag operators of the explained variable, the core explanatory variable, the control variable and the error term, that is, the spatial lag term or spatial cross term mentioned above. W weight matrix is consistent with the calculation of Moran index. The following will also conduct spatial metrological analysis based on these two weight matrices.

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4. Empirical Analysis

4.1. Data Source and Variable Description

Considering the availability of data, this study selected the GDP, fixed assets investment, employment number, number of patents granted, education population structure data, education expenditure, longitude and latitude data of provincial capital cities, and shortest highway mileage data of 31 provinces and cities in China (except Hong Kong, Macao, and Taiwan) from 1999 to 2019. Among them, provincial GDP, longitude and latitude data of provincial capital cities, and shortest highway mileage data of provinces come from Guotai 'an database; The number of employed persons, the number of patents granted, the population structure data of the educated population, and the education expenditure were all derived from the China Statistical Yearbook for 1999-2019. The investment in fixed assets is derived from the EPS database, and the missing data for 2018-2019 are calculated and supplemented by the growth rate of fixed asset investment obtained by the National Bureau of Statistics. The GDP of each region is reduced according to the deflator, and the fixed asset investment is also reduced according to the local fixed asset investment price index. Since there is no corresponding index to measure the change of education expenditure, it is deflated by the consumer price index of education. Therefore, the changes of the above three variables are the changes of actual values, without price changes, and the base period is 1999. This paper takes the GDP of each province and city as the explained variable to measure the economic growth. In order to eliminate the influence of heteroscedasticity, the absolute value variables are modeled after logarithmic processing.

Drawing on the research methods of Pan Wenqing (2012a), Wang Xuehui (2017), Cheng Mingwang(2019) and other scholars, this paper constructs market potential (MP) as the core explanatory variable. Its connotation is the expansion of the market provided to the region by the expansion of the economic volume of other regions, that is, the spillover effect and positive economic externalities (Cheng Mingwang, 2019). When the economic development of a region is rapid, its economic volume is often large, so the demand for products and services in the surrounding region is large, and the market scale for the surrounding region is also large, which means that the region can drive the development of the surrounding region (Pan Wenqing, 2012a). To sum up, market potential can be a good measure of economic spillover effect, and its calculation formula is as follows:

$$MP_{it} = \sum_{i \neq j} \frac{GDP_{jt}}{d_{ij}} \tag{11}$$

In formula (11), i and j represent different provinces, MP_{it} is the market potential of Province i in t years, $GDP_{it}$is the GDP of province i in t years, and d_{ij} represents the distance between provinces i and j. This formula indicates that the market potential of Province i is the weighted average sum of the GDP of other provinces, with the weight being the inverse of the distance between the two provinces. GDP can measure the level of aggregate demand in a region, which in turn reflects the size of the market in that region. The greater the GDP of a region, the greater the demand for products and services in the surrounding areas, and the stronger the driving effect on the surrounding areas, so it is reasonable to use GDP to construct market potential. d_{ij} is represented by highway mileage, and some scholars are represented by geographical distance. However, considering that the inter-provincial flow of input factors (labor force, fixed assets, etc.) mainly depends on transportation channels, this paper uses the shortest highway mileage between two provinces to represent the distance between provinces.

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Classical growth theory believes that capital and labor are the direct causes of economic growth, so this paper takes capital stock (K) and labor input (L) as two control variables. Investment has always been an important driving force for economic growth, and investment both in the current period and in previous years can play an important role in economic growth (Cheng mingwang, 2019). Drawing on the practice of Zhang Xueliang (2012), Cheng Mingwang(2019) and other scholars, this paper adopts the perpetual inventory method to estimate the capital stock, and the calculation formula is as follows:

$$K_t = K_{t-1}(1-\delta_t) + I_t \tag{12}$$

In Formula (12), K_t and K_{t-1} represent the fixed capital stock in year t and year t-1 respectively, δ_t represents the depreciation rate in year t , and I_t represents the new investment in fixed assets in year t expressed at constant prices. The first is the determination of the base period capital stock. According to the practice of Cheng Mingwang (2019), the formula for calculating the base period capital stock in 1999 is $K_{1999} = \frac{I_{1999}}{g_{1999-2003}+\delta}$, where $g_{1999-200}$ is the average growth rate of fixed asset investment from 1999 to 2003. The depreciation rate δ is set at 10.96%.

The effect of labor factors on economic growth is manifested in both quantity and quality of labor input. The improvement of labor quality is one of the reasons for increasing marginal returns. With reference to the practice of Fan Gang et al. (2011), the calculation formula of labor input (L) is as follows:

$$\begin{aligned} &L = Number\ of\ employed \times Years\ of\ education\ per\ capita \\ &Years\ of\ education\ per\ capita\ = \\ &(Illiteracy \times 0 + Primary \times 6 + Junior \times 9 + Senior \times 12 + College\ or\ above \times 16) \\ &\div \text{Total}\ population\ above\ 6\ years\ old \end{aligned} \tag{13}$$

Considering that there are many factors affecting economic growth, in addition to capital stock and labor input, the following three control variables are added in this paper: (1) innovation level, measured by the number of patents granted by each province each year. (2) The level of education, measured by the annual investment in education by each province. (3) Industrial structure, measured by the proportion of the added value of the tertiary industry to that of the secondary industry.

The specific meanings of each variable are summarized in Table 1, where ln represents logarithm taking:

Table 1. The specific meaning of each variable

	Variable name	Symbol	Variable meaning
Explained variable	Economic level	*lnGDP*	Real GDP of the province
Core explanatory variable	Market potential	*lnMP*	Economic spillover effects on the province
Control variable	Capital stock	*lnK*	Capital stock of the province as measured by perpetual inventory method
	Labor input	*lnL*	Both qualitative and quantitative labor factor inputs are considered
	Innovation level	*lnPAT*	Number of patents granted
	Educational level	*lnEDU*	Educational expenditure
	Industrial structure	*INS*	The proportion of added value of tertiary industry in added value of secondary industry

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4.2. Spatial Correlation Analysis of Provincial Economic Level

According to the steps of spatial measurement, it is necessary to first determine whether the explained variables have spatial correlation. If so, it is appropriate to use the spatial measurement model; otherwise, the basic panel model can be used. This paper uses two spatial weights to test the global correlation of Moran's I index for provincial GDP, and the results are shown in Table 2.

Table 2. Global Moran index test results

Year	0-1 Weight matrix (W_{01})			Inverse geographical distance weight matrix (W_d)		
	Moran's I index	z-value	p-value	Moran's I index	z-value	p-value
1999	0.097	3.601	0.000	0.060	2.514	0.012
2000	0.098	3.622	0.000	0.059	2.503	0.012
2001	0.098	3.644	0.000	0.059	2.509	0.012
2002	0.098	3.648	0.000	0.059	2.499	0.012
2003	0.098	3.636	0.000	0.057	2.462	0.014
2004	0.097	3.630	0.000	0.057	2.459	0.014
2005	0.095	0.036	0.000	0.055	2.401	0.016
2006	0.094	3.545	0.000	0.053	2.362	0.018
2007	0.095	3.572	0.000	0.053	2.368	0.018
2008	0.097	3.635	0.000	0.054	2.396	0.017
2009	0.096	3.605	0.000	0.053	2.366	0.018
2010	0.096	3.599	0.000	0.053	2.361	0.018
2011	0.094	3.548	0.000	0.052	2.334	0.020
2012	0.093	3.515	0.000	0.052	2.328	0.020
2013	0.093	3.502	0.000	0.052	2.326	0.020
2014	0.093	3.505	0.000	0.053	2.343	0.019
2015	0.092	3.493	0.000	0.053	2.364	0.018
2016	0.091	3.461	0.001	0.055	2.408	0.016
2017	0.090	3.444	0.001	0.056	2.431	0.015
2018	0.091	3.451	0.001	0.057	2.459	0.014
2019	0.091	3.466	0.001	0.058	2.496	0.013

According to Table 2, the results of the Moran index test based on two different weight matrices show that when the null hypothesis of no spatial correlation is rejected at the 5% level, the Moran index is significantly positive, indicating that there is a significant positive spatial correlation between the GDP of various regions in China, that is, the economic growth of one province will also drive the economic growth of neighboring provinces. First, on the whole, the Moreland index under the 0-1 weight matrix is larger than the Moreland index under the anti-geographical distance matrix, but the overall difference is not large. Secondly, from the perspective of time, the overall fluctuation of the Moran index is not large, showing a slow decline trend, that is, the correlation of provinces is slightly decreased. However, since the results of Moran index test are affected by the weight matrix, the spatial correlation of provincial economy should be determined according to the estimation results of the spatial econometric model.

The global analysis above shows that there is a positive spatial correlation among provinces in China, and the economic correlation and agglomeration among provinces can be intuitively explained from the Moran scatter plot. The Molan scatter charts of provincial GDP in 1999, 2008 and 2019 based on 0-1 weight matrix and anti-geographic distance matrix are shown in Figure 1 to Figure 3.

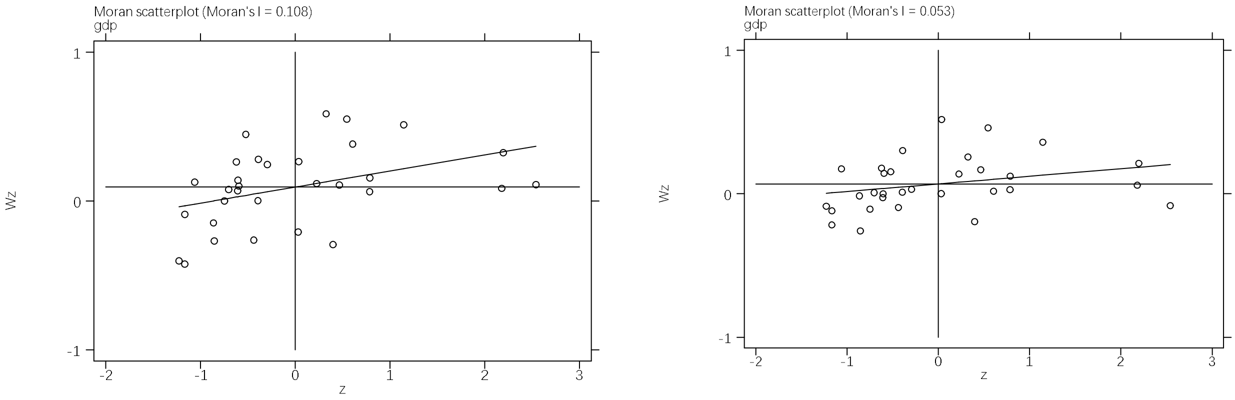

Figure1. Molan scatter chart of provincial GDP in 1999 (Left: based on 0-1 weight matrix; Right: based on inverse geographical distance weight matrix)

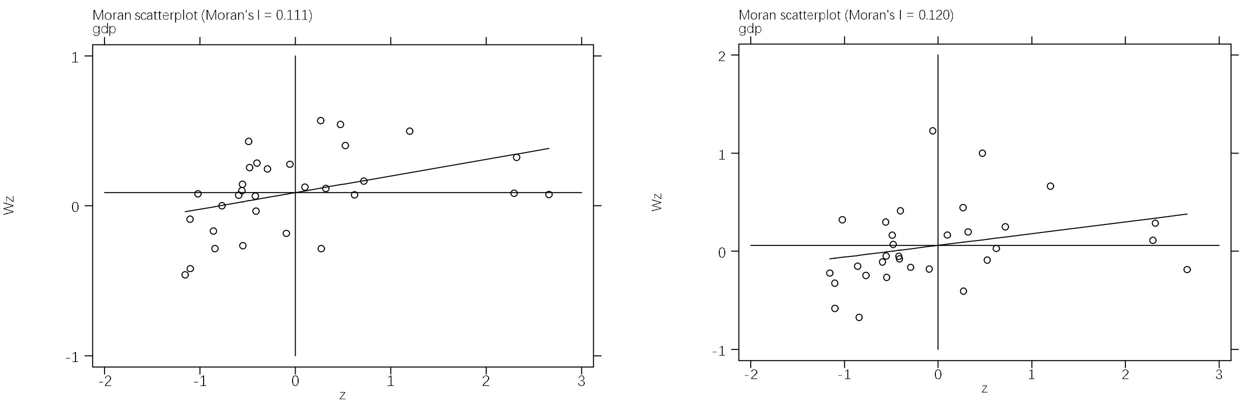

Figure 2. Molan scatter chart of provincial GDP in 2008 (Left: based on 0-1 weight matrix; Right: based on inverse geographical distance weight matrix)

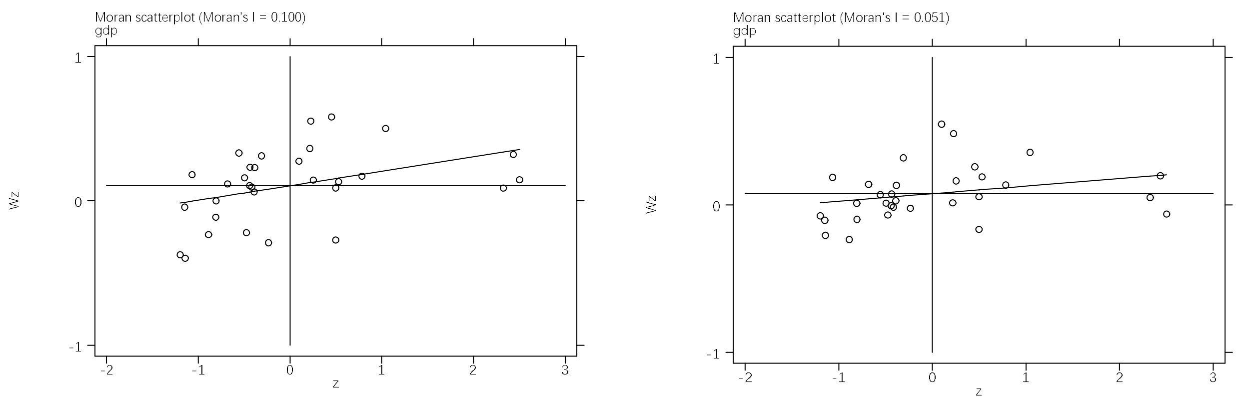

Figure 3. Molan scatter chart of provincial GDP in 2019 (Left: based on 0-1 weight matrix; Right: based on inverse geographical distance weight matrix)

The Moran scatter plot is divided into four quadrants. The first quadrant indicates that the observed values of the individual and the surrounding individuals are high, that is, high aggregation (HH). The second quadrant indicates that the observed value of the individual is low while the observed value of the surrounding individual is high, that is, the low-high cluster (LH). The third quadrant indicates that the observed value of the individual and the observed value of the surrounding individual are low, that is, low low cluster (LL). The fourth quadrant indicates that the individual has a higher observation value and the surrounding individual has a lower observation value, which is the high-low clustering (HL). On the whole, there are more regions with typical observations (i.e., regions in the first and third quadrants) than those with atypical observations (i.e., regions in the second and fourth quadrants), indicating that China's local spatial agglomeration features are relatively obvious, and provinces with higher GDP levels are also surrounded by provinces with higher GDP levels. The provinces with backward economic development are also more located in the middle of the provinces with backward economic development. From the perspective of time, based on the Moran scatter plot of 0-1 weight matrix, the number of regions with atypical observations has changed from 9 in 1999 to 7 in 2019. Based on the Moran scatter plot of the inverse geographical distance weight matrix, the number of regions with atypical observations has changed from 10 in 1999 to 9. This indicates that the local agglomeration in China has a slightly enhanced trend.

From the above analysis, it can be seen that there is a close spatial correlation between the economic growth of various provinces in China, whether from a global perspective or a local perspective, and how this spatial correlation affects the economic growth of various provinces in China needs to be determined through econometric analysis.

4.3. Stationarity Test

In order to avoid false regression in panel data estimation, stationarity test of variables should be carried out first, that is, unit root test should be carried out on seven variables including *lnGDP, lnMP, lnK, lnL, lnPAT, lnEDU* and *INS*. Table 3 shows the LLC test and Fisher Dickey-Fuller test.

Table 3. Unit root test results

variable	LLC test		Fisher Dickey-Fuller test	
	Adjusted t value	p value	z value	p value
lnGDP	-3.7925	0.0001	-6.8406	0.0000
lnMP	-4.8399	0.0000	-7.5545	0.0000
lnK	-21.5715	0.0000	-36.8418	0.0000
lnL	-4.2546	0.0000	-5.6549	0.0000
lnPAT	-1.6029	0.0545	-8.3197	0.0000
lnEDU	-11.1429	0.0000	-15.5901	0.0000
INS	-15.4281	0.0000	-11.8353	0.0000

The stationarity test results show that the original sequence is stationary. In the LLC test, the variable *lnPAT* rejects the hypothesis of the existence of unit root at the level of 10%, while other variables reject the null hypothesis at the level of 1%. In the Fisher Dickey-Fuller test, all variables reject the null hypothesis at the 1% level. Based on the above two test results, all the variables are stationary series, which can be used for quantitative analysis.

4.4. Basic Panel Model without Considering Spatial Factors

Since this paper mainly studies the spillover effect of economic growth in China's provinces, and the index to measure this spillover effect is market potential, basic panel regression can be carried out. In view of the spatial correlation between the economic growth of China's provinces has been found in the previous analysis, it is more reasonable to use the spatial econometric model to estimate. In order to compare the basic panel model with the spatial econometric model, this paper first estimates the formula (10) without the spatial weight matrix, and also conducts the Hausman test and overrecognition test to select the fixed and random effects. Table 4 shows the estimated results of the basic panel model.

Table 4. The estimated results of the basic panel model

Variable	OLS	Fixed effect	Random effect
lnMP	0.248***	0.772***	0.601***
	(0.000)	(0.000)	(0.000)
lnK	0.625***	0.227*	0.375***
	(0.000)	(0.055)	(0.000)
lnL	0.377***	0.031	0.150**
	(0.000)	(0.743)	(0.025)
lnPAT	0.200***	0.067***	0.093***
	(0.000)	(0.001)	(0.000)
lnEDU	-0.283*	-0.015	0.085
	(0.066)	(0.831)	(0.212)
INS	-0.020	-0.009*	-0.007
	(0.354)	(0.093)	(0.154)
_cons	-2.057***	1.728	-0.447
	(0.002)	(0.141)	(0.460)
Number of observations	651	651	651
R^2	0.968	0.992	
log-likelihood	71.291	923.344	
Hausman Test			F= 260.01 (0.000)
Overrecognition test			$\chi^2 = 83.921$ (0.000)
F	412.697	1784.398	
p	0.000	0.000	0.000

Note: Figures in brackets are P-values of each estimated result; The representative coefficients of ***, ** and * are significant at the significance level of 1%, 5% and 10%, respectively. The same below.

First of all, from the test results of model selection, the F value of Hausman test was 260.01, and the χ^2 value of overrecognition test was 83.921, both of which rejected the null hypothesis at the significance level of 1%, and considered that the estimation method of fixed effect model was better. From the point of view of goodness of fit R^2 and log-likelihood function value, the fixed-effect model is better than mixed regression OLS. Second, from the perspective of coefficient significance, no matter which model shows that market potential has been an important driving factor for the economic growth of Chinese provinces in the past two decades, and other factors have also promoted the economic growth of provinces to varying degrees. In the fixed effect model, there is a significant positive correlation between market potential, capital stock and innovation level and *GDP*. There is no significant positive correlation between labor input and *GDP*. There is a significant negative correlation between industrial structure and *GDP.* Specific analysis, the regression coefficient of market potential is 0.772, indicating that

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every 1% increase in the market potential of each province, that is, the spillover effect from other provinces, the provincial *GDP* will increase by 0.722%. The traditional factor input capital still plays a positive role in promoting the economic growth of each province, but it is not as large as the elasticity of the market potential. The regression coefficient of capital stock is 0.277, indicating that each 1% increase in capital stock will increase provincial *GDP* by 0.277%. The innovation level coefficient is smaller than the first two, and every 1% increase, the provincial economy grows by 0.067%. Although the coefficient of industrial structure is statistically significant, its absolute value is small, and it can be considered that it has no great impact on the economic growth of each province. Labor input and education do not pass the significance test.

To sum up, classical growth theory still has explanatory power to provincial economic growth, and capital input is still the driving force of economic growth. At the same time, the new economic geography also has a strong explanatory power to the economic growth of the provinces. In the past 20 years, the economic spillover measured by the market potential of the provinces is an important factor that cannot be ignored.

4.5. Global Estimation Analysis based on Spatial Metrology Model

Table 5. Estimation results of spatial metrology model based on 0-1 weight matrix

Variable	SAR(W_{01})	SDM(W_{01})	SAC(W_{01})	SEM(W_{01})
ρ	0.079***	0.083	0.087***	
	(0.001)	(0.615)	(0.006)	
λ			0.233	0.576
			(0.682)	(0.122)
lnMP	0.652***	0.550***	0.676***	0.638***
	(0.000)	(0.000)	(0.000)	(0.000)
lnK	0.268**	0.506***	0.273	0.452
	(0.032)	(0.004)	(0.260)	(0.132)
lnL	0.083	0.123	0.064	0.109
	(0.420)	(0.262)	(0.523)	(0.341)
lnPAT	0.070***	0.041	0.058*	0.056
	(0.000)	(0.110)	(0.060)	(0.147)
lnEDU	0.000	0.019	-0.038	0.021
	(0.998)	(0.837)	(0.632)	(0.822)
INS	-0.009*	-0.010	-0.010*	-0.010
	(0.092)	(0.103)	(0.090)	(0.111)
_cons	0.753	0.147		-0.282
	(0.591)	(0.933)		(0.909)
Number of observations	651	651	651	651
Sigma^2	0.004***	0.003***	0.003***	0.004***
	(0.001)	(0.000)	(0.000)	(0.000)
R^2	0.824	0.934	0.792	0.920
log-likelihood	799.326	833.218	933.881	798.769
AIC	-1.6e+03	-1.6e+03	-1.8e+03	-1.6e+03

In order to more accurately measure the effect of economic spillover on economic growth, four spatial econometric models are analyzed below, and then the explanatory power and effect of the model is determined according to AIC, log-likelihood and R2. Specifically, the smaller the

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AIC value, the stronger the explanatory power of the model; The greater the log-likelihood function value and goodness of fit R^2, the greater the goodness of fit of a model with a smaller $Sigma^2$ value. The Hausman test conducted in SAR, SDM and SEM models shows that the random effects model is not rejected, so the following report is the random effects estimation results of SAR, SDM and SEM models. The SAC model has only fixed effects, so the estimated results of the fixed effects of the SAC model are reported below. Since the results of the spatial metrology model vary depending on the weight matrix, the model estimates based on the 0-1 weight matrix and the anti-geographic weight matrix are reported below. Table 5 and Table 6 give the estimated results based on the 0-1 weight matrix and the anti-geographic distance weight matrix.

According to the coefficients of core explanatory variables in Table 5 and Table 6, the estimated results of the eight models based on the two spatial weight matrices all show that the coefficients of market potential are significantly positive, and all are greater than 0.5, which indicates that the economic growth of provinces in the past two decades is mainly due to the spillover effects from other provinces. In terms of model selection, according to $Sigma^2$ and log-likelihood values, $Sigma^2$ of all models is almost the same regardless of weight, but log-likelihood value of SAC model is maximum, while AIC value is minimum, so SAC model is believed to have the best fitting effect and the strongest explanatory power among the models. Considering that in the 0-1 weight matrix, the coefficient ρ representing the spatial effect of the dependent variable in SAC model is significant, while the coefficient λ representing the error space term is insignificant, and comparing the significance of coefficients of SAR model and SAC model, it can be seen that the coefficients of SAR model are more significant. Therefore, the following analysis focuses on the results of SAR model.

Firstly, the coefficient ρ, which represents the spatial effect of the independent variable, is significant in the 0-1 weight matrix, but not in the inverse geographical distance weight matrix. This shows that there are differences in judging whether the spatial effect exists under different weights. However, based on the above Moran index test, there is indeed a spatial correlation between provincial GDP, so it is also believed that spatial factors exist in the analysis of SAR model.

Secondly, the regression coefficients of market potential are 0.652(0-1 matrix) and 0.708(anti-geographic distance matrix), both of which are significant at the 1% level, indicating that each 1% increase of market potential results in 0.652%(0-1 matrix) and 0.708%(anti-geographic distance matrix) growth of provincial *GDP.* This estimated coefficient is smaller than the coefficient of the fixed effects model mentioned above. The possible reason is that the fixed effects model mentioned above does not distinguish the direct and indirect effects of the independent variable on the dependent variable, that is, the coefficient of the fixed effects model is the sum of the direct effects and indirect effects -- the total effect, while the coefficient of the SAR model is the direct effect. It also shows that basic panel regression without considering spatial factors can lead to bias in coefficient estimation. No matter what weight matrix is based on, the coefficient of market potential is greater than that of other variables, and the contribution rate of economic spillover effect to economic growth is much greater than that of other factors. This shows that in the past two decades, the market-oriented reform has achieved relatively obvious results. Resources and production factors flow more smoothly across regions, and their allocation among provinces is optimized. The inter-provincial market separation and trade barriers have been gradually broken down, and inter-provincial market development and trade cooperation have become more frequent. As China enters a new stage of development, it is important to continue to promote high-quality economic development and deepen market-oriented reform. At the same time, strengthening inter-provincial economic interaction makes the spillover effect of economy more powerful to promote economic growth.

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Table 6. Estimation results of spatial measurement model based on inverse geographical distance weight matrix

Variable	SAR(W_d)	SDM(W_d)	SAC(W_d)	SEM(W_d)
ρ	0.012	-0.466	0.223	
	(0.950)	(0.188)	(0.242)	
λ			-0.620	-0.051
			(0.498)	(0.986)
$lnMP$	0.708***	0.105	0.591***	0.726**
	(0.001)	(0.861)	(0.000)	(0.045)
lnK	0.271**	0.453**	0.150	0.259
	(0.034)	(0.038)	(0.239)	(0.724)
lnL	0.068	0.082	0.026	0.066
	(0.521)	(0.352)	(0.764)	(0.625)
$lnPAT$	0.075***	0.046*	0.062***	0.075***
	(0.000)	(0.070)	(0.000)	(0.000)
$lnEDU$	0.019	0.030	0.006	0.019
	(0.804)	(0.752)	(0.934)	(0.832)
INS	-0.009*	-0.011*	-0.007	-0.008
	(0.096)	(0.071)	(0.122)	(0.476)
_cons	1.015	1.782		1.142
	(0.544)	(0.598)		(0.817)
Number of observations	651	651	651	651
$Sigma^2$	0.004***	0.003***	0.004***	0.004***
	(0.001)	(0.000)	(0.000)	(0.004)
R^2	0.855	0.914	0.745	0.848
log-likelihood	791.707	842.606	926.508	791.715
AIC	-1.5e+03	-1.6e+03	-1.8e+03	-1.6e+03

Third, other control variables also play a role in economic growth to a certain extent. Capital input still plays an important role in economic growth, but not as important as market potential, with coefficients of 0.268(0-1 matrix) and 0.271(anti-geographic distance matrix), both at the 5% significance level. This also shows from the side that the extensive growth mode has changed, and the production efficiency has been improved. The regression coefficients of innovation level are 0.070(0-1 matrix) and 0.075(anti-geographic distance matrix), both of which are significant at the 1% level, but the coefficient is small, which also indicates that the current provincial innovation level has little effect on economic growth. The technological progress brought about by the improvement of innovation level should have a strong driving force for economic growth, but the estimated results show that the innovation level has no obvious effect on economic growth, which may be because the current innovation achievements are obstructed to transform into actual productivity, such as insufficient funds, which requires the coordination of multiple forces. The industrial structure has a small negative impact on economic growth, and it is still an important task to promote industrial transformation and upgrading and optimize the industrial structure. The effect of labor input is not detected in the model.

The direct effect, indirect effect and total effect of each explanatory variable are also calculated in the regression of the spatial econometric model. Direct effect measures the average influence of independent variable x in this region on dependent variable y in this region, indirect effect measures the average influence of regional x on dependent variable y in other regions, and total effect measures the average influence of independent variable x on dependent variable y in all regions. Bai Junhong et al. (2017) pointed out that in a spatial econometric model containing spatial lag terms, the influence of independent variables on dependent variables cannot be simply characterized by regression coefficients. The core explanatory variable of this paper, market potential, has already measured the impact of other regions on this region, but this index alone may not include all the factors of spatial spillover. The direct, indirect and total effects of market potential may be able to measure more multidimensional influences between provincial economies. Therefore, in order to explore how the market potential affects the economic growth of each province, Table 7 shows the direct, indirect and total effects of the market potential variable in the SAR model.

Table 7. Direct effects, indirect effects and total effects of lnMP in SAR model

Matrix	Effect	Coefficient	t-statistic	P value
0-1 weight matrix	Direct effect	0.656***	7.163	0.000
	Indirect effect	0.054***	3.509	0.000
	Total effect	0.710***	7.720	0.000
Anti-geographic distance matrix	Direct effect	0.717***	3.183	0.001
	Indirect effect	-0.014	-0.101	0.919
	Total effect	0.704***	5.748	0.000

As can be seen from Table 7, under the 0-1 weight matrix, both the direct and indirect effects of market potential are significantly positive at the 1% level. Under the inverse geographical distance weight matrix, the direct effect of market potential is significantly positive at 1% level, while the indirect effect is not significant. This indicates that the market potential not only affects the region, but also affects other regions, that is, the *GDP* of other provinces has a spillover effect on this province, and this spillover effect will affect more provinces, and the direct spillover is larger than the indirect spillover. It can be seen that the economic interaction of the provinces is not one-way or two-way, but should be network-like. Compared with the fixed effect model coefficient mentioned above, the direct effect of SAR model is smaller, which also indicates that the direct effect of the model without considering the spatial effect may overestimate the market potential to a certain extent. In the above SAR model, the coefficient of market potential is 0.652(0-1 matrix) and 0.708(anti-geographic distance matrix). In the total effect decomposition of Table 7, the direct effect coefficient of market potential is 0.656(0-1 matrix) and 0.717(anti-geographic distance matrix). Combined with the definition of direct effect (the average influence of independent variable x in this region on dependent variable y in this region), it can be roughly believed that in the undecomposed estimation results, the coefficient of market potential is the coefficient to measure the size of direct effect, and the market potential size of this region changes by 1%. Regional GDP changes 0.656%(0-1 matrix) and 0.717%(inverse geographical distance matrix).

4.6. Estimation and Analysis of Spatial Econometric Model Localization and Time Trend

The above is a regional analysis, that is, the average economic development of China's 31 provinces. From the perspective of space, China has a vast territory, and the development of different economic belts is quite different, and the characteristics of spatial agglomeration are different. In the above Moran scatter plot, the four quadrants are distributed in different provinces, which also indicates that the spatial agglomeration of different economic zones is different. From the perspective of time, over the past 20 years, the economy of each province has fluctuated to a certain extent due to the influence of the international market, national

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policies, political environment and other factors. The following is an analysis of the economic spillovers of various provinces in China based on the two periods of 1999-2008 and 2008-2019. Meanwhile, the country is divided into three economic belts: East, middle and West, and the heterogeneity of economic spillovers in each region is compared. The eastern region includes 11 provinces and cities such as Beijing, Tianjin, Hebei and Liaoning. The central region includes Shanxi, Jilin, Heilongjiang, Shanxi and other 8 provinces and cities; The western region includes 12 provinces and cities such as Inner Mongolia, Guangxi, Chongqing and Guizhou.

Since the above analysis mainly focuses on the SAR model, and the Hausman test of the three regions all shows that the fixed-effect model is better than the random effect model, this paper uses the SAR fixed-effect model to further analyze the provinces, eastern regions, central regions and western regions of the country respectively. In addition, the scope of the variable market potential is slightly reduced, and only the *GDP* of the provinces within the economic belt is used to construct the market potential of the provinces in the economic belt. Taking the eastern region as an example, the market potential of Guangdong Province is constructed by the *GDP* of other eastern provinces. Table 8 shows the estimation results of SAR models for provinces, eastern region, central region and western region of China based on 0-1 weight matrix

As shown in Table 8, firstly, from the perspective of the overall goodness of fit of the SAR model, the goodness of fit of the provinces, eastern, central and western regions of the country ranges from 50%-80%, indicating that the estimation results based on the population and subsamples can explain more than half of the variability of the dependent variables. The goodness of fit in the eastern region is better than that in the central and western regions. From the perspective of AIC values, the AIC values of the estimated results of the three economic belts are similar, indicating that the explanatory power of SAR model is similar for different regions. From the perspective of coefficient ρ, which represents the spatial effect of independent variables, ρ of the central and western regions is significant at 1% level, while ρ of the eastern region is not significant, indicating that the interaction between provinces in the central and western regions is more significant than that in the eastern region.

Secondly, from the perspective of the coefficients of the core explanatory variables, the coefficients of the market potential of the three economic belts are all significant at the level of 1%, and all are greater than 0.5, indicating that the spillover effect generated by the economic interaction within each economic belt can effectively promote economic growth. From 1999 to 2019, the highest marginal contribution rate of market potential was in the central region (1.509), followed by the eastern region (0.718) and the lowest was in the western region (0.637). It can be seen that the spillover effect of different regions has different effects on economic growth. The eastern region, with its many ports along the coast, was one of the first regions in China to open up, and its economic development has benefited to some extent from the vast overseas market. The cost of foreign trade in the central region is higher than that in the eastern region, while the cost of economic exchanges among provinces is lower.

Therefore, the economic spillover between provinces in the central region has a stronger driving force for economic growth than that in the eastern region, and the coefficient of market potential performance in the central region is higher than that in the eastern region. For the western region, it may be due to the relatively low economic level of each province, which can not play a good role in promoting each other, so the role of economic spillover effect on economic growth is weakened. In general, the spillover effect of the eastern region is closer to the national level (coefficient is 0.690), which also shows that the eastern region is a big growth pole of China's economic development.

Table 8. Estimation results of SAR model for the whole country and three economic zones

Variable	Nationwide	Eastern region	Central region	Western region
ρ	0.089***	-0.038	-0.565***	0.159***
	(2.915)	(0.860)	(0.000)	(0.001)
$lnMP$	0.690***	0.718***	1.509***	0.637***
	(0.000)	(0.000)	(0.000)	(0.000)
lnK	0.228**	0.278**	0.089	0.334*
	(0.045)	(0.034)	(0.209)	(0.074)
lnK	0.054	0.127	-0.146	0.151
	(0.585)	(0.554)	(0.212)	(0.171)
$lnPAT$	0.063***	0.091***	0.013	0.023
	(0.000)	(0.001)	(0.480)	(0.438)
$lnEDU$	-0.031	-0.086	0.012	-0.131
	(0.654)	(0.603)	(0.928)	(0.350)
INS	-0.009*	-0.005	-0.099***	0.016
	(0.078)	(0.193)	(0.000)	(0.642)
Number of observations	651	231	168	252
$Sigma^2$	0.003***	0.003**	0.001***	0.003**
	(0.000)	(0.011)	(0.001)	(0.015)
R^2	0.768	0.714	0.541	0.564
log-likelihood	932.719	327.629	338.051	357.575
AIC	-1.8e+03	-615.258	-638.103	-675.150

Thirdly, from the coefficient of other control variables, the situation of each region is also different. In terms of capital input, its marginal contribution rate is the highest in the western region (0.334), followed by the eastern region (0.278) and the lowest in the central region (0.089). It can be seen that the less developed western areas rely more on capital input to drive economic growth. In addition, the coefficient of innovation level is significant only in the eastern region, and the coefficient is higher than the other two regions, indicating that the economic prosperity of the eastern region is also due to innovation development compared with the central and western regions. However, the coefficient of industrial structure is only significant in the central region and is negative, indicating that it is more negatively affected by the change of industrial structure than the other two regions. For the central region, the task of industrial transformation and upgrading may be heavier. The coefficients of labor input and education level were not significant.

Table 9 shows the estimated results of economic spillover effects of various provinces in China during the two periods of 1999-2007 and 2008-2019. Similarly, since the model mainly analyzed above is the SAR model, and the Hausman test in both periods shows that the fixed effects model is better than the random effects model, the estimation results of the SAR fixed effects model based on the 0-1 weight matrix are listed in Table 9.

As shown in the table, the coefficient of market potential has increased over time, from 0.667 in 1999-2007 to 0.708 in 2008-2019. It can be seen that with the continuous growth of China's economy, the spatial correlation and spillover effect among provinces have been strengthened. It can be seen that the effect of market-oriented reform is more and more remarkable, and inter-provincial trade cooperation is closer. The coefficient of innovation level also increases with time, indicating that technological progress brought about by innovation has become an increasingly important factor in promoting a country's economic growth. The rising contribution of capital stock and labor input to economic growth indicates that the utilization efficiency of input factors in China has been improved, and the extensive economic growth model is changing to the high-quality development model.

Table 9. The estimation results of SAR model in different periods of the country

Variable	1999-2007	2008-2019
ρ	0.125***	0.055
	(0.000)	(0.143)
$lnMP$	0.677***	0.708***
	(0.000)	(0.000)
lnK	0.174***	0.510
	(0.006)	(0.251)
lnL	0.068	0.091
	(0.377)	(0.166)
$lnPAT$	0.036**	0.054***
	(0.012)	(0.001)
$lnEDU$	-0.008	-0.239**
	(0.867)	(0.026)
INS	-0.010	-0.005*
	(0.565)	(0.077)
Number of observations	279	372
Sigma^2	0.001**	0.001***
	(0.048)	(0.000)
R^2	0.666	0.804
log-likelihood	577.241	714.823
AIC	-1.1e+03	-1.4e+03

4.7. Robust Test

In order to verify the robustness of the above results, we examine whether the core explanatory variables change greatly under different conditions. After changing the definition of the data of the market potential of the core variable, the robustness of the above results is tested. In the above, the market potential is constructed as $MP_{it} = \sum_{i \neq j} \frac{GD\_jt}{d_{ij}}$, where iand j represent different provinces, and d_{ij} represents the distance between different provinces, expressed as highway miles. The robustness test is performed after d_{ij} is replaced by the geographical distance in latitude and longitude between different provinces. The estimation results from Table 10 to Table 13 show that after changing the data definition of core variables, the significance level, coefficient symbol and coefficient size of the estimation coefficients are consistent, indicating that the model setting in this paper is relatively reliable and the estimation results are robust.

Table 10. Satial metrology model based on 0-1 weight matrix

Variable	SAR(W_{01})	SDM(W_{01})	SAC(W_{01})	SEM(W_{01})
ρ	0.080***	0.083	0.088***	
	(0.001)	(0.615)	(0.007)	
λ			0.229	0.585
			(0.687)	(0.109)
lnMP	0.647***	0.540***	0.672***	0.627***
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	651	651	651	651
Sigma^2	0.004***	0.003***	0.004***	0.004***
	(0.001)	(0.000)	(0.000)	(0.000)
R^2	0.823	0.939	0.787	0.926
log-likelihood	796.437	830.558	931.189	795.994
AIC	-1.5e+03	-1.6e+03	-1.8e+03	-1.6e+03

Table 11. Satial metrology model based on inverse geographical distance weight matrix

Variable	SAR(W_d)	SDM(W_d)	SAC(W_d)	SEM(W_d)
ρ	0.074	-0.336	0.276*	
	(0.658)	(0.272)	(0.076)	
λ			-0.675	-0.086
			(0.447)	(0.975)
lnMP	0.639***	-0.434	0.538***	0.725**
	(0.001)	(0.760)	(0.000)	(0.036)
Number of observations	651.000	651.000	651.000	651.000
Sigma^2	0.004***	0.003***	0.004***	0.004***
	(0.001)	(0.000)	(0.000)	(0.004)
R^2	0.860	0.841	0.734	0.844
log-likelihood	788.852	843.844	924.837	788.737
AIC	-1.5e+03	-1.6e+03	-1.8e+03	-1.6e+03

Table 12. AR model for the whole country and three economic zones

Variable	Nationwide	Eastern region	Central region	Western region
ρ	0.090***	0.060	-0.565***	0.158***
	(0.004)	(0.775)	(0.000)	(0.001)
lnMP	0.686***	0.614***	1.508***	0.640***
	(0.000)	(0.001)	(0.000)	(0.000)
Number of observations	651	231	168	252
Sigma^2	0.003***	0.004**	0.001***	0.003**
	(0.000)	(0.012)	(0.001)	(0.015)
R^2	0.762	0.756	0.515	0.528
log-likelihood	930.072	324.879	340.787	357.911
AIC	-1.8e+03	-609.757	-643.575	-675.823

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Table 13. SAR model in different periods of the country

Variable	1999-2007	2008-2019
ρ	0.124***	0.057
	(0.000)	(0.131)
lnMP	0.676***	0.692***
	(0.000)	(0.000)
Number of observations	279	372
Sigma^2	0.001**	0.001***
	(0.048)	(0.000)
R^2	0.656	0.814
log-likelihood	577.023	713.416
AIC	-1.1e+03	-1.4e+03

5. Conclusion and Suggestion

With the economic development and the deepening of market reform, the market separation between provinces has gradually broken down, and the free flow of products and factors across provinces has not only improved the efficiency of resource allocation, but also expanded the market scope of various regions. The scale of market demand created by the economic development of neighboring provinces will promote the economic growth of the province. This paper takes the spillover effect represented by market potential as the research object, and uses the spatial econometric model to discuss the impact of spillover effect on economic growth.

Thirdly, we also focuses on whether the economic spillover effect is heterogeneous in different economic zones. The effect of provincial spillover effect on economic growth is different in eastern, central and western regions. The central region relies more on its own economic cycle to promote economic growth, and the regression coefficient of its market potential is the largest. Because the western region is not very developed, its market potential has less effect on economic growth than the eastern and central regions. The eastern region not only benefits from the economic spillover effect, but also benefits from the promotion of the vast overseas market, so the regression coefficient of market potential is between the central and western regions.

Secondly, we regards market potential as a direct measurement indicator of economic development spillover effect, and incorporates traditional factors such as capital input and labor input into the analysis framework, using panel data from 1999 to 2019 to analyze the economic growth of various provinces. The results show that, on the one hand, the economic growth of the provinces is still inseparable from the accumulation of capital and labor, and is also affected by the level of innovation. On the other hand, the market potential, which represents the spillover effect, has a significant positive impact on the provincial economy, which exceeds the marginal returns of capital, labor and other factor inputs. On the other hand, the market reform has achieved some results, the correlation between different regions has strengthened, and the economic growth has shifted to a more scientific model.

Thirdly, we also focuses on whether the economic spillover effect is heterogeneous in different economic zones. The effect of provincial spillover effect on economic growth is different in eastern, central and western regions. The central region relies more on its own economic cycle to promote economic growth, and the regression coefficient of its market potential is the largest. Because the western region is not very developed, its market potential has less effect on economic growth than the eastern and central regions. The eastern region not only benefits from the economic spillover effect, but also benefits from the promotion of the vast overseas market, so the regression coefficient of market potential is between the central and western regions.

Finally, from the perspective of time trend, the role of market potential on economic growth has increased over time. In the case of deteriorating external environment, spillover effect between provinces is undoubtedly an important driving force for domestic great circulation.

Based on the above research conclusions, this paper puts forward the following suggestions. First, strengthen the economic interaction among provinces and promote the inter-provincial flow of resources. The regression results show that among many factors, the market potential plays the most important role in economic growth, and the neighboring provinces have a driving effect on the provincial economy. The construction mode of the variable of market potential reflects the cross-regional flow of resources and other factors by means of transportation, so it is necessary to strengthen the economic interaction among provinces

Second, break down factors and market barriers, and deepen the market-oriented reform of factors and products. Different provinces have different requirements for foreign fixed asset investment and talent settlement, and relaxing the investment threshold and reducing the requirements for talent introduction will help the cross-regional flow of factors. Deepening the market-oriented construction of factors and products can make it easier for various factors and products to flow across districts, and the spatial spillover brought by their flow can benefit the surrounding areas more.

Third, coordinate the development of different regions. The effect of market potential on eastern, central and western regions is different. For the eastern region, its economic development has benefited from the vast overseas market to a certain extent, and it needs to strengthen inter-provincial exchanges while maintaining the overseas market. For the central and western regions, the eastern region needs to play a leading role.

Fourth, we need to raise the level of innovation. The above results show that the coefficient of innovation level is only significant in the estimated results of the eastern region, and the innovation level of the central and western regions has no effect on economic growth. Therefore, the innovation level of the central and western regions should be improved so that it can drive the economic growth of the central and western regions to a certain extent.

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