International Journal of Security and Its Applications
Vol. 10, No. 10 (2016) pp.249-260
http://dx.doi.org/10.14257/ijsia.2016.10.10.23

A Dynamic Semi Parametric Panel Spatial Lag Model for Brain Drain and Economic Stability Based on the Security Perspective

Shengming Chen[1, *], Yabin Zhang[2] and Azhong Ye[3]

[1]*School of Economics & Trade, Hunan University, Changsha 410079, China*
[2] *School of Economics & Trade, Hunan University, Changsha 410079, China*
[3] *School of Economics & Management, Fuzhou University, Fuzhou 350108, China*
**Corresponding Author: Shengming Chen, 541846267@qq.com*

Abstract

In this article, the authors research on the effect of international mobility of talent impact on Chinese economic development based on nonlinear relationship. From the perspective of the heterogeneity of human capital, this article introduces brain drain into a production function and analyzes the relationship between brain drain and economic development of the home country, and this paper draws an conclusion that moderate brain drain enhance the economic development of home country, but the unlimited brain drain will weaken the home country's production capacity. On the contrary, it will cause the loss of economic of the home country. On the other hand, this article use Chinese Provincial Panel Data during 1997-2014 to construct the indicators of brain drain, and then use dynamic semi-parametric spatial lag model to empirical test the above inference. And find that there is indeed optimal level of brain drain in our country, but the level of the eastern coastal provinces is too high which inhibit the economic development of this region. Therefore, develop differentiated brain drain policies for coastal and inland, be a reasonable guide to the transnational flow of talent is important to increase China's economic.

***Keywords**: brain drain, economic development, dynamic semi-parametric, spatial lag model*

1. Introduction

Human resources are a critical national resource wealth, their Rational flow conducive to national economic development. Deepening economic globalization has not only promoted the rapid development of the knowledge economy and inter-country regional flow of talent, but also into the global upsurge of immigrants, but the attendant phenomenon of brain drain in developing countries to developed countries increasingly high-quality highlights Loss of a large number of people in developing countries has been constantly plagued developing countries, these countries already scarce human capital is more scarce. According to the "2015 China International Migration Report" show: the high number of migrants worldwide in 2013 research 232 million, accounting for 4.2 percentage sum of the world's population, more than over 195 million in 2005, up 19%. The report also points out that the total size of Chinese immigrants is very large, China has become the brain drain superpower. A large number of high-quality personnel transnational migration caused by the brain drain which caused many concerns, especially the impact of brain drain on economic growth have become the focus of public attention. Currently scholars generally use the traditional linear regression model to conclude that the impact of brain drain on economic growth is absolutely positive or negative.

---
[*] Corresponding Author

ISSN: 1738-9976 IJSIA

However, in real life, it may also exist a large number of non-linear relationship between the variables of economic systems. Based on this, by using a dynamic semi-parametric panel spatial lag model, paper studies nonlinear effects of the brain drain on economic growth, and according to the results, this paper argues that China needs to develop differentiated brain drain policies for coastal and inland, and guide rational international talent drain in order to accelerate the achievement of Talent Strategy.

2. Establishment of a Dynamic Semi Parametric Panel Spatial Lag Model

The dynamic semi parametric panel spatial lag model not only can analyze the dynamic behavior of economic agents, but also can control the economic heterogeneity between individuals. The specific form of the model are as follows:

$$\ln y_{it} = \alpha_i + \rho W \ln y_{it} + \beta_1 \ln y_{it-1} + \beta_2 \ln k_{it} + \beta_3 \ln h_{it} + G(p_{it}) + u_{it} \tag{1}$$

Subscript i represents the provinces, the subscript t represents time; $G(p_{it})$ represents non-parametric part; p_{it} represents brain drain; y_{it} represents the average level of output; k_{it} represents the average capital stock; h_{it} represents The average level of human capital; α_i , β_1 , β_2 and β_3 are separately coefficients of provinces intercept and other explanatory variables; ρ is Spatial lag coefficient of explained variable; u_{it} is about $N(0,\delta^2)$ random disturbances. W is the spatial weights. The explained variable of the model is not only influenced by explanatory variables, but also Space influenced by dependent and explanatory variables. The model includes a linear part of the known relationship and another part of the unknown non-linear relationship. It is estimated as follows:

If $E[G(p_{it})] \neq 0$, it can be classified as α_i. Therefore, it may be assumed that $E[G(p_{it})] = 0$.

Method for Estimating all coefficients about $\alpha_i, \rho, \beta_1, \beta_2, \beta_3$ $G(p_{it})$ in the modle (1) are as follows:

First, we assume that the parameters about $\alpha_i, \rho, \beta_1, \beta_2, \beta_3$ are known,By the model (1) can be obtained:

$$\begin{aligned} G(p_{it}) &= E(\ln y_{it} | p_{it}) - \alpha_i - \rho E(W \ln y_{it} | p_{it}) - \beta_1 E(\ln y_{it-1} | p_{it}) \\ &- \beta_2 E(\ln k_{it} | p_{it}) - \beta_3 E(\ln h_{it} | p_{it}) \end{aligned} \tag{2}$$

So, we can get a preliminary estimate nonparametric part about $G(\cdot)$:

$$\begin{aligned} \hat{G}(p_{it}; \rho, \beta_1, \beta_2, \beta_3) &= \hat{E}(\ln y_{it} | p_{it}) - \alpha_i - \rho \hat{E}(W \ln y_{it} | p_{it}) - \beta_1 \hat{E}(\ln y_{it-1} | p_{it}) \\ &- \beta_2 \hat{E}(\ln k_{it} | p_{it}) - \beta_3 \hat{E}(\ln h_{it} | p_{it}) \end{aligned} \tag{3}$$

Combined with model 3 and model 1, we can obtain the following

$$\ln y_{it} - \hat{E}(\ln y_{it}|p_{it}) = \rho[W\ln y_{it} - \hat{E}(W\ln y_{it}|p_{it})] + \beta_1[\ln y_{it-1} - \hat{E}(\ln y_{it-1}|p_{it})]$$
$$+ \beta_2[\ln k_{it} - \hat{E}(\ln k_{it}|p_{it})] + \beta_3[\ln h_{it} - \hat{E}(\ln h_{it}|p_{it})] + u_{it} \tag{4}$$

By using instrumental variable estimation can be obtained fitting parameters about $\hat{\rho}, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3$ .owing to $E[G(p_{it})] = 0$, we can get estimates of α_i :

$$\hat{\alpha}_i = E(\ln y_{it}) - \hat{\rho}E(W\ln y_{it}) - \hat{\beta}_1 E(\ln y_{it-1}) - \hat{\beta}_2 E(\ln k_{it}) - \hat{\beta}_3 E(\ln h_{it}) \tag{5}$$

Finally, we use local linear estimation method to estimate $\hat{E}(\ln y_{it}|p_{it})$, $\hat{E}(W\ln y_{it}|p_{it})$, $\hat{E}(\ln y_{it-1}|p_{it})$, $\hat{E}(\ln k_{it}|p_{it})$, $\hat{E}(\ln h_{it}|p_{it})$ .And get $\hat{G}(p_{it})$ and Its first order partial derivatives $\partial\hat{G}(\cdot)/\partial p_{it}$.

$$\hat{G}(p_{it}) = \hat{G}(p_{it}; \hat{\rho}, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3) \tag{6}$$
$$\partial\hat{G}(\cdot)/\partial p_{it} = \hat{G}(p_{it}; \hat{\rho}, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3)/\partial p_{it} \tag{7}$$

The dynamic semi parametric panel spatial lag model can use the partial map constituted by $\partial\hat{G}(\cdot)/\partial p_{it}$ which reflect the nonlinear effects of brain drain on the region's economic growth.

3. Literature Review

Brain drain and talent loss are two different concepts, the results they produce are not the same. Talent loss is a one-way flow of talent outflow, which will definitely result in loss of a country's human capital stock, technical innovation and production capacity. The brain drain is a major outflow of countries to study, exchange, work, *etc*., which will affect a country's economic development and technological innovation uncertaintyly [1]. In recent years there has been great controversy about how brain drain affects a country's economic development. It is generally believed that the brain drain caused by the loss of talent outflows damaged the economic development, resulting in "brain drain negative results." Grubel and Scott (1966) [2] created a neo-classical framework, they believe that the outflow of qualified personnel in makes the domestic shortage of skilled labor, which reduced the level of human capital and productivity levels, led to further reduce the economic development potential. Bhagwati and Hamada (1974) [3] further modified neoclassical framework, and studied adverse effects of brain drain on economic development by using of a general equilibrium model. Miyagiwa (1991) [4] that the labor force with external economies of scale will continue to accelerate low-income countries brain drain, which will seriously hamper its economic development. Zheng (2005) [5] combines neo-classical growth theory with brain drain and human capital, and thinks that even a small amount of high-quality brain drain will bring huge economic losses to China.

Since the mid-1980s, scholars have re-examined the impact of brain drain on economic development, and explored the potential benefits of brain drain, and gradually formed a "brain drain positive benefits" theory. They believe that brain drain will bring the incentive effects of human capital, talent return and overseas capital return, which promote economic development in the home country. First, the incentive effect of human capital. Tark (1997) [6] found that brain drain in a short period of time will reduce a country's human capital stock, but the high income from brain drain directly stimulate the country to increase investment in education, However, due to the high threshold of relocation, many people who have completed higher education but have not been given the opportunity to go abroad have indirectly increased the human capital of the home country and thus promoted its economic growth. Second, the talent back effect. Studies by Mayr, Peri (2008) [7] and Li Ping (2012) [8] show that many high-quality graduates who have completed higher education abroad or have rich practical experience have returned to their home countries and have made full use of their overseas accumulation Assets, social relations, innovative thinking and human capital, improve domestic labor productivity, and promote economic growth. Third, overseas capital return benefits. Lucas and Stark (1985) [9] argued that remittances from overseas migrants could improve domestic household incomes, provide substantial financial support to the countries or enterprises. Because of the level of educational development, investment in research and economic development, the relationship between the brain drain and economic growth can not be generalized. This paper will focus on whether there is a nonlinear relationship between brain drain and economic growth. In the process of brain drain, whether there is inter-regional differences and spatial clustering phenomenon? This will become the focus of research and analysis.

In view of this, the article will discuss the non-linear effects of the brain drain on economic development from the theoretical and empirical aspects: First, On the theoretical side, this paper proves whether there is "the optimal level of brain drain", taking into account the heterogeneity of human capital and using the Cobb-Douglas production function. Second, on the empirical side, this paper constructs the brain drain indicators to estimate the brain drain situation in Chinese provinces, and tries to apply the semiparametric space lag model to the panel data, and test the theoretical inference.

4. Theoretical Model

4.1. Model Settings

Talent mainly refers to those who have high professional skills or expertise, is the human resources of the higher quality of the individual workers. As a traditional economic growth factor, the labor force can only be measured by the number, but the human capital can reflect the quality of their own level. In view of this, the article introduces human capital H into the Cobb-Douglas production function with constant returns to scale: $Y = A_0 K^{\alpha} (LH)^{1-\alpha} e^{\varepsilon}$, And according to the formula $y = Y / L$, and then get the per capita production function:

$$y = A_0 k^{\alpha} h^{1-\alpha} e^{\varepsilon} \tag{8}$$

Among them, assuming that technological progress factors A_0 are constant, y, k and h represent per capita output, per capita capital input and per capita human capital stock, e represents other factors that affect output, α and ε represent capital investment and other factors that influence the elasticity of average output($0 < \alpha < 1$).

Based on the heterogeneity of human capital, this paper considers an open economy with N number of labor with different levels of human capital.

Assuming that the level of labor force human capital τ follows a normal distribution, The distribution function is $P(\tau)$ ($\tau > 0$),Therefore, the sum of the labor force with the level of human capital τ is $l(\tau) = L * P(\tau)$ .Assuming the level of human capital τ for the labor force of human capital stock is:

$$h_0(c, \tau) = c^{\beta} \tau \tag{9}$$

c is education investment, β is the elastic coefficient of human capital stock to education investment, $0<\beta<1$ .Assuming that workers will be γ times the human capital stock income compensation, the maximum net income is:

$$Max\ U = -c + \gamma h_0(c,\tau) \tag{10}$$

In an open economic environment, the probability of outflow of workers (*i.e.,* the level of brain drain) is A, in other conditions are the same, only in the foreign remuneration higher than domestic, some labor will tend to work abroad. Therefore, under the same conditions, assuming that the income of labor abroad to stay in the domestic workers of w times.At this time to maximize the net income is:

$$Max\ U = -c + \gamma[pwh_0 + (1-p)h_0] \tag{11}$$

From formula (11), we can calculate the optimal amount of education fund c^* and optimal human capital h_0^*, And because c^* and h_0^* are the labor force level of human capital factors, Then the country's optimal average human capital stock is:

$$h = H/L = \frac{1}{L}\int_0^\infty h_0^*(\tau)l(\tau)d\tau \tag{12}$$

4.2. General Equilibrium Analysis

1. If there is no brain drain, by solving equation (10), get the optimal amount of labor education investment $c^* = (\gamma\beta\tau)^{1/(1-\beta)}$, Then the optimal human capital stock of labor force is:

$$h_0^* = (c^*)^\beta \tau = \gamma^{\beta/(1-\beta)}\beta^{\beta/(1-\beta)}\tau^{1/(1-\beta)} \tag{13}$$

The optimal average human capital is:

$$h_f = \int_0^\infty \gamma^{\beta/(1-\beta)}\beta^{\beta/(1-\beta)}\tau^{1/(1-\beta)}P(\tau)d\tau = \gamma^{\beta/(1-\beta)}\beta^{\beta/(1-\beta)}\int_0^\infty \tau^{1/(1-\beta)}P(\tau)d\tau \tag{14}$$

2. If there is brain drain, by solving equation (11), get the optimal amount of labor education investment $c_W^* = \{\gamma\beta\tau(pw+1-p)\}^{1/(1-\beta)}$,Then the optimal human capital stock of labor force is:

$$h_0^* = (c_W^*)^\beta \tau = (pw+1-p)^{\beta/(1-\beta)}\gamma^{\beta/(1-\beta)}\beta^{\beta/(1-\beta)}\tau^{1/(1-\beta)} \tag{15}$$

The optimal average human capital in open economies is:

$$h = (1-p)[1+p(w-1)]^{\beta/(1-\beta)}h_f \tag{16}$$

Equation (16) shows that the optimal average human capital stock is a function of the level of labor force outflow p , $h = h(p)$.

If $p=0$,then $h = h_f$, it indicates there is no brain drain,then $y = A_0 k^\alpha h^{1-\alpha} e^\varepsilon$ .If $p=1$,then $h=0$,it indicates All of the labor force flows to high-income countries or regions,then $y=0$ .If $0<p<1$, then $h>0$,thus:

From the assumptions can see $0 < \alpha < 1$, $w > 1$, $0 < \beta < 1$,and $h_f > 0$,Therefore, equation can be reduced to $sign(\partial y / \partial p) = sign[\beta w - 1 - p(w-1)]$.

Corollary 1: If $\beta < 1/w$, $sign(\partial y / \partial p) < 0$, Brain drain will inhibit their own economic growth, and the greater the level of outflow, the greater the impact, this time called "talent cross-flow trap."

Corollary 2: If $\beta > 1/w$, The optimal outflow level makes the total output of the outflow country the highest, $p^* = (w\beta - 1)/(w-1)$, Therefore, $y_M = A_0 k^{\alpha}[(1-\beta)\beta^{\beta/(1-\beta)} w^{1/(1-\beta)} h_f /(w-1)]^{1-\alpha} e^{\varepsilon}$.

If $0 < p < p^*$, $sign(\partial y / \partial p) > 0$; If $p^* < p < 1$, $sign(\partial y / \partial p) < 0$.

Corollary 2 shows when $\beta > 1/w$,There is the optimal level of brain drain p^*, so that a country's economic development will be the best. In general, when $0 < p < p^*$,the brain drain can enhance the level of economic development of developing countries;when $p^* < p < 1$,Brain drain leads to a net loss of home country economic development. Therefore, the brain drain on the economic development of the impact of overseas is not absolute, the appropriate brain drain can promote home country economic growth. However, when the scale of the brain drain exceeds the optimal value, the sustained outflow will restrain the economic growth of the home country.

5. Model Settings and Data Description

5.1. The Establishment of Econometric Model

There is a significant positive correlation between regional economic development. With the deepening of the development of various provinces and cities, the flow of factors, information flow and regional cooperation will promote inter-regional economic growth of mutual influence. This agglomeration feature is more and more significant, so we can not ignore the spatial correlation of regional economic growth. According to the form of spatial correlation, spatial econometric models are often divided into spatial error model (SEM) and spatial lag model (SLM). As shown in Table 1, LM LAG is more statistically significant than LME RR (53.4927> 35.9616) and R-LMLAG (17.5333) is significant and R-LMERR (0.0022) is insignificant, which indicates that the SLM model is more in line with objective reality . In this paper, the lag of the dependent variable is introduced as the independent variable to modify the estimation bias caused by omitting other important variables, so as to control the accumulation effect of economic growth.

At the same time, in view of the possible non-linear effect of brain drain on economic growth, this article will non-parametric brain drain to more accurately represent the relationship between the brain drain and economic growth.

Table 1. Test Statistics and Statistics

Test statistics	LM(lag)	R-LM(lag)	LM(error)	R-LM(error)
statistics	53.4927*** (0.000)	17.5333*** (0.000)	35.9616*** (0.000)	0.0022 (0.963)

Note: ***, ** and * indicate significant levels at 1%, 5% and 10%, respectively.

Based on the above analysis, we selects the panel data of 30 provinces in China from 1997 to 2014, and discusses the relationship between the brain drain and economic growth in China. We construct the following a dynamic semi parametric panel spatial lag model (see Appendix 1 for model estimation):

$$\ln y_{it} = \alpha_i + \rho W \ln y_{it} + \beta_1 \ln y_{it-1} + \beta_2 \ln k_{it} + \beta_3 \ln h_{it} + G(p_{it}) + u_{it} \tag{17}$$

Subscript i represents the provinces, the subscript t represents time; $G(p_{it})$ represents non-parametric part; p_{it} represents brain drain; y_{it} represents the average level of output; k_{it} represents the average capital stock; h_{it} represents The average level of human capital; α_i , β_1 , β_2 and β_3 are separately coefficients of provinces intercept and other explanatory variables; ρ is Spatial lag coefficient of explained variable; u_{it} is about $N(0,\delta^2)$ random disturbances. W is the spatial weights. We use the more commonly used binary adjacency matrix to determine the spatial weight matrix $W = (w_{ij})$:

$$w_{ij} = \begin{cases} 1, & \text{When the regions i and j are adjacent} \\ 0, & \text{Other cases} \end{cases} \tag{18}$$

5.2. Variables Description

1. The measure of the explained variable (y)

y : Taking into account the impact of inflation, this paper combines the CPI price index and the regional total population at the end of 1997 to calculate the constant price of 1997-2014 per capita real gross domestic product (y). The data come from the China Statistical Yearbook.

2. The measure of the explanatory variables (p , k , h)

p : According to Li Ping *et. al.*, (2012) [8], this paper compares the number of students studying abroad TRM_{it} with the number of college graduates GRA_{it} to measure the level of brain drain, $p_{it} = TRM_{it} / GRA_{it}$. But the data on the number of Chinese students did not follow the provincial division, We use the method of Zhang Yong *et. al.*, (2009) [10] to construct the index of infrastructure, to decompose the number of Chinese students over the years into 30 provinces of China, specific practices are: Taking the five indicators as the gravitational factor of the flow of talent, the number of college students, GDP, trade and the actual use of FDI, R & D internal expenditure and investment in education. Because there is a high degree of multiple collinearity of the indicators, we can not simultaneously enter the model as a variable, So the five indicators were returned to the number of students studying abroad to get their degree of influence on the number of students studying abroad, and then get the degree of influence as a sum of weights, and then come to the region over the years the comprehensive weight of gravity,:

$$index_{it} = \alpha_1 x_{it}^1 + \alpha_2 x_{it}^2 + \alpha_3 x_{it}^3 + \alpha_4 x_{it}^4 + \alpha_5 x_{it}^5 \tag{19}$$

$index_{it}$ represents the provincial weight of the gravitational weight of the calendar year, x_{it}^1 , x_{it}^2 , x_{it}^3 , x_{it}^4 , x_{it}^5 represent the proportion of the number of college students, the GDP, the total amount of trade and actual use of FDI, the expenditure of R & D and the investment in education in the provinces over the years. Finally the provinces over the years the number of students studying abroad by $index_{it}$ times the number of Chinese students abroad TRM_t^{total} over the years, $TRM_{it} = TRM_t^{total} \times index_{it}$,Data from the calendar year "China Statistical Yearbook" and Guotai'an database.

k : In this paper, we use the methods and results of Goldsmith (1951) [11] and Zhang (2004) [12] to estimate the fixed capital stock k of each province, and obtain the regional capital stock value from 1997 to 2014 according to the following formula:

$$K_{it} = I_{it} + (1-\delta)K_{it-1} \tag{20}$$

The base capital stock K_{i0} is estimated by Zhang Jun (2004), and the depreciation rate δ is 9.6%. The fixed asset price index and the fixed asset price index are derived from the "China Statistical Yearbook" of the provinces over the years.

h : Using the method of Yue Shujing (2006) [13], the average years of schooling are used to measure the level of human capital. The average education years is calculated as:

$$h_{it} = col_{it} \times 16 + sen_{it} \times 12 + jun_{it} \times 9 + pri_{it} \times 6 \tag{21}$$

Among, col_{it} , sen_{it} , jun_{it} , pri_{it} indicate the proportion of people with tertiary education and above, high school, junior high school and primary school education in the region, aged 6 and over. The population structure of education data from the calendar year, "China Demographic Yearbook."

6. Empirical Analysis

In order to further explore the relationship between China's brain drain and economic growth, Firstly, unit root test and co integration test are carried out on explanatory variables such as economic growth and brain drain. Then, by comparing the traditional regression model, the spatial lag model and the semi-parametric spatial lag model, this paper studies the nonlinear relationship between Chinese talent drain and economic growth.

6.1. Unit Root Test and Cointegration Test

Most panel data are nonstationary in time dimension. To avoid false regression, we need to carry out unit root test and cointegration test for each variable. We first carry out the unit root test for each variable. Test results in Table 2 show that that $\ln y$, $\ln k$, $\ln h$ and p are a single-order single whole.

Table 2. The Results of the Test Panel Unit Root Unit

variable	Lny	Lnk	Lnh	p	D(lny)	D(lnk)	D(lnh)	D(p)
Statistic value	14.63 (1.0000)	46.61 (1.0000)	12.47 (1.0000)	-0.98 (0.1640)	-5.58 (0.0000)	-2.76 (0.0029)	-15.36 (0.0000)	-14.6 (0.0000)

Note: ***, ** and * indicate significant levels at 1%, 5% and 10%, respectively.

Then we carry out the cointegration test, using Kao (1999) and Pedroni (1999) co-integration test method.the original hypothesis for the variables there is no cointegration relationship. As can be seen from Table 3, five of the eight statistics reject the null hypothesis at the significance level of 1%, ie there is a long-term cointegration relationship between the variables in most regions.

Table 3. Results of Cointegration Test for Each Panel Variable

Inspection method	Test statistics	Statistical value	Probability value
Kao Test method	ADF	-5.7907***	0.0000
Pedroni Test method	Panel v	-1.9996	0.9772
	Panel rho	1.1744	0.8799
	Panel PP	-5.1209***	0.0000
	Panel ADF	-3.6508***	0.0001
	Group rho	3.6236	0.9999
	Group PP	-5.0776***	0.0000
	Group ADF	-2.5832***	0.0049

6.2. Model Comparison and Estimation

We adapt the general fixed effect model, the spatial lag model and the semi parametric space lag model respectively, and compare the results of the three regression analysis (see Table 4). Panel data can be divided into fixed effects and random effects, depending on individual effect settings. According to the results of Hausman test in Table 4, we deny the original hypothesis that the model is random effect at 1% significance level, so we choose the fixed effect model as the basis for selecting the fixed-effect semiparametric space lag model.

The regression results of the general fixed effect model and the spatial lag model show: (1) The effect of capital stock and human capital on economic growth is significantly positive, indicating that classical growth theory is still applicable to the explanation of the phenomenon of sustained economic growth in China, namely, capital accumulation and human capital are two indispensable factors for sustained economic growth. (2) The coefficient $\ln y_{it-1}$ is positive at 1% level, and the contribution of per capita output to per capita output of the next period is more than 70%. This shows that the cumulative effect of controlling economic growth is obvious and further explains the necessity of using dynamic model. (3) The coefficient $W \ln y_{it}$ is positive at the level of 1%, which indicates that the spillover effect is an important factor that can not be neglected in China's regional economic development and reveals the mechanism of inter-regional spillover effects on regional economic development: High economic development level of the regionvwhich has a larger economic scale and considerable development prospects, led directly to the region and the neighboring provinces of economic development, That is, the region's economic growth will have a positive effect on the economic development of the neighboring areas, and bring about the economic development of the neighboring areas.

Brain drain is the key variable in this paper, the first two models show that the impact of brain drain p_{it} on economic growth is insignificant, Is there no relationship between brain drain and economic growth? Obviously yes, this paper attempts to use dynamic semi-parametric space model to do further adjustments. The semi-parametric panel-fixed spatial lag model not only can keep the regression results similar to the traditional model, but also can reflect the non-linear effects of the brain drain variables p_{it} on economic growth through the partial derivatives. The abscissa of the partial derivative graph represents the brain drain variable, and the vertical axis represents the partial derivative $\partial \hat{G}(\cdot) / \partial p_{it}$ of economic growth, which is the change in per capita GDP caused by the increase of one unit of human resource outflow.

Table 4. Empirical Results of Three Models of Regression Analysis

	Ordinary model	Space lag model	Dynamic Semiparametric Space Lag Model
Constant	0.7627*** (0.0000)	0.1782*** (0.0011)	—
$\ln k_{it}$	0.0664*** (0.0000)	0.0328*** (0.0003)	0.0255*** (0.0020)
$\ln h_{it}$	0.1782*** (0.0011)	0.1270** (0.0115)	0.0920* (0.0751)
p_{it}	-0.0680 (0.4722)	0.0619 (0.4835)	See figure 2
$\ln y_{it-1}$	0.7775*** (0.0000)	0.7352*** (0.0000)	0.9351*** (0.0000)
$W \ln y_{it}$		0.1900*** (0.0000)	0.0542* (0.0634)
R^2	0.9985	0.9986	0.9986
Hausman	64.9249*** (0.0000)	-79.5379*** (0.0000)	

Note: ***, ** and * indicate significant levels at 1%, 5% and 10%, respectively.

We can see from Figure 2: (1) On the whole, the optimal level of talent drain in China is close to 0.055, With the higher level of brain drain, brain drain on the role of economic growth will become increasingly smaller. At this point the brain drain positive effect is greater than the negative effect. When the brain drain level is higher than 0.055, the partial derivative value turns negative, and the negative effect of talent drain will become more and more serious, At this point the outflow of domestic high-quality talent will begin to become increasingly serious, human capital continues to decline, will not be conducive to China's economic development. This empirical result is consistent with the theoretical deduction, there is an optimal value of brain drain, In the early stage, with the increasing scale of brain drain, the return of talent and the incentive effect of human capital will inevitably enhance the human capital level. But when the outflow exceeds the optimal value, the sustained outflow will have adverse effects on economic development. . (2) On the region, brain drain in each China's provinces and cities has significant differences. As of 2014, the eastern coastal areas of 11 provinces and cities outflow average has been as high as 0.071, As of 2014, the eastern coastal areas 11 provinces outflow average has been as high as 0.071, While the median outflow of the central and western regions is only 0.0405, did not reach the optimal value of 0.055 in the vicinity, which means that China's central and western regions are still low talent drain, thus encouraging international mobility of talent will be conducive to further enhance the real economy in the Midwest. At the same time the eastern coastal provinces have a high talent drain, they will weaken the human capital level and threaten China's economic development.

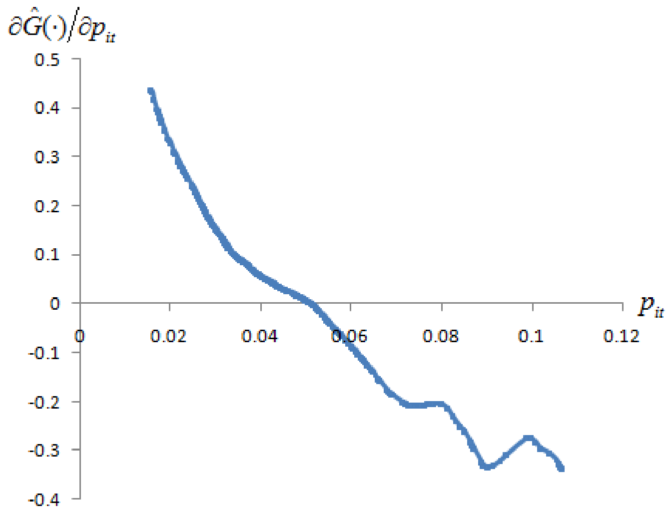

Figure 2. Partial Derivative Map of Brain Drain (p_{it}) on the Economic Growth ($\ln y_{it}$)

7. Conclusion

China's expanding scale of brain drain can bring a positive impact on China's economic growth? There is not yet a sound theoretical framework to explain this problem. Therefore, in theory, the article introduces human capital outflow into Cobb-Douglas production function from the angle of human capital heterogeneity, and discusses the non-linear relationship between brain drain and economic growth. In the empirical study, the paper constructs the brain drain indicators, combined with China's provincial panel data from 1997 to 2014, using the dynamic semi parametric space method to test the above-mentioned theoretical inference. The empirical results are in line with theoretical expectation. The results show that:

(1) The dynamic semi parametric space model can capture the influence of spatial agglomeration on economic growth, and also depict the possible nonlinear relationship between talent drain and economic growth. The spatial agglomeration effect is an important factor which can not be neglected in China's regional economic growth. The provinces with rapid economic development will produce positive radiation effect on the surrounding area's economic growth level and bring about the economic growth in the neighboring areas. (2) The non-linear effect of brain drain on economic growth will gradually change from promoting to restraining. That is to say, moderate brain drain exaltation the level of our country's economic growth, but unrestricted brain drain will weaken China's economic productive capacity (3) There is indeed an "optimal brain drain level" in China. At present, the gap of talent drain is obvious in China. China's eastern coastal areas of brain drain level is too high, we need to properly control the trend of the eastern region of brain drain. And most of the central and western provinces are still lower than the "optimal brain drain level", we need to actively encourage the central and western regions to study abroad.

References

[1] Ghosh B. N. and Ghosh R., "Economics of brain migration", Deep & Deep, **(1982)**, pp. 50-65.
[2] Grubel H. B. and Scott A. D. "The International Flow of Human Capital", The American Economic Review, vol. 56, **(1966)**, pp. 268-274.
[3] Bhagwati J. and Hamada K., "The Brain Drain, International Integration of Markets for Professionals And Unemployment: A Theoretical Analysis", Journal of Development Economics, vol. 1, **(1974)**, pp. 19-42.

[4] Miyagiwa K., “Scale Economies in Education and the Brain Drain Problem”, International Economic Review, **(1991)**, pp. 743-759.
[5] Z. Daowen, “The Brain Drain and Economic Growth:An Econometric Analysis of the Loss of Brain Drain ”, Journal of Zhongnan University of Finance and Economic, vol. 5, **(2005)**, pp. 41-45.
[6] Stark O., Helmenstein C. and Prskawetz A., “A Brain Gain with A Brain Drain”, Economics Letters, vol. 55, **(1997)**, pp. 227-234.
[7] Mayr K. and Peri G., “Return migration as a channel of brain gain”, National Bureau of Economic Research, **(2008)**, pp. 44-60.
[8] L. Ping, Z. Yu and X. Jiayun, “Brain Drain,Human Capital Accumulation and Economic Growth--An Empirical Study Based on Chinese Provincial Panel Data”, Finance & Trade Economics, vol. 7, **(2012)**, pp. 71-78.
[9] Lucas R. and Stark O., “Motivations to remit: Evidence from Botswana”, The Journal of Political Economy, **(1985)**, pp. 901-918.
[10] Z. Yong, W. Xi and G. Mingming, “Development Potential Comparison between China and India”, Economic Research Journal, vol. 7, **(2009)**, pp. 21-30.
[11] Goldsmith R W., Part I. “A Perpetual Inventory and National Wealth”, Studies in Income and Wealth, **(1951)**, pp. 5-74.
[12] Z. Jun, W. Guiying and Z. Jipen, “The Estimation of China’s provincial capital stock: 1952—2000”, Economic Research Journal, vol. 5, **(2004)**, pp. 35-44.
[13] Y. Shujing and L. Chaoming, “Human Capital Accumulation and Regional Total Factor Productivity”, Economic Research Journal, vol. 1, **(2006)**, pp. 90-96.

