The Econometric Study on Effects of Chinese Economic Growth of Human Capital

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Abstract

In the case of population dividend which tends to disappear, to choose a new driving force of economic growth has become essential. In this "new normal" economy, in essence, the supply-side reform is to optimize the allocative capital, labor and land. Raising human capital may be the source of economic growth in the new situation. In academia today, there is consensus that human capital is an important driver of economic growth, but how human capital promotes economic growth mechanism remains controversial. This paper discusses mechanism and classification of heterogeneous effects of human capital on economic growth, on which hypothesis is based. It uses demographic data from the country's 30 provinces and autonomous regions to analyze and verify this. The last comprehensive actual situation in China is concluded.

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Key words: human capital; heterogeneity; spillover effects; panel data; spatial econometric model

1. Introduction

Under the new normal, the Chinese economy is experiencing accelerated conversion of kinetic energy of the old and the new. To enhance human capital may be sources of growth in the new situation. In today's academic world, it is generally considered that human capital is an important theoretical driver of economic growth. But for the conduction mechanism there is a big difference between the two in the empirical analysis in various countries. Since each different scholar uses the estimated data and different selection methods. This will lead to different conclusions, and therefore economic growth of human capital remains a place worthy of study and discussion, which possesses distinct theoretical and practical significance.

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The contents are as follows: The first part is about the definition and measurement of human capital. The second part amplifies building models and hypotheses put forward to analyze the heterogeneity of human capital on economic growth mechanism, which is from two angles, imitation method and imitation trends, having discussed imitate innovation effect of human capital. The third part, on the provincial level, displays the empirical study of the economic growth effects of human capital. At first, the framework of spatial factors not taken into consideration, this part analyzes the economic growth effects of human capital. And then, incorporating spatial autocorrelation framework, the paper studies economic growth effects of human capital. Moreover, on the regional level, the empirical study of the economic growth effects of human capital is then discussed. The fourth part is the conclusion and recommendations.

2. Background

Based on the previous studies, the paper will broadly define it as human capital: human capital gains such in the quality of all human body health, as morals, knowledge, skills and other qualities of expression through investments in economic benefits, It is worth having coagulation factors. Human capital is defined narrowly as to the level of education on behalf of human capital, that is, to enhance investment in education brought about by human qualities. This paper primarily discusses the narrow human capital.

So far, in academia, measurement of human capital has not reached a consensus. Generally, measurement of human capital of is divided into two ways: one is based on input angle, also called cost-method, that is for getting knowledge and skills, material resources plus costs and plus other expenses required inputs in the accumulated process, including production, development and continuation; the other is based on output angle, that is to measure human capital level from human capital input in production get of returns, mainly including future returns method and current income method. It is more typical of educational period method, the value of the investment estimation method, production function wage laws and so on when Investment law is applied in practice.

To some extent, years of population education can represent the human capital stock of a country or region. Therefore, this paper uses years of population education indicator to study. Here we will divide educational attainment as follows: no schooling or illiterate, elementary, middle, high school, college. Years of education are set to: 0 year, 6 years, 8 years, 12 years and 16 years. The following are formulas of human capital calculation:

Total levels of human capital:

\[ h_{pt} = \sum_{a=0}^{5} EH_{ait, a} * \frac{n_{it, a}}{N_{it}} \]  

High levels of human capital :

\[ h_{Ait} = \sum_{a=5}^{5} EH_{ait, a} * \frac{n_{it, a}}{N_{it}} \]  

Primary level of human capital:

\[ h_{Ylt} = 1 - h_{Ait} \]

\( EH_{ait, a} \) is a level of education for the average years of schooling\( p_{it, a} \) is the number of \( a \) level of education of employees in region \( i \) in year \( t \) accounts for the proportion of the number of employees at the end of year in region \( i \) in year \( t \). \( n_{it, a} \) is population over the age of 6 years who get educational attainment of \( a \) in region \( i \) in year \( t \). \( N_{it} \) is the number of people over the age of 6 years in region \( i \) in year \( t \). \( M_{it} \) is the number of employees in educational attainment of \( a \) in region \( i \) in year \( t \). \( N_{it} \) is the number of people over the age of 6 years in region \( i \) in year \( t \). \( M_{it} \) is the number of employees in region \( i \) in year \( t \).

3. Methodology

The role of general labor and skilled labor in the production process is different. General labor is mainly used for production resource input factor. Skilled labor is largely to create a new product, or copy the technology leaders in the region to create analogous, but for the region it is new in terms of products and
services. Human capital acting on economic growth effect can be classified in two ways: About the first kind, firstly, it is the production factor. Secondly, it is used to improve the productivity of other factors such as investment in physical capital. Thirdly, as a carrier of knowledge, it generates independent innovation and promotes the absorption of new technologies. Fourthly, it is to imitate as a leading technology tools to catch up with other leading regions. About the second kind, it is divided into internal and external effects. The internal effects of human capital refers to the "personal productivity of their human capital effect"[1].The external effects also known as externalities or spillover effects, which can be understood as a person who has a high level of human capital to improve other factors of production, including the role of other human productivity[2].

It has been proved that, compared to independent innovation, imitative innovation has three major advantages, which are low cost, low risk, and more quickly achieving technological upgrading. For developing countries, the use of innovative imitation effects to exert subsequent advantage is of great importance. From the space sense, the spillover effects of advanced human capital contain innovation effect of advanced human capital (including near hood and faraway area) and the interaction effect between regions. Due to the relatively simpler and easier to be spread, digested and absorbed, the technology spillover of primary human capital can improve productivity in more short term. As the new technology from research to adapt production needs a longer period and lack of technical human capital may also occur during the production course, independent innovation spillover effects of advanced human capital probably may not appear in time, by comparison to primary human capital.

This article will make Benhabib and Spiegel’s former model [3] extended to the regional level. The expression of formula is as follows:

\[
\frac{A_i(t)}{A(t)} = g(H_i) + c(H_i)\left(\frac{\max_j A_j(t)}{A_i(t)} - 1\right)
\]

(4)

The first item of formula 4 on the right is the regional innovation of human capital. The second item is pursuit, namely income gap between a certain region and the leading technology region. From the view of imitation innovation trends, Benhabib and Spiegel[3] expressed the convergence of form, while Benhabib and Spiegel’s latter model[4] was divergent form, as follows:

\[
\frac{A_i(t)}{A_i(t)} = g(H_i(t)) + c(H_i(t))\left(1 - \frac{A_i(t)}{\max_j A_j(t)}\right)
\]

(5)

Formula 5 conveys the same meaning. The difference is that the results of these two formulas are different. Formula 4 indicates a convergence trend that regional economic differences will narrow. Formula 5 means a divergence trend that regional economic differences will widen.

Reference to Romer’s [5] hierarchical thinking, this paper may be assumed as follows:

Assumption 1: Human capital is divided into two grades that play a catalytic role in advancing economic growth. One grade works as a direct factor of production as well as physical capital. The other grade serves as a tool to promote technological progress, and then transfer to the economic growth. Preliminary view is held that the role of higher education level will promote technological progress, playing an indirect conduction mechanism. Expressed in the following equation:

\[
H = H_A + H_Y
\]

(6)

Here \(H_A\) and \(H_Y\) are advanced human capital and primary human capital, respectively. Let \(H_A\) replace \(H_i\) in formula (5), which means advanced human capital may promote technical progress by autonomous innovation and imitation innovation, bringing about economic prosperity. (formula (7),(8))

\[
\frac{A_i(t)}{A(t)} = g(H_A) + c(H_A)\left[1 - \frac{A_i(t)}{\max_j A_j(t)}\right]
\]

(7)

\[
\frac{A_i(t)}{A(t)} = g(H_A) + c(H_A)\left(\frac{\max_j A_j(t)}{A_i(t)} - 1\right)
\]

(8)

Formula (7) and Formula (8) are forms of convergence and divergence of frontier imitating way, respectively. Convergence form indicates that backward areas access to technology spillover and spillover...
effects of human capital by imitating, achieving a successful catch-up of the forefront of technology areas, and even go beyond. However, divergence form denotes that backward regions cannot achieve it.

In practice, due to the remote distance, or large economic gap between backward areas and technological frontier areas, backward areas cannot imitate leading technology of frontier regions or attract top talents of frontier areas. Owing to the strong self-cumulative and path-dependent qualities of technology, technology gap is made too large. This will make the introduction of technology areas difficult to combine the region's human capital and to achieve a moderate match of R&D capital stock. It will weaken the motivation of technological innovation capability of human capital, resulting in backward areas of human insufficient capital accumulation, productivity fall and innovation efficiency drops, unable to accomplish technology absorption and innovation or integrated innovation[6].

Thus, backward regions can choose the next best thing to imitate their surrounding developed areas, to absorb technology diffusion effect in these areas. Based on this perspective, the article attempts to extend Benhabib and Spiegel mechanism, in which an imitation innovation considers peripheral imitation way. Meantime, it brings the economic distance and geographic distance into spatial factors.

Formula (9) and (10) indicate peripheral-imitation-convergence way and peripheral-imitation-divergence way, respectively. Compared to Formula (7) and (8), it can be simply understood that advanced human capital innovation and imitation items are given different weights, or as technological innovation to mimic the surrounding developed area. In addition to considering two kinds of imitation, leading edge of the region around and forefront of technology areas, backward areas will also analyse according to their own specific circumstances. Surely, some areas possess better technology. If backward areas cross these boundaries, globally take into account technology diffusion of all regions, and adopt catch-me mode, they will harvest technology diffusion effect. This can include that the technology gap is too large, small and modest imitation effect, which attract a variety of technology diffusion effects.

Formula (8) and (9) respectively recount multilateral-imitation-convergence way and multilateral-imitation-divergence way. In the study of economic growth effects of human capital as above, if we channel it into spatial spillover effect, we will continue to make the following assumptions:

Assumption 2: Human capital has spillover effects, including the production interaction, technology diffusion and innovative interactive between regions. The spillover effects of primary human capital, at this time, may attain maximum.

Assumption 3: Human capital in the form of technology diffusion between China’s regions is divergent. It performs not only in enrolling and imitating cutting-edge technologies, but also in miming relatively developed areas in surrounding cities and even nationwide.

Assumption 4: Peripheral-imitation-convergence way and multilateral-imitation-divergence way are more suitable to portray the actual situation. Multilateral-imitation-divergence way holds the overall best.

Panel models used in this article are deduced in the following steps: The first step consists of two models Benhabib-Spiegel[3,4]proposed. It divides the role of human capital for economic growth into two parts. One is autonomous innovation effect, and the other is imitation innovation. Afterwards, models are derivative into two directions, which are imitation-convergence way and imitation-divergence way. Then every step needs two trends to study. The second step includes human capital heterogeneity. The third step adds overflow space variables of human capital to the equation, assuming that two levels of human capital have spillover effect. The
fourth step is extended to peripheral imitation model, that is, considering the surrounding developed regions around area \( i \). Area \( i \) takes in technology diffusion in these regions. The fifth step is about multilateral imitation mode, namely, considering the global scope of the area. As long as those are more developed than region \( i \), region \( i \) will mimic those developed areas. Because more models are shown, we here will just take three panel models of the convergence trends as an example. Expressed as follows:

(A) Frontier-Imitation-Convergence-Model (abbreviated FICM)

\[
\log \frac{y_{it}}{y_{i0}} = \beta_1 + \beta_2 h_{Ait} + \beta_3 h_{it} \left(1 - \frac{y_{it}}{y_{\text{max},t}}\right) \frac{1}{a_{i,\text{max}}} + \beta_4 \log \frac{k_{it}}{k_{i0}} + \beta_5 \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \beta_6 \sum_{l \neq j} w_{ij} h_{Ait} + \\
\beta_7 h_{Ait} \left(1 - \frac{y_{it}}{y_{\text{max},t}}\right) \frac{1}{a_{i,\text{max}}} + \beta_8 \sum_{l \neq j} w_{ij} \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \beta_9 \sum_{l \neq j} w_{ij} \log \frac{k_{it}}{k_{i0}}
\]

(B) Peripheral-Imitation-Divergence-Model (abbreviated PIDM)

\[
\log \frac{y_{it}}{y_{i0}} = \psi_1 + \psi_2 h_{Ait} + \psi_3 \log \frac{k_{it}}{k_{i0}} + \psi_4 \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \psi_5 \sum_{l \neq j} w_{ij} h_{Ait} + \psi_6 \sum_{l \neq j} [w_{ij} \left(1 - \frac{y_{it}}{y_{j0}}\right) + h_{Ait} + \psi_7 \sum_{l \neq j} w_{ij} \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \psi_8 \sum_{l \neq j} w_{ij} \log \frac{k_{it}}{k_{i0}}] y_{jt} > y_{it}
\]

(C) Multilateral-Imitation-Divergence-Model (abbreviated MIDM)

\[
\log \frac{y_{it}}{y_{i0}} = \psi_1 + \psi_2 h_{Ait} + \psi_3 \log \frac{k_{it}}{k_{i0}} + \psi_4 \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \psi_5 \sum_{l \neq j} w_{ij} h_{Ait} + \psi_6 \sum_{l \neq j} \left(1 - \frac{y_{it}}{y_{j0}}\right) h_{Ait} + \\
\psi_7 \sum_{l \neq j} w_{ij} \log \frac{h_{v_{it}}}{h_{v_{i0}}} + \psi_8 \sum_{l \neq j} w_{ij} \log \frac{k_{it}}{k_{i0}} y_{jt} > y_{it}
\]

\( y_{it}, y_{i0}, y_{\text{max},t} \) are respectively the actual value of GDP per worker in period \( t \), the actual value of GDP per worker during the base period in region \( i \) and the actual value of GDP per worker in leading region. They are all converted to 1997 = 100 constant prices in order to eliminate the price factor influences. \( h_{it}, h_{Ait}, h_{v_{it}} \) are separately human capital per worker in region \( i \) in period \( t \), advanced human capital per worker and primary human capital per worker. The sum of latter two equals to the former. \( k_{it}, k_{i0} \) are respectively capital stock per worker in base area \( i \) during the period \( t \) and during the base period. \( d_{i,\text{max}} \) means spherical distance of region \( i \) and leading regions. Errors in formulas obey normal distribution. \( w_{ij} \) are spatial weight matrix elements.

4. Data

In this paper, the perpetual inventory method is used to measure physical capital. In addition, three auxiliary control variables will be introduced here. The openness (open) indicator is represented by dependence on foreign trade, namely, import and export volume accounts for the proportion of GDP, acting on behalf of changing open trade markets. Total imports and exports are translated into Renminbi level with the average exchange rate for each year. The government (gov) factor: Budget expenditure divided by the proportion of GDP is served as an agent. Population changes (n) factor: to a certain degree, it reflects the basic characteristics of each region's population resources. Some papers used growth rates of employees. Because each variable in our models acts as average variable labor, it concerns the impact of changes in the natural population, namely natural population growth rate.

This article uses in the empirical analysis a first-order neighbor spatial weights matrix \([8,9]\) and distance attenuation spatial weights matrix. Since this analysis comes across 30 provinces and autonomous regions, which basically are bordered area, the use of first-order neighbor spatial weights matrix is logical. Besides, imitation effects of advanced human capital getting from leading region are assigned with distance attenuation spatial weights matrix. Imitation effects of advanced human capital getting from the surrounding leading region are endowed with both economic distance and unstandardized spatial weights matrix. Imitation effects of advanced human capital getting from multilateral leading region are assigned with economic distance matrix. Such spatial weight contains both economic distance as well as spatial weight. To some extent, it avoids subjectivity spatial weight settings, leading to better effects of spatial regression model than ordinary regression.
That is why this paper has put forward the hypothesis mentioned in the previous section 4. That the effect of the peripheral imitation mechanism will be superior to either multilateral mechanism or frontier imitate mechanism.

The specific configuration process of those types of weight matrix is as follows:

\[
\begin{pmatrix}
    y_{1t} & y_{2t} & \ldots & y_{30t} \\
    y_{1t} & y_{1t} & \ldots & y_{1t} \\
    y_{1t} & y_{2t} & \ldots & y_{30t} \\
    \vdots & \vdots & \ddots & \vdots \\
    y_{1t} & y_{2t} & \ldots & y_{30t} \\
\end{pmatrix}
\]

If \( \frac{y_{it}}{y_{jt}} - 1 < 0 \), let \( a_{ij} = 0 \); otherwise if \( \frac{y_{it}}{y_{jt}} - 1 > 0 \), let \( a_{ij} = \frac{y_{it}}{y_{jt}} - 1 \).

5. Empirical results

This paper will split imitation effect of human capital into three kinds. They are frontier imitate, peripheral imitate and multilateral imitate. From the trend of convergence and divergence, as well as to incorporate spatial factors or spatial factors not included in two dimensions, it exerts a deep study on varied economic growth effects of heterogeneous human capital. The spillover effects of advanced human capital are composed of three segments effects of human capital. In other words, they are imitation effect of advanced human capital, distance imitation effect and interactive innovation effects of neighboring regions.

5.1. Analysis of Chinese Provincial Economic Growth Effects of Human Capital

Thanks to numerous models, some of the results are summarized as follows:

Table 1. Results of Spatial-Frontier-Imitation-Divergence-Model

<table>
<thead>
<tr>
<th>Independent variable (Coefficient)</th>
<th>(1) (RE)</th>
<th>(2) (RE)</th>
<th>(3) (FE)</th>
<th>(4) (RE)</th>
<th>(5) (FE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1122***</td>
<td>-0.0316</td>
<td>-0.1906**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0288)</td>
<td>(0.0229)</td>
<td>(0.0855)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \log k_{it} )</td>
<td>1.0242***</td>
<td>0.8318***</td>
<td>0.8064***</td>
<td>1.0134***</td>
<td>0.9967***</td>
</tr>
<tr>
<td></td>
<td>(0.0382)</td>
<td>(0.0308)</td>
<td>(0.0313)</td>
<td>(0.0257)</td>
<td>(0.0255)</td>
</tr>
<tr>
<td>( \log h_{Yit} )</td>
<td>0.2811***</td>
<td>0.4453***</td>
<td>0.4754***</td>
<td>0.4333***</td>
<td>0.4602***</td>
</tr>
<tr>
<td></td>
<td>(0.0964)</td>
<td>(0.0748)</td>
<td>(0.0750)</td>
<td>(0.0807)</td>
<td>(0.0807)</td>
</tr>
<tr>
<td>( h_{Alt} )</td>
<td>0.0891***</td>
<td>0.0740***</td>
<td>0.0754***</td>
<td>0.1096***</td>
<td>0.1165***</td>
</tr>
<tr>
<td></td>
<td>(0.0107)</td>
<td>(0.0088)</td>
<td>(0.0098)</td>
<td>(0.0088)</td>
<td>(0.0095)</td>
</tr>
<tr>
<td>( h_{Alt} \left( 1 - \frac{y_{it}}{y_{max}} \right) )</td>
<td>-0.0831***</td>
<td>-0.0586***</td>
<td>-0.0502***</td>
<td>-0.1406***</td>
<td>-0.1503***</td>
</tr>
<tr>
<td></td>
<td>(0.0196)</td>
<td>(0.0131)</td>
<td>(0.0135)</td>
<td>(0.0187)</td>
<td>(0.0193)</td>
</tr>
<tr>
<td>( h_{Alt} \left( 1 - \frac{y_{it}}{y_{max}} \right) \left( \frac{1}{d_{max}} \right) \sum_{j \neq i} w_{ij} h_{Alt} )</td>
<td>-7.3377**</td>
<td>-3.4595</td>
<td>-0.0502***</td>
<td>-0.0997</td>
<td>0.8032</td>
</tr>
<tr>
<td></td>
<td>(3.6198)</td>
<td>(2.5561)</td>
<td>(0.0135)</td>
<td>(2.9227)</td>
<td>(2.9664)</td>
</tr>
<tr>
<td>( \sum_{j \neq i} w_{ij} h_{Alt} )</td>
<td>0.0541***</td>
<td>-0.0158</td>
<td>-0.0237*</td>
<td>0.1086***</td>
<td>0.1176***</td>
</tr>
<tr>
<td></td>
<td>(0.0178)</td>
<td>(0.0132)</td>
<td>(0.0143)</td>
<td>(0.0195)</td>
<td>(0.0206)</td>
</tr>
<tr>
<td>( \sum_{j \neq i} w_{ij} \log h_{Yit} )</td>
<td>-0.2038</td>
<td>-0.3038***</td>
<td>-0.3507***</td>
<td>0.4945***</td>
<td>0.5437**</td>
</tr>
<tr>
<td></td>
<td>(0.1548)</td>
<td>(0.1069)</td>
<td>(0.1051)</td>
<td>(0.1694)</td>
<td>(0.1686)</td>
</tr>
<tr>
<td>( \sum_{j \neq i} w_{ij} \log k_{it} )</td>
<td>0.7036***</td>
<td>-0.4795***</td>
<td>-0.5011***</td>
<td>0.6332***</td>
<td>0.6381***</td>
</tr>
<tr>
<td></td>
<td>(0.0383)</td>
<td>(0.0306)</td>
<td>(0.0591)</td>
<td>(0.0305)</td>
<td>(0.0306)</td>
</tr>
</tbody>
</table>
Imitation effect has divergent trends. Apart from the big difference between coefficient of imitation effect, others have little difference. The absolute value of coefficient is significantly higher than convergence trend models. It shows that China’s spillover mechanism exhibits divergent trend. This may be due to technical barriers between developed regions and backward regions.

Spillover effects of advanced human capital in divergence mechanism are less than innovation effects of advanced human capital. Because advanced innovation effect of diverging trend areas is not as prominent as advanced spillover effects, we should mainly push technology imitation, and thus makes it play the role of spillover effects. By contrast, advanced innovation effect of regional convergence trend is more outstanding. So we here mainly advance technology innovation, making it undertake effect of innovation of advanced human capital. Using PIDM, we will obtain advanced innovation effect of 0.1094, spillover effect of 0.2951. If MIDM is used, we will gain such results as advanced innovation effect of 0.1101, spillover effects of 0.128.

The spillover effects of either advanced human capital or primary human capital have played a significant role in booming economy. In particular, the spillover effects of advanced human capital in PIDM. It indicates that externality of human capital in China is very obvious. The technical divergence can make economic progress available in underdeveloped areas nearby. When we put stress on advanced human capital spillover, we cannot ignore the role of primary human capital spillover in neighboring areas (Take MIDM for example, primary human capital spillover effects is 0.6226, the spillover effects of advanced human capital 0.128).

Table 2. Results of Spatial-Peripheral-Imitation-Divergence-Model

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>(Coefficient)</th>
<th>(RE)</th>
<th>(RE)</th>
<th>(RE)</th>
<th>(FE)</th>
<th>(FE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1344***</td>
<td>(0.0288)</td>
<td>-0.0343</td>
<td>(0.0227)</td>
<td>-0.2344**</td>
<td>(0.0982)</td>
</tr>
<tr>
<td>$\log \frac{k_i}{k_{i0}}$</td>
<td>1.0582***</td>
<td>(0.0393)</td>
<td>0.8072***</td>
<td>(0.0325)</td>
<td>1.0184***</td>
<td>(0.0326)</td>
</tr>
<tr>
<td>$\log \frac{h_{i0}}{h_{i00}}$</td>
<td>0.2590***</td>
<td>(0.0996)</td>
<td>0.4979***</td>
<td>(0.0769)</td>
<td>0.4229***</td>
<td>(0.0841)</td>
</tr>
<tr>
<td>$\frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij} (1 - y_{ij} / y_{i0}) }{h_{i0}}$</td>
<td>0.0461***</td>
<td>(0.0179)</td>
<td>0.2092***</td>
<td>(0.1607)</td>
<td>0.1434***</td>
<td>(0.1055)</td>
</tr>
<tr>
<td>$\frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij} \frac{h_{i0}}{h_{i00}} }{k_{i0}}$</td>
<td>0.6811***</td>
<td>(0.0399)</td>
<td>-0.5462***</td>
<td>(0.0325)</td>
<td>0.5946***</td>
<td>(0.0321)</td>
</tr>
<tr>
<td>splag</td>
<td>0.7875***</td>
<td>(0.0463)</td>
<td>0.8149***</td>
<td>(0.0313)</td>
<td>0.3866***</td>
<td>(0.0915)</td>
</tr>
<tr>
<td>(λ)</td>
<td>(0.1401)</td>
<td>(0.0915)</td>
<td>(0.0391)</td>
<td>(0.0312)</td>
<td>(0.1401)</td>
<td>(0.0915)</td>
</tr>
<tr>
<td>spar</td>
<td>-0.4717***</td>
<td>(0.0312)</td>
<td>0.7098***</td>
<td>(0.0289)</td>
<td>0.7427***</td>
<td>(0.0287)</td>
</tr>
</tbody>
</table>

See notes in Table 1.
Table 3. Results of Spatial-Multilateral-Imitation-Convergence-Model

<table>
<thead>
<tr>
<th>Independent variable (Coefficient)</th>
<th>(1) (RE)</th>
<th>(2) (RE)</th>
<th>(3) (RE)</th>
<th>(4) (FE)</th>
<th>(5) (FE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.1109</td>
<td>-0.3126***</td>
<td>-0.0775*</td>
<td>-0.0773**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.058)</td>
<td>(0.0392)</td>
<td>(0.0365)</td>
<td></td>
</tr>
<tr>
<td>( \log \frac{k_{it}}{k_{io}} )</td>
<td>1.5570***</td>
<td>1.8216***</td>
<td>1.6408***</td>
<td>1.6384***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.037)</td>
<td>(0.0401)</td>
<td>(0.0242)</td>
<td></td>
</tr>
<tr>
<td>( \log \frac{h_{it}}{h_{i0}} )</td>
<td>-1.4952***</td>
<td>0.6443**</td>
<td>-0.6488***</td>
<td>0.1887</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.4016)</td>
<td>(0.2251)</td>
<td>(0.2242)</td>
<td>(0.1616)</td>
<td></td>
</tr>
</tbody>
</table>

See notes in Table 1.

In common panel analysis, coefficient of imitation effect of advanced human capital is not stable in a significant positive effect, but counterproductive. Even if it is not notable in ordinary regression, it is counterproductive. After the addition of the argument spatial items, there is still a spatial correlation to be discovered. In spatial panel model analysis, there exists a cross-sectional correlation between provinces. Therefore, spatial panel data analysis is more able to obtain useful information from the disturbance item.

By imitating multilateral way, it is proved that the spillover effects no longer focus on the imitation effect of advanced human capital, but rather to separate a portion to the spillover effects of innovation in advanced human capital. Nevertheless, it is not obvious that primary human capital produces spillover effects. Compared to frontier imitate fashion, peripheral imitation model can care for two spillover effects, spillover effects of innovation and technological imitation in advanced human capital. Peripheral imitation model can exceed frontier imitate fashion (Take divergent trends in surrounding imitate for example, advanced spillover effects is 0.2951, multilateral imitate 0.128, but frontier imitate is -0.0327). The study shows that multilateral approach is better than frontier imitate way (Take convergence trend for example, senior spillover effects in multilateral imitate is 0.1374, surrounding imitate 0.0540, but frontier imitate is -11.3099).

5.2. Analysis of Chinese Regional Economic Growth Effects of Human Capital

Table 4. Results of Imitation-Convergence-Model for regions

<table>
<thead>
<tr>
<th>Independent variable (Coefficient)</th>
<th>(1) Northeast</th>
<th>(2) East</th>
<th>(3) Middle</th>
<th>(4) West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.1109</td>
<td>-0.3126***</td>
<td>-0.0775*</td>
<td>-0.0773**</td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.058)</td>
<td>(0.0392)</td>
<td>(0.0365)</td>
</tr>
<tr>
<td>( \log \frac{k_{it}}{k_{io}} )</td>
<td>1.5570***</td>
<td>1.8216***</td>
<td>1.6408***</td>
<td>1.6384***</td>
</tr>
<tr>
<td></td>
<td>(0.043)</td>
<td>(0.037)</td>
<td>(0.0401)</td>
<td>(0.0242)</td>
</tr>
<tr>
<td>( \log \frac{h_{it}}{h_{i0}} )</td>
<td>-1.4952***</td>
<td>0.6443**</td>
<td>-0.6488***</td>
<td>0.1887</td>
</tr>
<tr>
<td></td>
<td>(0.4016)</td>
<td>(0.2251)</td>
<td>(0.2242)</td>
<td>(0.1616)</td>
</tr>
</tbody>
</table>
Xianyu Chang and Yong Shi  /  Procedia Computer Science   91  ( 2016 )  1096 – 1105

Notes: 1. Northeast indicates model results within northeast region. The same situation is for East, Middle and West. 2. See notes 1-2 in Table 3.

Following the first part of the empirical analysis framework, this paper will analyze effect of mechanisms within China’s four regions, namely east, west, northeast and middle region. It will also study whether the effect of human capital in each region is consistent with that in provincial analysis.

When 30 Chinese provinces are divided into four regions, different scenes can be seen in each region. In east and north east region with higher level of human capital, the imitation effects of advanced human capital have convergence trends (Table 4). The western region is a clear divergence trend (Table 5). The central region is rendered uncertain trend. It may converge or may diverge. It is worth mentioning that northeast region has gradually lost its position as previously described at the beginning of the leading human capital advantage. Only in the implementation of multilateral imitate way can innovation effect of its senior human capital works well. In China, club divergence phenomenon in western region is significant, while such phenomenon in east, northeast and central regions is uncertain. It confirms the idea of human capital on economic growth transmission mechanism.

The role of physical capital stock is significantly promoted, and regional interaction of physical capital stock is functioning well in boosting the economic growth. Although the role of primary human capital is still less than that of physical capital stock, but the difference is very small. It is market openness that creates an eminent advance. If the regulation of government is not forceful, the advancement of the natural population growth rate is not obvious. This conclusion is consistent with the situation nationwide regardless of the region.

Table 5. Results of Multilateral-Imitation-Divergence-Model for regions

<table>
<thead>
<tr>
<th>Independent variable (Coefficient)</th>
<th>(1) Northeast</th>
<th>(2) East</th>
<th>(3) Middle</th>
<th>(4) West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0858</td>
<td>-0.2977***</td>
<td>-0.1155***</td>
<td>-0.1044***</td>
</tr>
<tr>
<td></td>
<td>(0.0870)</td>
<td>(0.0482)</td>
<td>(0.0382)</td>
<td>(0.0327)</td>
</tr>
<tr>
<td>$\log \frac{k_{it}}{k_{io}}$</td>
<td>1.5108***</td>
<td>1.7505***</td>
<td>1.6904***</td>
<td>1.6304***</td>
</tr>
<tr>
<td></td>
<td>(0.0419)</td>
<td>(0.0377)</td>
<td>(0.0385)</td>
<td>(0.02457)</td>
</tr>
<tr>
<td>$\log \frac{h_{it}}{h_{ito}}$</td>
<td>-1.1602</td>
<td>0.7063***</td>
<td>-0.7009***</td>
<td>0.1699</td>
</tr>
<tr>
<td></td>
<td>(0.399230)</td>
<td>(0.2096)</td>
<td>(0.2609)</td>
<td>(0.1597)</td>
</tr>
<tr>
<td>$\frac{\sum_{i=1}^{N} (1 - \frac{y_{it}}{\bar{y}<em>{it}}) h</em>{it}}{N}$</td>
<td>0.0456***</td>
<td>0.1394***</td>
<td>0.1613***</td>
<td>0.1181***</td>
</tr>
<tr>
<td></td>
<td>(0.3798)</td>
<td>(0.0104)</td>
<td>(0.0490)</td>
<td>(0.02832)</td>
</tr>
<tr>
<td>$\sum_{i=1}^{N} (1 - \frac{y_{it}}{\bar{y}<em>{it}}) h</em>{it}$</td>
<td>0.0148**</td>
<td>0.0373***</td>
<td>-0.0102*</td>
<td>0.0048**</td>
</tr>
<tr>
<td></td>
<td>(0.0073)</td>
<td>(0.0059)</td>
<td>(0.0058)</td>
<td>(0.0024)</td>
</tr>
<tr>
<td>R$^2$ adjusted</td>
<td>0.9831</td>
<td>0.9523</td>
<td>0.9839</td>
<td>0.974</td>
</tr>
</tbody>
</table>

See notes in Table 4.

6. Conclusion and recommendations

In summary, the final conclusion shares partial agreement with Huang[11], that is, when human capital is measured by years of education, primary and advanced human capital can promote economic growth, but work in a different way. Primary human capital directly contributes to the final output of increase. Whereas, it is advanced human capital that stimulates economic growth via technological innovation. Consistent with Zhang[6], this study agrees that it cannot simply expand the technology introduction as well as digestion and absorption of expenditure to solve the problem in the digestion and absorption capacity of high-tech industry, but should increase investment in education to enhance human capital in technology backwardness.

This paper agrees that it is not the higher the level of human capital stock, the greater effect the technological innovation will have. However, as level of advanced human capital mounting, the effect of
technology innovation is not only significant and affects the peripheral regions. The spillover effects of innovation and imitate will exert, thereby increasing the productivity of the whole society, leading to increasing returns to sustained economic growth. As to the paths of technology imitation in major cities across the country, there is no single mode. We may choose to imitate the leading region or multilateral areas. There is no need to rigidly adhere to the convergence or divergence. We can choose either of them or even neutral trend. In addition, the club divergence in western China is shining. Meanwhile east, northeast and central regions are uncertain.

To this end, recommendations in view of the development of human capital are given as follows:

First of all, the investment in human capital should be increased and structure proportion of sub-region should be optimized, giving rise to advance human capital accumulation. Whether in developed eastern or backward western regions, investment in human capital is still particularly important. The level of human capital stock increase will make economic growth sustained and stable, while developed regions can drive backward regions to imitate to catch up, thus forming coordinated interaction between regions. Regions within China should increase investment in human capital in all aspects. The first is to increase education funding. Enlarging investment in higher education on the basis of universal primary education is a trend and must so that a large number of advanced human capital can be reserved. Ensuring the quality of higher education, it is of great importance for advanced human capital to achieve economic effects of innovation. Based on the optimization of human capital structure, balanced development in the region will be going well. Middle region should focus on independent innovation effects as well as increase the investment proportion of high-level human capital. West region should give attention to imitation innovation effect, raising the investment proportion of primary human capital. Both eastern and northeastern should take two steps and coordinate parallel.

Moreover, regional economic interaction may be strengthened and human capital spillovers may be enhanced, boosting technology diffusion. The spillover effects of human capital on economic growth are significant, and primary human capital is higher than that of advanced human capital, especially in the most prominent peripheral imitate effects of advanced human capital. As a result, emphasis should be put on the interaction between economic regions, especially among the neighborhood. To promote the communication of backward areas and surrounding developed areas, we should strengthen economic links between the eastern region and the midwest region. It is vital to foster technology diffusion to act more comprehensive and far-reaching, so as to realize China’s overall coordination economic development.

References

[7] ZHANG Jun