Empirical Research on the Relationship among Human Capital, Technological Innovation Capability and Economic Growth in Beijing-Tianjin-Hebei Region

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Abstract. This paper analysed the relationship among human capital stock, science and technology innovation capacity and regional economic growth comprehensively, by using 2000-2014 panel data of the Beijing-Tianjin-Hebei economic region. The main conclusions are as follows: human capital stock, scientific and technological innovation capacity and regional economic growth has long-term cointegration relationship in the region, and the level of human capital stock’s promote can more improve the regional economic growth significantly. Finally, this paper put forward some corresponding policy recommendations to promote the positive interaction of human capital investment, scientific and technological innovation and economic growth of Beijing-Tianjin-Hebei region.

Introduction

In recent years, China's economic development has been the impact of the international financial crisis, the trend of slowing economic growth is becoming more and more obvious with the deepening of its economic transformation and reform. Since 2011, China's economic growth rate continues to slow down, into a slowdown in the transformation of the economic new normal. The central economic work conference point out that China's economic growth momentum needs to be transformed from “factor scale” to “innovation driven” which is more dependent on the quality of human capital and technological progress in 2014. Li Yining further put forward that innovation and reform is the key to China's economic transformation under the pressure of a slowing economy in 2015.¹

Science and technology innovation capability reflects the potential of economic development of a country or region. Human capital as the essential factor resources and knowledge carrier of regional science and technology innovation ability, has a direct impact on the innovation capability of regional innovation subjects. As a favorable factor to solve the problems of economic development in the region, the human capital have a decisive influence on regional economic structure and economic development mode.¹

Beijing-Tianjin-Hebei economic region is the core power of the third pole of economic development in China, which plays an important role in the development of China's economy. The collaborative development of the region has risen to the national major strategy since 2014. At present, however, the overall economic strength of the region is weak compared to the Yangtze River Delta and the Pearl River Delta economic circle, and its regional economic development has the imbalance structure. Regional economic and social development is unbalance, human capital, regional science and technology innovation ability and economic growth of the interaction will further aggravate the development imbalance.

Based on the econometric model of the panel data of the region, this paper will analyze the relationship among human capital stock, regional innovation capability, and its impact on economic development.

¹ Li Yining’s lecture in the meeting prior to the opening ceremony of the National People's Congress in 2015.
growth in the area and analyze the influence factors of economic growth in the region. Then provide some corresponding policy recommendations on how to reduce the gap of region economic development and how to promote the coordinated development of Beijing-Tianjin-Hebei region.

**Literature Review**

The foreign research on the relationship among human capital, scientific and technological innovation and economic growth has made a wealth of research results. Schultz (1961) first put forward the concept of human capital, he believes that the consumption of material things belong to the category of human capital investment in reality, human capital growth significantly improve the quality of economic work, improvement of the quality of the work can further promote the economic growth.[2] Dakhli, Clercq (2004) made an empirical study by using innovation data of 59 countries in the word, he found that human capital plays a catalytic role in technology innovation process, and a country's overall level of human capital can have a positive effect on its innovation ability.[3] Gallie and Legros (2012) analysed the influence of the level of human capital and R&D on the technological innovation of enterprises by using some French companies data from 1986 to 1992. The research shows that human capital has a positive impact on technological innovation, human capital cannot be significantly promotes the production, but has a significant effect on total factor productivity.[4]

Domestic scholars started late. Lin Yifu, Zhang Pengfei (2005) analysed the suitability of science and technology of the developing country, thought that the technology innovation activities of the developing countries is limited to the human capital endowment, whether it is imitation or independent innovation activities, are built on the premise that a country have compatible human capital stock level.[5] Liu Zhiyong, Hu Yongyuan and Yi Xianzhong (2008) analyzed the human capital mechanism, made a conclusion that human capital promote the growth of economic as direct production elements, at the same time, promoting economic growth through technology innovation, which is a intermediary indirectly.[6] Zhu Min, Gao Yue (2012) using human capital data of overseas students from 1985 to 2008 in China, for the empirical analysis about human capital flow effect on absorption of FDI technology, that flow of human capital can enhance the absorptive capacity of China’s science and technology, and increase the contribution rate of FDI to the economic growth.[7] Lai Desheng, Ji Wenwen (2015) analysed human capital allocation of innovation by constructing the production, protection and the impact of profit model, thought that differences of the allocation of human capital leads to the differences in scale and innovation efficiency.[8]

However, previous studies mainly focus on the impact of human capital on economic growth, and the relationship among innovation ability and economic development level, lack of regional differences analysis on relationship among human capital, regional innovation capacity and economic growth of Beijing-Tianjin-Hebei region. This paper established a panel data model for empirical analysis by using the data of the region through eviews7 software, to investigate the relationship among the three economic subjects in the region.

**The Empirical Analysis**

**The Indicators and Data**

Based on previous research, this article selects the number of patent license PAT as the index to measure regional innovation capability of Beijing-Tianjin-Hebei economic region in a lot of indicators to evaluate output efficiency of science and technology as explained variable. Using GDP per capita index as a measure indicator of regional economic growth rate of Beijing-Tianjin-Hebei region, to be explained variable.

Selection the data of per capita GDP and the data of patent grant in Beijing-Tianjin-Hebei region in 2000-2014, as sample data, and construct econometric models. Data from China statistical
yearbook of the national bureau of statistics from 2001 to 2015, and science and technology of China statistical yearbook of National ministry of science and technology.

Education is an main impact factor to improve the human capital stock, the most widely method to calculate the human capital stock is by average education years, taking the population’s average years of education at age 6 and above of Beijing-Tianjin-Hebei region as a measure of the stock of human capital. Calculating formula is:

\[
HR = \frac{\sum P_i E_i}{P}
\]

Among them, HR is the stock of human capital; i=1,2,3... Represents the education level divided by the number of years of education; Pi represents the total number of population for the i level; Ei the average number of years of education for the i level; Represents the total population at age 6 and above. Classification average population education of Beijing-Tianjin-Hebei region as the following categories: Illiterate and semi-literate for 0 years, primary school for 6 years, junior high school for 9 years, high school (including Secondary specialized school) for 12 years, the University (College and above) for 16 years. The average education years of Beijing-Tianjin-Hebei region is selected according to related data in 2000-2014 through the formula, the data source from 2001-2015 “China Statistical Yearbook”.

Unit Root Test

To judge whether the original sequence contains intercept and trend items or not according to the LnHR, LnPAT and LnGDP data sequence trend graphics. The unit root test was carried out on the LnHR, LnPAT and LnGDP respectively through Augmented Dickey-Fuller Test. Determine the best lag order according to the AIC criteria. Through the ADF test, it is found that the original log time series is not stable, but the time series of the first order difference show the characteristic of the stationary. Test results are as follows:

**Table 1. Augmented Dickey-fuller Test.**

<table>
<thead>
<tr>
<th>variable</th>
<th>ADF</th>
<th>1% level</th>
<th>5% level</th>
<th>10% level</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔLnHR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>-3.8412</td>
<td>-4.0579</td>
<td>-3.1199</td>
<td>-2.7011</td>
<td>0.0145</td>
</tr>
<tr>
<td>Tianjin</td>
<td>-5.7313</td>
<td>-4.0579</td>
<td>-3.1199</td>
<td>-2.7011</td>
<td>0.0006</td>
</tr>
<tr>
<td>Hebei</td>
<td>-3.4456</td>
<td>-2.7550</td>
<td>-1.9710</td>
<td>-1.6037</td>
<td>0.0023</td>
</tr>
<tr>
<td>ΔLnGDP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>-3.7052</td>
<td>-4.0579</td>
<td>-3.1199</td>
<td>-2.7011</td>
<td>0.0184</td>
</tr>
<tr>
<td>Tianjin</td>
<td>-6.5080</td>
<td>-5.2954</td>
<td>-4.0082</td>
<td>-3.4608</td>
<td>0.0026</td>
</tr>
<tr>
<td>Hebei</td>
<td>-14.8499</td>
<td>-5.1376</td>
<td>-4.1302</td>
<td>-3.5018</td>
<td>0.0001</td>
</tr>
<tr>
<td>ΔLnPAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>-2.9140</td>
<td>-2.7550</td>
<td>-1.9710</td>
<td>-1.6037</td>
<td>0.0302</td>
</tr>
<tr>
<td>Tianjin</td>
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<td>-4.0579</td>
<td>-3.1199</td>
<td>-2.7011</td>
<td>0.0204</td>
</tr>
<tr>
<td>Hebei</td>
<td>-3.8449</td>
<td>-4.8864</td>
<td>-3.8290</td>
<td>-3.3630</td>
<td>0.0488</td>
</tr>
</tbody>
</table>

According to the test results, a differential sequence smooth at the critical level of 5%. Namely, the number of the log for human capital stock, regional economic growth and the number of patent applications is not smooth of Beijing-Tianjin-Hebei region. After the first order difference, the logarithm series is stable in the 5% significant level, to meet the cointegration premise, we can further carry out the cointegration test and establish the panel data model.

Cointegration Test

The cointegration relationship can describe the balance among multiple sequences, and the Cointegration Test is carried out by Engle-Granger Test in the model which was established in this paper. The least square method is used to estimate the regression model, and the residual sequence is obtained. Regression model is as follows:
\[
\text{LnGDP}_{it} = \alpha \text{LnPAT}_{it} + \beta \text{LnHR}_{it} + \varepsilon_i
\]  

(2)

Among them, \(i=1,2,3\) were expressed in Beijing city, Tianjin city and Hebei Province respectively, and \(t=1,2,\ldots,15\). To test the stationarity of the residual series, the residuals are free of trend and intercept according to the trend chart of residual series, as shown in Figure 1.

![Residual Series Trends](image)

Figure 1. The Trend of Residual series of Beijing-Tianjin-Hebei Region.

Further, the three residual sequences have been tested for unit root, and the residual series are stable under the significant level of 5\% according to \(p\) value. Thus, there is long-term cointegration relationship among variables HR, PAT, GDP of the Beijing-Tianjin-Hebei region. That is the long-term stability of the proportion of relations. We have known that human capital, regional innovation capacity and regional economic growth of Beijing-Tianjin-Hebei region are in the long-term equilibrium, this article will carry on the Grainger causality test to further reveal the direction of the causal relationship among the three factors.

**Granger Causality Test**

We can know that the covariance sequence of the residual series has passed the significant level of 5\% from above test results. Variable lag period was 1 based on the comprehensive judgment of the AIC and SC standards by several experiments.

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Beijing</th>
<th>Tianjin</th>
<th>Hebei</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnHR is not LnGDP’s granger cause</td>
<td>0.4104 acceptance</td>
<td>0.4041 acceptance</td>
<td>0.5258 acceptance</td>
</tr>
<tr>
<td>LnGDP is not LnHR’s granger cause</td>
<td>0.0581 rejection</td>
<td>0.0038 rejection</td>
<td>0.1199 acceptance</td>
</tr>
<tr>
<td>LnPAT is not LnGDP’s granger cause</td>
<td>0.6582 acceptance</td>
<td>0.1501 acceptance</td>
<td>0.1551 acceptance</td>
</tr>
<tr>
<td>LnGDP is not LnPAT’s granger cause</td>
<td>0.0555 rejection</td>
<td>0.0292 rejection</td>
<td>0.0471 rejection</td>
</tr>
<tr>
<td>LnHR is not LnPAT’s granger cause</td>
<td>0.1709 acceptance</td>
<td>0.2323 acceptance</td>
<td>0.6694 acceptance</td>
</tr>
<tr>
<td>LnPAT is not LnHR’s granger cause</td>
<td>0.0320 rejection</td>
<td>0.0088 rejection</td>
<td>0.0089 rejection</td>
</tr>
</tbody>
</table>

We can know that GDP is HR’s granger cause in Beijing and Tianjin; GDP is PAT’s granger cause in Beijing, Tianjin and Hebei; PAT is HR’s granger cause in Beijing, Tianjin and Hebei at the significant level of 10\%, at a time the explanatory variable lags one order. Conclusions are as follows: Regional economic growth can significantly increase the stock of human capital in Beijing and Tianjin. Regional economic growth can significantly increase the level of human capital stock in the Beijing-Tianjin-Hebei region. Science and technology innovation capability can significantly increase the level of human capital stock in the Beijing-Tianjin-Hebei region. It should be noted that
science and technology innovation capability and human capital stock to promote economic growth in the presence of time lag effect, the production of economic benefit is always lagging behind the improvement of innovation investment and the stock of human capital.

The Panel Data Model

The Pool object focuses on the analysis of the data of the time series that the members of the cross section, while the period is longer. This paper examines the time series data of 15 regions in Beijing, Tianjin and Hebei, from 2000 to 2014, 15 years. So this paper chooses to establish pool object in the Eviews software to complete the establishment of panel data model. To determine the difference of intercept is fixed or random by using the Hausman test in the model.

Assumption:

\[ H_0 : \varepsilon_i \text{ is not related to } X_{it} \text{ (Random effects)} \]
\[ H_1 : \varepsilon_i \text{ is not related to } X_{it} \text{ (Fixed effects)} \]

According to Hausman test results, reject the original hypothesis because the \( m \) value of the known statistic is 101.68, and its \( p \) value is less than the significant level 0.05. So, the panel data model should be set as a fixed effects model in this paper. The fixed effect model of human capital, technological innovation and economic growth of Beijing-Tianjin-Hebei region is as follows:

\[
\text{LnGDP}_{it} = 0.4595 \text{LnPAT}_{it} + 2.5667 \text{LnHR}_{it} + 0.5323
\]

\( t: \) (6.7697) (2.6536) (0.3209) (3)

Model can explain the contribution of the stock of human capital science and technology innovation capacity to regional economic growth to a certain extent. The influence coefficient of Human capital, scientific and technological innovation capacity on economic growth factors were 2.5667 and 0.4595. It shows that the stock of human capital, scientific and technological innovation capability and economic growth in the long-term cointegration of the premise, the three factors are positive correlation. Both human capital and scientific and technological progress can promote regional economic growth, that the impact of human capital on regional economic growth is more significant compared to the technological innovation ability, because of the coefficient of human capital stock is larger than that of science and technology innovation ability.

Conclusion and Suggestion

This paper made unit root test, cointegration test and Granger causality test respectively by using the panel data of Beijing-Tianjin-Hebei economic region of 2000-2014. Conclusions are as follows: The stock of human capital, science and technology innovation capacity and regional economic growth has a long-term equilibrium relationship. Human capital stock, scientific and technological innovation capacity can promote regional economic growth in Beijing-Tianjin-Hebei region. The science and technology innovation capacity are able to significantly increase the level of its human capital stock in the region. About contribution of the human capital stock and scientific and technological innovation factors to regional economic growth, it is concluded that human capital can promote regional economic growth more significantly than the regional innovation capability.

The deficiencies of this empirical analysis need to be point out is that this paper only examined the relevant panel data, the impact of economic and social economic growth on human capital and scientific and technological innovation capacity needs to be further investigated. But overall, improving the human capital and the regional innovation capability is an effective way to promote regional economic growth.

Facing the new normal state of economic development, China’s power of economic growth will change from investment driven mainly to a kind of multi-wheel driven of investment and consumption and innovation in the future, so the technological innovation and technological progress is crucial.[9] To promote the positive interaction of human capital investment, scientific
and technological innovation and economic growth of Beijing-Tianjin-Hebei region, there are several suggestions:

1) The innovation of science and technology is the important driving force of economic development. Beijing-Tianjin-Hebei economic region has abundant resources of science and technology innovation, the region should make full use of geographical and resource advantages, continue to increase investment in science and technology innovation, encourage enterprises to carry out scientific and technological innovation activities, and give tax policy support and preferential privilege to the enterprise for its research and development activities. Guide the mutual butt joint of industry-university-research production, promote the transformation of scientific and technological innovation, to create a good industry conditions and market demand for the development and application of new technology. At the same time, the region should also accelerate the strategic adjustment of economic structure, promote the optimization and upgrading of the industrial structure to realize the development that driven by innovation.

2) In the era of knowledge economy, human capital is replacing natural capital, material capital and other production factors, and gradually become an important driving force to promote the economic growth. The science and technology human resources of Beijing are rich, the city should continue to increase the investment on higher education, as well as to increase the cultivation of independent innovation oriented talents of high-end talent and incentives in the new period. Tianjin’s human capital stock level is high, the city should guarantee its basic education, and at the same time increase the investment on higher education to promote the degree of talent training and attraction in the process of undertaking industrial transfer from Beijing city. Hebei Province’s human capital stock level is far lower than Beijing and Tianjin, the improvement of basic education is still the most important problem, the city should make full use the human resources advantage of Beijing and Tianjin, and strengthen regional cooperation and innovation, to achieve the goal of sharing the human resource of Beijing and Tianjin region.

References