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Empirical studies of the relationship between technological innovation and economic growth - Shanghai-based panel data analysis

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ABSTRACT

This paper is mainly to study both the relationship between technological innovation and economic growth, and the dynamic equilibrium relationship between science and technology human capital and economic growth. In the current era, innovative talents of science and technology are gradually becoming the core elements of competition in national and regional development, but also becoming an important support for building an innovative country and the key to master the initiative. In this context, research on this topic has important and practical significance.

Firstly, in this paper, it builds an interpretation model of technology and economic growth to study the relationship between economic growth and technologic innovations. A positivistic model is established by applying the vector autoregressive (VAR) model in this paper. The positivistic model uses the regional gross domestic product (GDP) as a measurement of economic growth, the quantity of patent applications as indicator of the technological output and the number of students in colleges and universities as technological per 100,000 as indicator of innovation. Model pulse analysis and variance analysis are done in this paper. It reveals the long-run equilibrium relationship between economic growth, technological innovations and patent outputs by analyzing Shanghai's economy, the most independent and integrated economy. It can be concluded that this relationship is mutual influence, mutually reinforcing relationship in a long term. In the short term, the boost on technological innovations and patent outs by economic growth is obvious. However, there is no obvious effect in reverse. This indicates that it still need a gradual process to promote the contribution of technology to the economy.

KEYWORDS

Technological innovation; Economic growth; Empirical research; VAR model.

INTRODUCTION

With the knowledge of the outbreak of the growth and deepening economic globalization, technological innovation is not only increasingly becoming a strategic resource for national and regional development, but also becoming the core elements of competitiveness, it has become an important support for building an innovative country and the key to master the initiative. The overall objective of the long-term scientific and technological development in China has pointed out that: we would be an innovative country in 2020, provide support for building a moderately prosperous society, and lay a solid foundation for our country to become the world's scientific and technological power in the first half of this century. Achieving these goals depends on the people, but also because a large number of talents who have knowledge and understand the management of technological innovation[1]. According to the general requirements of the Eighteenth Party Congress that put forward a better implementation of this strategy, focusing on providing personnel to ensure the goal of building a moderately prosperous society. In this context, to study both the relationship between technological innovation and economic growth and the dynamic equilibrium relationship of science and technology human capital and economic growth have important practical significance.

A THEORETICAL OVERVIEW AND DESCRIPTION OF THE PROBLEM

The economics originator, Adam Smith, who said the factors of economic growth in the book which is called the Wealth of Nations, David Ricardo's classical economic was developed after summarizing Adam Smith's thinking, they recognize that land, capital and labor are the factors that promote economic growth. With the industrial revolution on behalf of opening the door to modernization, human society have developed rapidly by using science and technology, many scholars began to explore what the source and the power to promote social progress, and which factors that promote economic growth rapidly. In 1958 American economist Jacob Mincer built the investment in human capital earnings model to study the distribution of income, the studies show that education is an investment in human[2], this growth gradually becoming apparent over time, the higher the investment in human capital, the higher return in the late. This investment in human capital is divided in school education investment and after-school education investment by Mincer. Mincer’s research has pointed out that a human plays an important social role, the human is not equal to the labor, manpower with the knowledge and master scientific and technological productivity are staggering. Nobel Laureate Schultz pointed out that the quality of the population play an important role in promoting economic growth[3]. In the study of human and economic growth. Hirofumi Uzawa introduced education into the model, building educational role in promoting the economy is achieved through the improvement of the production part of the marginal technology on the basis of the Solow model[4], the establishment of Uzawa model of studies have shown that the rate of technological progress allocation of resources depends on the existing level of technology and education sectors, the contribution of the education sector output is indirectly achieved through its role in the production sector level. Paul Romer suggests that knowledge and specialized human capital is a major factor in promoting economic growth[5], they can not only contribute directly to economic growth, while the capital and labor to produce increments utility, these make the whole economies of scale increase , making sure long-term economic grow. Romer’s model regards knowledge as an independent factor into the growth model, and that the accumulation of knowledge is an important factor to promote modern economic growth; it divided knowledge into the general knowledge and professional knowledge, general knowledge can produce economies of scale, professional knowledge can generate elements of the incremental benefits. The combination of the two effects not only making the knowledge, technology and human capital generate incremental revenue, but also capital and labor, and other elements of increasing return. Lucas further study of the labor is divided into "raw labor" and "specialized human capital, the latter is the manpower to promote the true driving force of

economic growth[6]. In the inheritance of previous studies, the paper has built an explained model as shown below:

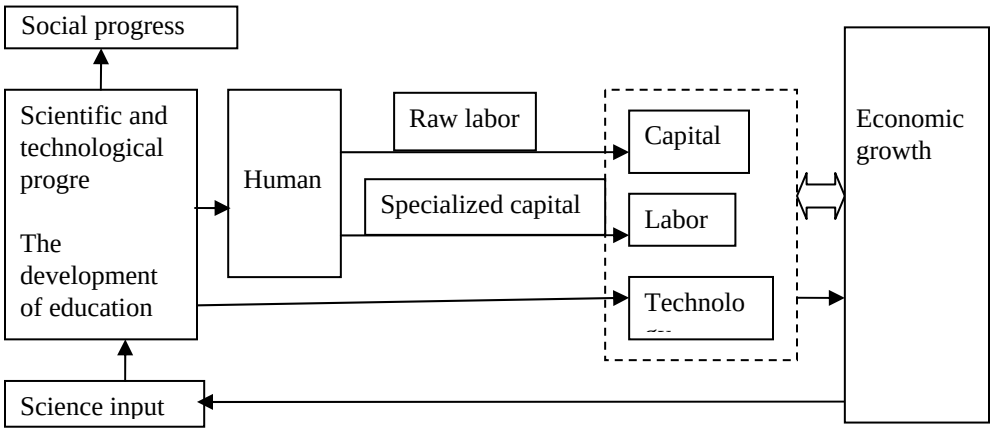

Figure 1 : Interpretation model of technological and economic growth

Model suggests that factors of production requires a combination of a certain proportion and human knowledge determines the proportion of elements of the community as a whole. Human, capital and technology promote economic development, economic growth has also affected the labor, capital and technology, namely the impact of two-way each other; human capital can be divided into the original work and professional capital to promote the economy, both of them can promote economic growth, when economic grows, we further increase science investment to make scientific and technological progress. The development of education, technological progress and education can not only promote the development of society, but also enhance the quality of human capital, so there is a formation of a virtuous cycle to promote economic development and social progress.

On the basis of previous research, we use the auto-regression model to study the relationship between technological innovation and economic growth, test the interactive relationship between the two, and build the VAR model and error correction model, meanwhile take impulse response function analysis and variance decomposition analysis as methods of variables that affect quantitative analysis. All of these by using the relatively small geographical restrictions and the impact of macro-control data in Shanghai from 1993 to 2012, which is the most and highest correlation of sample size in Chinese economic area, and also the most independent and integrity.

DATA PROCESSING AND VAR MODEL

The paper selected regional GDP as a measure of economic growth, patent applications for scientific and technological output indicators, per 100,000 population college students for the technological innovation indicators. The patentee have mastered the technology in patent applications, patents require a long review process, and thus patent applications are more time-sensitive and convincing than patents granted as a measure of technology output[7]. The data from the National Bureau of Statistics Yearbook and the Ministry of Education statistics, according to the research needs and data restriction, the paper selects the 1993-2012 annual data, to process the data and draw the three groups of index data in LnGDP, LnTa, LnPa.

The Vector Autoregressive Model is put forward by Sims in 1980, it does not require strict accordance with the economic theory[8], in each equation of the model, the endogenous variable on the lagged values of endogenous variables in the model all regression in order to estimate the dynamic relationship of all the endogenous variables. The VAR model does not require strict economic theory as the basis, and not make function on the parameters, the explanatory variables does not include any current variables, so it is sought by people who study the dynamic time series data.

To establish the following vector autoregressive model:

$$LnGDP = \sum LnGDP_t + \sum LnTa_t + \sum LnPa_t + u \quad (1)$$

LnGDP: index of economic growth, on behalf of economic growth;

LnPa: index of patent applications, on behalf of patent applications, scientific and technological output indicators;

LnTa: index of technological innovation;

t = 1,2, ...; u is a random error term, called the pulse value in the VAR terms.

EMPIRICAL ANALYSIS

Stationarity Test

As the Index of economic growth, technological innovation index and patent applications index both are time-series data, changes over time, before building the model we should test the variables whether is stable, the paper uses the Dickey-Fuller ADF method to the stationarity test TABLE 1 of the LnGDP, LnTa, LnPa and first-order differential variable DLnGDP, DLnTa, and DLnPa, the results shown in TABLE 1.

TABLE 1 : Stationarity Test Results

the variable	ADF test value	Test class (c,t,k)	10% Critical value	Conclusion
LnGDP	-0.627287	(c,t,1)	-2.66055	Non-stationary
LnTa	-1.489353	(c,t,0)	-2.660551	Non-stationary
LnPa	0.004952	(c,t,2)	-2.660551	Non-stationary
DLnGDP	-4.029406	(c,t,2)	-2.681330	stationary
DlnTa	-2.750043	(c,t,3)	-2.673459	stationary
DlnPa	-4.187066	(c,t,2)	-2.666593	stationary

In the above table shows a significant level of 10%, although the time series variables LnGDP, LnPa and LnTa is non-stationary, its differential variables the DLnGDP, DlnPa and the DLnTa are smooth sequence.

Co-integration test

Description of the unit root test for each sequence, the LnGDP, LnPa and LnTa are integrated of order one sequence, they may exist among the co-integration relationship. Paper takes the Johansen test method to determine whether there is co-integration. If the co-integration relationship exists, the vector auto regression model (VAR) should be established, to reflect the short-and long-term relationship between the variables, the model lag order and co-integration test lag order also should be consistent. Building unconstrained VAR model to determine the relationship between variables co-integration optimal lag order, through a comprehensive comparison of the LogL, LR, FPE, SC, AIC, HQ and other statistics, we suggest that the effect of the second-order lag model is better. At this point, the Johansen co-integration test results show that economic growth, patent applications and technical market transactions in the whole sample, there exists a unique co-integrating vector.

TABLE 2 : Co-integration Relationship Test Results

Co-integration relationship between the null hypothesis	Amount of trace statistics	5% Critical value	P value	Conclusion
r=0	40.62562	21.12066	0.0000	Exist a co-integration relations
r=1	13.03001	14.25840	0.0259	

Point of view from the co-integration relationship, the index of economic growth, technological innovation index and patent applications index have a long-run equilibrium relationship in 1993-2012, and co-integration equation technological innovation and patent applications index is positively correlated with economic growth.

Regression model and its verification

Analysis of data use Eviews 7.0 Software established the third-order VAR model as follows:

TABLE 3 : VAR model of variable coefficient figure

the variable	LnPGDP	LnTa	LnPa
LnGDP (-1)	1.038546	-0.707445	-0.971612
LnGDP (-2)	-0.367412	0.529605	0.841862
LnTa (-1)	0.026403	1.451412	0.219503
LnTa (-2)	-0.021793	-0.599489	0.884110
LnPa (-1)	0.073401	0.167660	0.343496
LnPa (-2)	0.144198	0.021118	0.027116
U	1.483105	1.096198	1.444012
R-squared	0.998325	0.996696	0.996098
Adj. R-squared	0.997605	0.994899	0.994021

Select the economic growth index vector autoregressive model:

LnGDP=1.038546LnGDP(-1)-0.367412LnGDP (-2) +0.026403LnTa (-1) -0.021793LnTa (-2) +0.073401 LnPa (-1) +0.144198 LnPa (-2) +1.483105

From the short-term changes in economic growth point view, in addition to its own influence, other variables had no significant effect on economic growth, the maximum coefficient is 0.144198, indicating that economic growth have a dependence on equilibrium relationship between technological innovation and patent output in the long-run. It can be seen from the other two model coefficients, economic growth made a significance of talent and patent output, specifically manifested in economic growth index is big before economic growth, we can see economic growth in the demand for technology and talent.

Model testing: the reciprocal of the root mode of the VAR model was estimated less than 1, the regression model is stable inside the unit circle, otherwise the model is unstable, and the result is not valid. The model to test all the features of the derived model root location figure shows that all the characteristic roots are inside the unit circle, indicating that this paper made by the model is more stable, and the results is higher validity. The same time, this study all the goodness of fit of the VAR model R2 are greater than 0.9, indicating good model fit.

The impulse response analysis

Following a shock to the variables (Jolly Sharansky decomposition), and getting the relevant variables of the impulse response function graph. The horizontal axis represents the impact the role of lag period (unit: years), the vertical axis represents the variable changes, the solid line shows the impulse response function, it represents the reaction of the variable impact of change on the corresponding the variable.

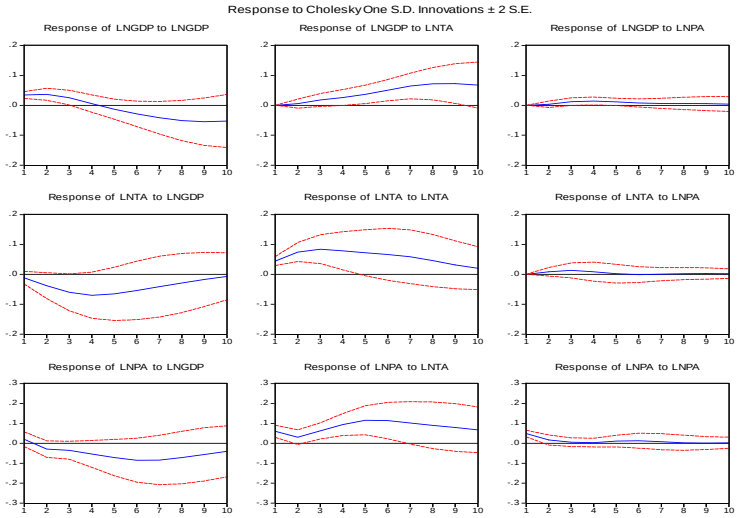

Figure 2 : Impulse response analysis

It can be seen from the figure, the positive impact of economic indicators after a series of spread makes a positive impact of talents, and increases the degree of influence as time continues to deepen, after the 8th to maintain a relatively stable high index, so the economic growth of patent applications index has a positive but not significant effects; changes in technological innovation index showing a negative index of economic growth impact, this possible explanation is that because the papers selected higher education institutions per 100,000 population rarely and directly involved in the production and of GDP creation, the lag effect is quite obvious, if you put it to work, it will play a role in the national economic growth, because both can become reverse results; patent application index table action's impact on human resources and economic growth is not significant.

The variance decomposition analysis

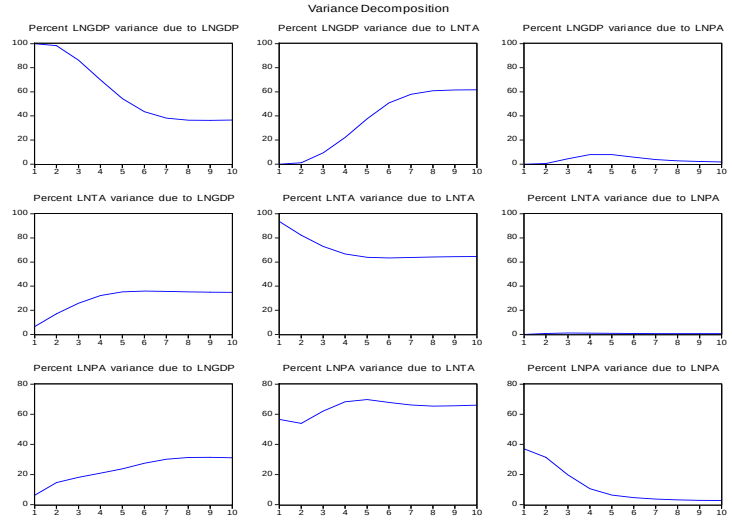

Figure 3 : Variance decomposition figure

This paper uses the variance decomposition analysis to analysis the variable changes, for a more intuitive analysis. It can be seen that economic growth index LnGDP index has a positive impact on technological innovation index LnPa and patent applications LnTa, and the growing increase over time.The economic growth of talent in the 5th subsequently reaches the maximum, accounting for 40% of the changes in technological innovation, economic growth impact on patent output in the 10th will to the

largest ,accounts for about 38% of the changes in patent output; technological innovation index changes on economic growth variance is more significant, the first 7th growth are large, when to 8th,it will achieve higher impacts, accounting for about 60%. Technological innovation index greatly impact on the changes of the patent variance, in the first 10th, a great impact on patent output, wandering up and down 60%, indicating that technological innovation has a significant effect on patent outputs, patent applications index had little effects on economic growth and technological innovation variance changes indicated that economic growth in China's patent applications did not meet the mutual influence mutually reinforcing virtuous circle.

CONCLUSIONS

From the co-integration relationship, China's economic growth index, technological innovation index and patent applications index, there is a long-run equilibrium relationship. Technological innovation index and patent applications index index of economic growth co-integration equation are positive, indicating that economic growth, technological innovation and patent output, are also having a positive correlation, consistent with the results of previous studies. From the vector autoregressive model point of view, remove the variable itself, the current talent index and patent output index had no significant effect on economic growth. However, the current economic growth index had an exponential impact on technological innovation and patent output. This shows that technological innovation and patent output require a process to play impact on economic growth, while economic growth is a great demand for technological innovation and scientific and technological output, the need promotes the supply of more patents output and talents. The above analysis verified the assumptions of the interactive model which has been explained in the paper of the first part .On the based of VAR model impulse response function analysis, it can be seen that the impact of changes in the economic growth index is positive on talents, and as time increases the degree of impact is deepening, however, the impact of technological innovation index on economic growth there is no obvious promotion in the short term. Variance decomposition can more clearly see the impact of the variables. The influence of economic growth on technological innovation variance of changes is up to 40% without considering the variables on its own. Economic growth's impact on patent output is up to the maximum at the 10th, accounting for 38% of patent output changes; technological innovation index variance's changes greatly affect the patent, patent applications index's impact on economic growth and technological innovation variance is not obvious.

In summary, China's economic growth index, technological innovation index and patent output index in 1993-2012 have a long-term equilibrium relationship by the typical analysis of the data in Shanghai area, and this long-term relationship is positive and relevant. Economic growth, technological innovation and patent output reached a mutual influence in the long term. Economic growth greatly impact on technological innovation and patent output, but the talent and patent output the reaction of economic performance is not significant in the short term, indicating that technological innovation and patent output, these two indicators contribute to economic growth now seems still not obvious, while the entire role needs a long process and cycle. Therefore, academics, educators and the community need to focus on how to further improve the education and training system for science and technology talent, improve the talent on the contribution rate of technological progress, and enable them to play an important role in China's economic development and strategy-based transformation.

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