

An Empirical Study on the Impact of Technological Innovation on Economic Growth—Taking Shandong Province as an Example

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Abstract. In 2018, the government work report put forward the idea of promoting the economic growth by the strategy of innovation-driven development. As an economic province, the level of technological innovation is also improving. The paper verified the facilitation of technological innovation on economic growth by selecting relevant data of Shandong Province from 2001 to 2016. We found that the level of technological innovation has a significant positive impact on economic growth through econometric models (e.t R&D Expenditure, the number of patents granted and equivalent full time equivalent of R&D personnel), but the effect is less than the impact of capital input and labor input on economic growth.

The Relationship between Technological Innovation and Economic Growth

Generally, there is a reciprocal relationship between technological innovation and economic growth.

On the one hand, technological innovation can drive economic growth. Firstly, technological innovation can enhance labor productivity and the utilization of production factors, thereby saving production costs and improving the competitiveness of products in the market, and thus promoting the rapid development of the economy. Secondly, technological innovation can open up new product and consumer markets, increase consumer demand and improve the structure of social demand, thus driving the economy forward. Finally, technological innovation can develop new energy and new materials, which is conducive to the development of new products and the optimization and upgrading of industrial structure, thus promoting the sustainable development of the economy.

On the other hand, economic growth can provide strong support for technological innovation. First of all, when the economy grows substantially, more resources will be devoted to technological innovation, and the scientific research conditions will be improved greatly, which will enhance the enthusiasm and creativity of scientific researchers to engage in technological innovation activities, which will have a strong role in promoting technological innovation activities. Secondly, economic growth requires accelerated technological innovation objectively, the process of transforming science and technology into real productivity will also be accelerated, and so as to it can improve the quantity and quality of technological innovation. Finally, economic growth speeds up the pace of innovation and upgrading. Because the previous scientific and technological achievements are the foundation and premise of the existing scientific and technological achievements and the existing scientific and technological achievements will create conditions for the future production of scientific and technological achievements, the unique characteristic of scientific and technological development will speed up the upgrading of innovative technology.

In this paper, we will verify the promoting effect of technological innovation on economic growth by using the actual data of Shandong province from 2000-2016 years.

Build the Model

We will use C-D production function, it is one of the classical models widely used in economics, and the equation of the model is:

$$Y = AK^{\alpha}L^{\beta} \quad (1)$$

In this equation, Y represents output, K is Capital input, L is Labor input, and A is a technological factor, which includes many factors besides capital and labor input. In this function, Y is influenced by A, K and L, and technical level is one of the most important factors, so many economists also believed that technological innovation is the source of economic growth. Therefore, we selected labor input L, capital input K and technological innovation level T as the explanatory variables according to the purpose of this study, and the production function is expanded as:

$$Y_t = CK_t^{\alpha}L_t^{\beta}T_t^{\gamma} \quad (2)$$

We take the natural logarithm on both sides of the equation (2) to obtain a linear measurement model.

$$\ln Y_t = C + \alpha \ln K_t + \beta \ln L_t + \gamma \ln T_t + u_t \quad (3)$$

In this function, Y is economic output, C is a constant term, K is capital input, L is Labor input, T is technological innovation level, α , β , γ are elasticity coefficients, t is year t, and u is residual error.

Data Sources and Variables Selection

We choose time series data from 2001 to 2016. The economic output Y is the explained variable, it is reflected by the annual gross domestic product (GDP) of Shandong Province in billions of yuan, in those explanatory variables, capital input K is reflected by the total investment of fixed assets in the whole society, in billions of yuan, labor input L is reflected by the number of employed persons at the end of the year according to three industries, with a unit of 10000, technology level is a comprehensive index, it is reflected by R&D Expenditure(T1), the number of patents granted(T2) and equivalent full time equivalent of R&D personnel(T3). All data come from the Shandong statistical yearbook.

Empirical Test Results

ADF Unit Root Test

ADF unit root test can determine whether time series is stable, we use the SIC criterion to determine the maximum lag order, and the results are shown in Table 1. We can see that variable lnT2 rejects the original hypothesis of unit roots at a significant level of 1%, variable lnT1 rejects the original hypothesis of unit roots at a significant level of 5%, and variables lnGDP, lnK, lnL, ln T3 rejected the original hypothesis of unit roots at a significant level of 10%. So the entire variable sequence is stationary.

Table 1, ADF unit root test results

variable	Test type	ADF-value	1%	5%	10%	P-value	Result
LnGDP	(c,t,0)	-3.553247	-3.516485	-3.321245	-3.145465	0.0786	stable
LnK	(c,t,1)	-3.483580	-4.134213	-3.946478	-3.723254	0.0652	stable
LnL	(c,t,0)	-3.973386	-4.523361	-4.322621	-4.119873	0.0854	stable
LnT1	(c,t,0)	-4.153246	-3.851614	-3.776512	-3.545233	0.0248	stable
LnT2	(c,t,0)	-4.420136	-4.112532	-4.065120	-3.867564	0.0000	stable
LnT3	(c,t,1)	-3.820152	-3.652121	-3.413325	-3.213214	0.0551	stable

Cointegration Test

The results of unit root test indicate that the 6 variables are flat panel data sequences without unit roots, so we do not need to regress the differential processing. In this paper, KAO test is used to test the cointegration relationship among variables (refer with: Table 2).

Table 2, Cointegration test results

ADF	t-Statistic	Prob.
	-7.145021	0.0000
Residual variance	0.003423	
HAC variance	0.003552	

The test results show that there are co-integration relationships between the six variables, and regression of the variables directly does not affect the validity of the estimation results.

Granger Causality Test

We examine the relationships between T1, T2, T3 and economic growth by Granger causality test (refer with: Table3). R&D expenditure and the number of patents granted are the reasons for economic growth, the equivalent full time equivalent of R&D personnel is not the cause of economic growth, economic growth is Granger's reason for the equivalent full time equivalent of R&D personnel, but it is not Granger's reason for R&D expenditure and the number of patents granted.

Table3, Granger causality test results

Hypothesis	F-value	P-value	Judgement
LnT1 is not the cause of lnGDP change	3.392512	0.0425	reject
lnGDP is not the cause of LnT1 change	1.894461	0.2843	Accept
LnT2 is not the cause of lnGDP change	8.254319	0.0209	reject
lnGDP is not the cause of lnT2 change	4.523977	0.2238	Accept
LnT3 is not the cause of lnGDP change	3.596322	0.2835	Accept
lnGDP is not the cause of lnT3 change	8.323541	0.0052	reject

Regression Results

We used OLS least squares method to regress variables T1, T2, T3 and GDP, K, L, the results are shown in table 4. We can see that the variables have obvious autocorrelation by comparing the DW values with the standard values table. We use iterative method to eliminate autocorrelation (refer with: Table 5), the three indexes of technological innovation level and the regression equations of variables GDP, K and L all pass the significant test, and the fitting degree of the equation is very good judging from the adjusted R-squared value.

Table 4, Regressive results

variable	R-squared	Adjusted R-squared	P-value	DW-value	Significance	Autocorrelation
R&D expenditure	0.995044	0.990828	0.000000	0.572129	significant	yes
the number of patents granted	0.983546	0.981445	0.000000	0.518248	significant	yes
the equivalent full time equivalent of R&D personnel	0.993976	0.993054	0.000000	0.675317	significant	yes

We see that three variables of technological innovation are positively correlated with economic growth from coefficient, the strong and weak of the influence of technological innovation on economic growth are R&D expenditure (0.101422), the number of patents granted (0.0563212), the equivalent full time equivalent of R&D personnel (0.0248101), but the elasticity coefficients of the three variables of technological innovation level are smaller than those of capital input K and labor input L.

Table 5, Eliminate the auto-correlation

variable	Coefficient			Parameter			Result
	α	β	γ	Adjusted R-squared	P-value	DW-value	
R&D expenditure	0.656334	1.223154	0.101422	0.998855	0.0000	1.742159	significant
the number of patents granted	0.745413	1.417523	0.0563212	0.997616	0.0000	1.685432	significant
the equivalent full time equivalent of R&D personnel	0.318597	1.316877	0.0248101	0.998212	0.0000	1.878224	significant

Summary

From the above analysis, we get the following conclusions: Firstly, at present, capital investment and labor input are the main contributors to promote Shandong's economic growth, which shows that Shandong's economic development is still in the stage of extensive growth driven by labor agglomeration and capital; therefore, it is particularly important to change the mode of economic growth. Secondly, technology has a significant positive impact on economic growth, and therefore, the focus of Shandong's future economic growth is improving the level of technological innovation. Finally, we can improve the level of technological innovation by increasing R&D investment and encouraging enterprises to apply for patents.

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