Analysis of Educational Investment Spillovers and Their Mechanisms: Based on a Log-linear Model

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Abstract: Education investment is a key factor driving China's economic growth and an important driver of economic transformation and upgrading. Based on this, this paper puts forward three hypotheses on the mechanism of education input promoting economic growth, using China's 2001-2019 statistics, a log-linear model, and SPSS data processing software to analyze the intrinsic mechanism of China's education input promoting economic growth. The results show that (1) the increase in educational input promotes economic growth, to a certain extent, through the intermediary mechanism of increasing scientific and technological output, and educational input improves the transformation of scientific and technological achievements, which makes economic growth gain the necessary growth driver, and then promotes economic development. (2) Educational inputs promote economic growth through the mediating transmission mechanism of human capital, which in turn affects production efficiency. Education investment raises the level of human capital, which makes economic growth obtain the necessary human capital supply and thus improve the level of economic growth. Recommendations are also made in terms of both educational investment and educational equity.

1 INTRODUCTION

The relationship between investment in education and economic growth has been a classical issue studied by scholars (Du, 2020, Zhao, 2020). Neoclassical economic growth theory says that economic growth is attributed to three major factors: capital accumulation, labor input, and technological progress, while investment in education has an important role in promoting technological progress and human capital accumulation. In other words, investment in education can both directly promote economic growth and indirectly promote economic growth through the existence of intermediary factors, which means that there is a spillover effect of investment in education.

China, as a late-developing catch-up economy, has been developing for decades, creating a miracle of world economic development and attracting high attention globally. China's education spending has grown year after year, surpassing 5 trillion yuan in 2019, accounting for 5 percent of the country's GDP. What role does China's education investment play in the process of economic growth? And what is the transmission mechanism of the spillover effect of education investment? This paper will focus on the above two questions for theoretical analysis and empirical research.

2 ANALYSIS OF THE TRANSMISSION MECHANISM OF INVESTMENT IN EDUCATION FOR ECONOMIC DEVELOPMENT

Tang Lizhi and Li Yujia construct a three-period intergenerational overlap model along with the formation mechanism of endogenous skill premiums, in which "educational inputs form human capital and human capital is transferred between generations", and find that the effect of educational inputs on skill premiums differs under different human capital levels. Under China's dualistic human capital structure, public education investment plays a role in reducing the skill premium when the level of human

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capital is low and high, but private education investment expands the value of the skill premium when the level of human capital is low (Tang, 2020, Li, 2020). Wu Weiwei, on the other hand, used fixed effects, spatial measures and threshold effects models based on provincial panel data to identify differences in financial inputs to higher education in regions with different levels of growth. The results show that although economic growth is conducive to promoting higher education financial investment, regions with higher levels of economic growth do not show a stronger willingness to invest in higher education compared to other regions; local higher education financial investment is influenced by economic proximity and there is a significant spatial demonstration effect (Wu, 2021). Using panel data of 30 provinces in China from 2006-2015, Jiang Yucheng and Jia Ting Yue examined the economic effects of public education expenditure structure on industrial labor productivity and identified the channels of influence of various types of public education expenditure from the perspective of human capital accumulation (Jiang, 2020, Jia, 2020).

The above studies show that human capital is one of the important factors driving economic growth. Education is of great importance in promoting human capital formation. On the one hand, educational inputs promote the accumulation of knowledge, technical proficiency and thus improve the knowledge skills and technical skills of individuals. The general increase in individual productivity promotes the increase in productivity of the society as a whole, which in turn promotes economic growth. On the other hand, educational inputs contribute to knowledge accumulation, which in turn influences the creation of new knowledge and the birth of new technologies, which in turn enhances the quality of the country's human capital and promotes the development of science and technology, which further boosts economic growth, thus creating a significant spillover effect on economic development. Therefore, we propose hypothesis 1.

H1: Educational inputs contribute to economic growth by raising the level of human capital.

Developing higher education is a positive move to cope with population aging and drive industrial structures upgrading. Using inter-provincial panel data from 2009-2018, Wang Xiyuan and Liang Qiaoling find that the increase in higher education investment helps to attenuate the negative impact of population aging on industrial structural upgrading through empirical analysis. The promotion effect of higher education investment on industrial structural upgrading is mainly based on the mediating mechanism of advanced human capital; while the mediating mechanism based on science and technology output is not significant, indicating that the supply of science and technology output of universities fails to match effectively with the demand for science and technology for industrial structural upgrading (Wang, 2021, Liang, 2021). Educational input can accelerate the free flow and optimal allocation of social resources among industries, which is an important means to promote the optimization and upgrading of industrial structure. By constructing an index of industrial structure rationalization and upgrading, Deng Chuang and Fu Rong examined the changing pattern and regional differences of China's industrial structure from two dimensions of industrial structure layout optimization and industrial structure upgrading, and further empirically investigated the non-linear influence mechanism of financial education investment on the degree of industrial structure rationalization and upgrading in China based on a panel smoothing threshold regression model. The study shows that the financial investment in education in China can play a better role in promoting the optimization and upgrading of industrial structure, and the impact of financial investment in education on the rationalization and advanced degree of the industrial structure shows significant threshold characteristics as the level of education increases (Deng, 2017, Fu, 2017). Matching human resources and industrial transformation and upgrading is an important influencing factor of industrial transformation and upgrading. By constructing an index system for evaluating the suitability of industrial structure transition and human resources development, Fu Tao used the suitability evaluation model to evaluate the suitability of both transition and development in China from 2000 to 2015, showing that the overall matching degree between the two in China showed a rising trend and asymmetric characteristics (Fu, 2016). Educational inputs have a spillover effect through knowledge, i.e. they further promote the innovative activities of enterprises through research and development and creativity, which in turn promote industrial upgrading and influence economic development. The mechanism of industry-university-research can be utilized to promote technological innovation and knowledge transformation through the integration of schools and enterprises, and thus promote the optimization and upgrading of the industrial structure by rationalizing the full and effective use of resources. Therefore, hypothesis 2 is proposed in this paper.

H2: Increased inputs to higher education increase science and technology output, which in turn drives industrial structural upgrading.

There is a mutually reinforcing relationship between technological progress and economic growth. Qianqian Sang and Yuxiang Li studied the mechanism of the role of education investment in promoting high-quality economic development through panel data of 237 prefecture-level cities from 2006-2016 and found that education investment improves total factor productivity and enhances economic development dynamics by promoting independent innovation and enhancing the ability to digest and absorb foreign technology and innovation (Sang, 2021, Li, 2021). Education is the foundation of technological innovation, and education funding investment is an important factor influencing regional technological innovation. Ge Yao, on the other hand, based on the panel data of 29 provinces in China from 2006 to 2016, used the threshold model to analyze the effect of education funding investment on regional technological innovation. The results show that: there is a threshold effect of education funding investment on regional technological innovation in each region of China; at different levels of economic development, education funding investment has a U-shaped relationship with regional technological innovation (Ge, 2018).

Educational inputs are indispensable for knowledge accumulation, which in turn recommends technological innovation, thereby improving firm innovation outcomes and productivity, i.e., educational inputs generate spillovers through technological innovation implicitly and evolutionarily, which in turn promotes economic growth. Therefore, we propose hypothesis 3.

H3: Educational inputs contribute to economic growth by increasing scientific and technological output.

3 MODEL CONSTRUCTION AND EMPIRICAL ANALYSIS

3.1 Model Construction

The transmission mechanism of educational inputs to economic growth is tested by using human capital and science and technology output as mediating variables to test the mechanism and to test whether educational investments ultimately act on economic growth level by increasing the level of human capital and increasing science and technology output. The mediating effect model is as follows:

$$Ln\mathrm{GDP} = \mathrm{C} + \gamma_1 Ln\mathrm{E}_{\mathrm{invest}} + \gamma_2 Ln\mathrm{Med}^K + \sum_j \omega_i x_i + \mu(1)$$

where C is the constants and μ is a random variable.Med^K is the mediating variable, when k = 1, its human capital; when k = 2, its university science and technology production; $\sum_j \omega_i x_i$ are the respective control variables.

3.2 Description of Variables

(1) By using GDP as an indicator of economic growth, therefore, GDP is chosen as the explanatory variable in this paper and the logarithm of GDP is taken.

(2) Explanatory variables. The key explanatory variable in this paper is education input (E_invest), China's education mainly relies on government input, and the government's financial investment in education is the main force of education input, so the logarithm of China's financial education expenditure is used to represent education input.

(3) Mediating variables. The first, human capital (H_cap). Human capital is expressed as the average number of years of education of employed persons. The measurement uses the calculation method of Wang Xiyuan and Liang Qiaoling, the average years of education = 17 × the share of employees with a college education and above + 13.5 × the share of employment with high school education + 10.5 × the share of employment with junior high school education + 7.5 × the share of employment with primary school education + 1.5 × the share of employment with illiteracy or semi-literacy (Wang 2021, Liang 2021). Second, technological output (T_out). The number of patent applications is an important manifestation of independent innovation capability, and this paper uses the number of patent applications received as a proxy variable for independent innovation.

(4) Control variables. To control the impact of other time-varying factors on total factor productivity, the investment rate (F-invest) is expressed as the logarithm of the fixed capital investment of the whole society, and foreign investment (FDI) is expressed as the logarithm of the actual amount of foreign capital utilized multiplied by the average exchange rate of the year, according to the existing theory and empirical experience.

4 EMPIRICAL RESULTS

4.1 Description of the Sample and Data

This paper conducts an empirical study using data from China for 19 years from 2001-2019. The data are obtained from the China Statistical Yearbook for all years. The descriptive statistics of each variable are shown in Table 1.

Table 1: Descriptive statistics for each variable.

Variable Name	instructions	Sample size	average value	variance (statistics)	max	min
LN GDP	economic growth	19	12.82	0.49	13.80	11.62
LN E-invest	Financial expenditure on public education	19	9.46	0.75	10.60	8.03
LN H-cap	human capital	19	11.23	0.21	11.24	11.20
LN T-out	Scientific and technical outputs	19	13.88	0.97	15.29	12.22
LN FDI	foreign investment	19	13.37	0.07	13.77	12.87
LN F-invest	Fixed asset investment	19	12.27	0.91	13.38	10.52

4.2 Empirical Results

Investment in education drives economic growth by increasing the level of human capital as well as the output of technological innovation. The following are the results of a mechanical test based on mediating transmission effects.

(1) Mediating effects of scientific and technological outputs

The results of the empirical analysis show that the regression coefficient of educational inputs on economic growth is positive and passes the 5% level of a significance test and that investment in education has significant utility in increasing science and technology output. Educational inputs promote scientific and technological output, which in turn affects economic growth.

From the results of the intermediary effect test, it is clear that the increase in educational input promotes economic growth, to a certain extent, through the intermediary mechanism of increasing scientific and technological output; in other words, educational input increases the transformation of scientific and technological achievements, which allows economic growth to gain the necessary growth drivers, which in turn promotes economic development.

Table 1: Mediating effects of science and technology outputs.

	B	p
C	-0.836	0.581
LN E-invest	0.424 ***	0.009
LN T-out	0.356 ***	0.010
LN F-invest	0.042	0.637
LN FDI	0.181 ***	0.005
F=2655.67	R=0.99	R^2=0.99

Note: *, **, *** indicate that each variable is significant at the 10%, 5%, and 1% levels, respectively

(2) Mediating effects of human capital output

The estimated coefficient of the effect of education expenditure on economic growth is positive and passes the 5% significant level test, indicating that increased investment in education can promote economic growth. The estimated coefficient of the impact of educational inputs on human capital is positive and passes the 5% significant level test, and the empirical results indicate that the estimated coefficient of human capital inputs affecting economic growth is positive and passes the test, indicating that educational inputs affect economic growth through human capital, indicating a significant mediating effect.

Table 2: Mediating effects of human capital output.

	B	p
C	38.192 *	0.087
LN E-invest	0.515 ***	0.004
LN F-invest	0.322 **	0.049
LN FDI	0.232 ***	0.001
LN H-cap	0.074 **	0.047
F=2071.67	R=0.99	R^2=0.99

Note: *, **, *** indicate that each variable is significant at the 10%, 5%, and 1% levels, respectively

From the results of the intermediary effect test, it is clear that increased investment in education promotes economic growth, to a certain extent, through the intermediary mechanism of raising the level of human capital, in other words, investment in

education raises the level of human capital, which allows economic growth to obtain the necessary supply of human capital and thus increases the level of economic growth.

5 CONCLUSIONS AND RECOMMENDATIONS

The relationship between educational input and economic growth has been the focus of research. Based on China's actual development experience, this paper puts forward three hypotheses and analyzes the spillover mechanism of educational input driving economic growth by constructing a mediating effect model. The following conclusions are obtained through empirical research.

(1) Education inputs have a mediating effect through science and technology output. From the results of the intermediary effect test, it can be seen that the increase in education input promotes economic growth, to a certain extent, through the intermediary mechanism of increasing scientific and technological output, in other words, education input increases the transformation of scientific and technological achievements, which makes economic growth obtain the necessary growth driver and thus promotes economic development.

(2) Educational inputs contribute to economic growth through the intermediary transmission mechanism of human capital, which in turn affects production efficiency. The increase in educational investment promotes economic growth, to some extent, through the mediating mechanism of raising the level of human capital; in other words, educational investment raises the level of human capital, which makes it possible to obtain the necessary supply of human capital for economic growth and thus raise the level of economic growth.

Based on the above research findings, this paper puts forward relevant policy recommendations from two aspects. On the one hand, increase investment in education, improve infrastructure construction, and give play to the intermediary role of education in human capital formation and technological innovation to further promote economic development. On the other hand, promote educational equity. Investment in education is not only about investment in hardware and equity but also about investment in "software", especially the allocation of teachers. Educational resources should be tilted towards remote places to further promote equity in education across the country, thereby effectively raising the average productivity of society as a whole and promoting economic growth.

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