The Impact of Fiscal Spending on Science and Technology on the Development of the Digital Economy

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Abstract: The digital economy is becoming a new driving force for global economic development. According to the UN report, China has the second largest digital economy in the world. In the face of new challenges brought by the digital economy, China is committed to innovation-driven development and promotes high-quality development of the digital economy. Fiscal investment in science and technology can promote scientific and technological innovation, which plays a vital role in the digital transformation of enterprises and the promotion of digital economic infrastructure construction. The main aim of the paper is to study the impact path of fiscal investment in science and technology on digital economy by taking China as an example. The research uses China's 2013-2021 digital economy development index and intensity of fiscal investment in science and technology to empirically test the impact of fiscal investment in science and technology on the development of digital economy. The study found that fiscal spending on science and technology promotes enterprises' digital technology innovation and digital infrastructure, thus motivating the innovative development of digital economy.

Keywords: fiscal investment of science-and-technology; digital economy; innovation

JEL Classification: E62; L86; H50

1. Introduction

The term "digital economy" was first coined by Tapscott (1996), who in his book *The Digital Economy: Promise and Peril in the Age of Networked Intelligence* first defined the economic model of presenting information flows digitally as "digital economy". Literally, the digital technology economy is the foundation of the digital economy. Since the development of the early digital economy is closely related to the Internet, the digital economy is also called the Internet economy. Subsequently, the digital economy is generally understood as the economic activity generated by the flow of data and information through networks. The definition of a thing always reflects times and trends it appears. In the 1990s, the Internet was the mainstream technology, and the early definition of "digital economy" was also mainly related to the Internet. Later, with the innovative development of mobile and sensor networks, cloud computing and big data, new technologies have been added to the definition of the digital economy. Nowadays, if the digital economy is to achieve sustainable and high-quality development, technological innovation cannot be ignored. The digital economy is the most dynamic area of innovation, and innovation is an important driving force for the high-quality development of the digital economy.

Messina (2018) points out that the digital economy is not uniquely driven by technology, it also requires adequate, flexible, and low-cost Information Systems. The development of digital economy is highly dependent on positive external products such as digital infrastructure and enterprise digital technology innovation. Sturgeon (2021) argues that rich countries or poor countries, big companies or small companies can increasingly rely on new, often low-cost or free, digital economy tools to improve organizational efficiency, accelerate the development of new products, and support the upgrading of the digital economy. The tool of fiscal expenditure on science and technology has such an effect. In the absence of government intervention, the marginal private income of digital infrastructure construction and enterprise digital technology innovation is lower than the marginal social income and the marginal private cost is higher than the marginal social cost, which cannot realize the optimal allocation of resources by the market, resulting in insufficient investment in digital infrastructure construction, the lack of enterprise innovation motivation and the loss of social welfare. In order to realize the improvement of pareto, our country can "compensate" for the loss of social welfare through fiscal spending, and provide long-term and effective fiscal support for digital infrastructure construction and digital technology innovation, thus increasing the allocation of resources to digital infrastructure construction and digital technology research and development.

Among them, the fiscal expenditure on science and technology can effectively reduce the cost of digital transformation of enterprises and drive them to accelerate the pace of innovation (Kleer, 2010). The support of financial expenditure on science and technology can help enterprises alleviate financing difficulties and increase investment in digital transformation. Through direct fiscal support (fiscal subsidies, fiscal interest discounts, etc.), the government selects high-efficiency and high-potential enterprises that meet the funding conditions and provides funds to these enterprises (Howell, 2015) to improve their fiscal conditions (Czarnitzki et al., 2011). Therefore, fiscal investment in science and technology can promote the innovation of digital technology, then have an impact on the development of digital economy.

On the other hand, the fiscal expenditure on science and technology can bring the whole industrial chain of digital infrastructure construction into the direction of development fund support. Then precisely support the construction of digital infrastructure projects and promote the comprehensive development of its construction. (Lin, 2019) The quantity, quality and price of digital infrastructure determine the speed and height of digital economy. Therefore, fiscal investment in science and technology can promote the construction and innovation of digital infrastructure, thus promote the high-quality development of the digital economy.

Based on previous studies of scholars and my own reasoning hypothesis, the main goal of this paper is to test the impact of fiscal investment in science and technology on the innovation and development of digital economy and its action path.

2. Methodology

The main purpose of this paper is to examine the impact path of fiscal investment in science and technology on digital economy. The impact of fiscal expenditure in science and technology on digital economy is reflected in digital technology innovation and digital

infrastructure. Fiscal investment in science and technology plays a significant role in enterprises' scientific and technological innovation. At the same time, fiscal investment in science and technology plays an important role in promoting the development of digital economy infrastructure. Both technological innovation and digital economy infrastructure are likely to have an impact on the development of the digital economy. Based on the above analysis, hypothesis is put forward in this paper:

H: fiscal science and technology expenditure has a positive promoting effect on the high-quality development of digital economy.

The data of fiscal science and technology expenditure in this paper are from China Statistical Yearbook. Based on the connotation of digital economy, this paper adopts the CRITIC method to construct the development level index of digital economy (Report on China's Digital Economy Development Index, 2021). The evaluation system of digital economy development index is shown in Table 1. Based on this standard, the digital economy development index from 2013 to 2021 can be calculated.

Table 1. The evaluation system of digital economy development index

Level 1 metrics	Level 2 metrics	Level 3 metrics	Raw metrics
Digital Economy Development Index	Digital infrastructure	New infrastructure	number of supercomputing centers
			number of data centers
			number of data exchanges
		Data elements	the number of data element enterprises
			proportion of enterprises with data elements
		Auxiliary enterprises	number of ancillary businesses
			proportion of auxiliary enterprises
	Digital technology	Digital technology companies	digital technology enterprise investment
			digital technology business operations
			digital technology enterprise output
		Digital technology innovation	passion for digital technology innovation
			the effectiveness of digital technology innovation

3. Results

Based on the above analysis, the following model is designed to test the hypothesis:

$$y_t = \beta_0 + \alpha_1 x_t + \alpha_2 lnpop_t + \alpha_3 lneopen_t + \alpha_4 lnfainv_t + \varepsilon_t \quad (1)$$

In Formula (1), the subscript t represents time (year), the explained variable y_t is the development level index of digital economy, and the explanatory variable x_t is the intensity of government spending on science and technology, which is equal to the government expenditure on science and technology divided by the general public budget expenditure.

The remaining variables are control variables. pop_t represents population density, which is equal to the total population of the country divided by the land area and then logarithm. $eopen_t$ represents the level of economic openness, equal to the total volume of imports and exports divided by GDP; $fainv_t$ represents the proportion of fixed asset investment in GDP. I used Stata 17.0 software to perform unit root test on the time series of dependent variable y and main explanatory variable x. D(*) is a first-order difference and D2(*) is a second-order difference. The data of the above variables are obtained from the Chinese Statistical Yearbook after calculation and sorting.

3.1. Empirical Analysis

In order to avoid "pseudo regression", it is necessary to use ADF (Augmented Dickey—Fuller) test to test the stationarity of each variable.

Table 2. ADF test results

Variable	ADF value	MacKinnon5% threshold	Conclusion
Y	1.991	-3.000	Non stationary
D(Y)	-2.199	-3.000	Non stationary
D2(Y)	-10.894	-3.000	Stationary
X	-0.415	-3.000	Non stationary
D(X)	-2.758	-3.000	Non stationary
D2(X)	-3.323	-3.000	Stationary

As can be seen from the above table, both y and x sequences are second-order integral. Further Johansen co-integration test shows that there is a co-integration relationship between x and y, which can be used for regression analysis of the model.

3.2. Regression Interpretation

The preliminary results obtained by regression analysis are as follows:

$$y_t = -389351.4 - 0.512x_t + 495058.6lnpop_t - 1525lneopen_t - 20598.7lnfainv_t + \varepsilon_t$$

$$R^2 = 0.9312$$

Firstly, R^2 is approximately 1, indicating that the model has a good fitting degree. However, the coefficient before the main explanatory variable is less than 0, which is inconsistent with the original hypothesis. There are also multicollinearity problems between other variables. The results of the multicollinearity test are as follows.

Table 3. Multicollinearity test

	y	*x*	*pop*	*eopen*	*fainv*
y	1.0000				
x	0.9315	1.0000			
pop	0.8873	0.9660	1.0000		
eopen	-0.6274	-0.7666	-0.8834	1.0000	
fainv	-0.9075	-0.8724	-0.7506	0.3833	1.0000

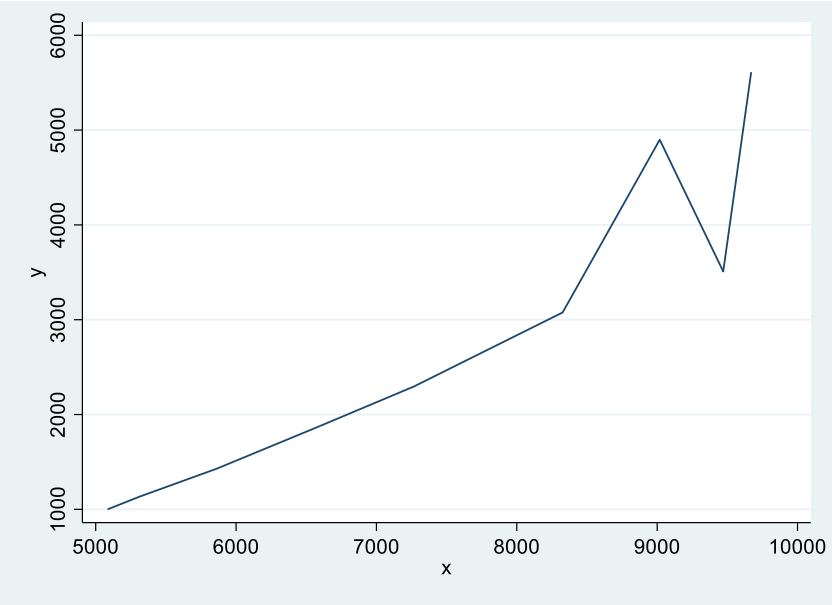

Figure 1. The graph shows the linear relationship between variables y and x

According to the multicollinearity test, the explanatory variables are highly correlated. And we can draw a conclusion that variable y and variable x only conform to the linear correlation in a certain interval value, beyond the interval value, the relationship between the two is worth further discussion. If we do the regression for y and x separately, we get an equation that looks like this:

$$y = -3602.113 + 0.8597x + \varepsilon$$

Meanwhile, the significance level of the equation is less than 5%. Adj R-squared is 84.87%. Coefficient before variable x > 0, indicating that fiscal expenditure on science and technology has a positive effect on the development level of digital economy. This result can prove the hypothesis in this paper.

4. Discussion

Because the measurement of digital economy started late in China and my academic level is limited, the data of digital Economy Development Index can only date back to 2013, and there are only 9 observed values so far. The sample size is too small, so it inevitably leads to the multicollinearity of the estimation model. The hypothesis proposed above cannot be proved completely. From the analysis of appeals, we can see that the theoretical analysis of this paper is correct. To a certain extent, the financial investment in science and technology can promote the high-quality development of digital economy (the development of digital economy is represented by the rise of level index).

After further review of literature, I found that there is not a simple linear relationship between fiscal investment in science and technology and the development of digital economy. Government spending on science and technology promotes innovation. The externality of scientific and technological innovation makes its activity quality lower than the market equilibrium level. This market failure requires the "visible hand" of the government to intervene and guide scientific and technological innovation. As an important force driving

scientific and technological innovation activities, the government can provide momentum for scientific and technological innovation through industrial policies and fiscal spending on science and technology (Lee, 2011). Fiscal spending on science and technology is more targeted and may be more effective than other approaches (Guo, 2016).

Technological innovation has a dual effect on the development of digital economy (Luo, 2019). Limited financial investment in science and technology, the more investment in non-digital technology innovation, will affect the speed of development of digital economy; Otherwise, it will speed up the development of digital economy. It can be seen that the fiscal expenditure on science and technology has both crowding out effect and promoting effect. Therefore, there may be a positive "U-shaped" nonlinear relationship between the fiscal expenditure on science and technology and the development level of digital economy. Relatively speaking, financial investment in science and technology really promote the improvement and construction of digital infrastructure, and then promote the high-quality development of digital economy through the development of digital infrastructure.

5. Conclusions

To sum up, the innovative development of the digital economy needs to be promoted by fiscal policies. The concrete manifestation of the high-quality development of digital economy is the double wheel drive of digital industrialization and industry digitization. Financial investment in science and technology innovation should be more targeted and should not be blindly invested. Later research should focus on the inflection point of the relationship between the fiscal expenditure on science and technology innovation and the development of digital economy, and invest funds within a specific range to maximize the efficiency of capital utilization.

Countries and regions should also formulate fiscal spending policies in line with local conditions of digital economy development. While guiding innovation and promoting innovation in digital technology and infrastructure, the government should not forget to nurture and support digital talents.

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References

China Statistical Yearbook. (2021). *National Bureau of Statistics of the People's Republic of China: Statistical Bulletin of national science and technology expenditure* [Data set]. Retrieved September 22, 2021, from http://www.stats.gov.cn/tjsj/tjgb/rdpcgb/qgkjjftrtjgb/202109/t20210922_1822388.html.

Czarnitzki, D., Hanel, P., & Rosa, J. M. (2011). Evaluating the impact of R&D tax credits on innovation: A microeconometric study on Canadian firms. *Research Policy*, *40*(2), 217–229. https://doi.org/10.1016/j.respol.2010.09.017

Guo, D., Guo, Y., & Jiang, K. (2016). Government-Subsidized R&D and Firm Innovation: Evidence from China. *Research Policy, 45*(6), 1129–1144. https://doi.org/10.1016/j.respol.2016.03.002. (in Chinese)

Howell, S. T. (2017). Financing Innovation: Evidence from R&D Grants. *American Economic Review*, *107*(4), 1136–1164. https://doi.org/10.1257/aer.20150808

Kleer, R. (2010). Government R&D subsidies as a signal for private investors. *Research Policy*, *39*(10), 1361–1374. https://doi.org/10.1016/j.respol.2010.08.001

Lin, H. W., & Shao, P. J. (2019). Research on the influencing factors of Blockchain to the high-quality development of digital economy. *Guizhou Social Sciences*, *12*, 112–121. (in Chinese)

Lee, C. Y. (2011). The Differential Effects of Public R&D Support on Firm R&D: Theory and Evidence from Multi-country data. *Technovation*, *31*(5), 256–269. https://doi.org/10.1016/j.technovation.2011.01.006

Luo, Y. H. (2019). Analysis on the Mechanism of ICT Promoting High-quality Development of Digital Economy such as big data Artificial intelligence blockchain. *Social Sciences of Guizhou*, *12*, 122-132. (in Chinese)

Messina, M. (2018). Designing the New Digital Innovation Environment. In Bongiorno, G., Rizzo, D., & Vaia, G. (Eds.), *CIOs and the Digital Transformation*. Springer, Cham. https://doi.org/10.1007/978-3-319-31026-8_9

Sturgeon, T. J. (2021). Upgrading strategies for the digital economy. *Global Strategy Journal*, *11*(1), 34–57. https://doi.org/10.1002/gsj.1364

Tapscott, D. (1996). *The Digital Economy: Promise and Peril in the Age of Networked Intelligence*. McGraw-Hill.

Zero One Think Tank. (2021). *Report on China's Digital Economy Development Index* [Data set]. Retrieved July 8, 2021, from https://www.djyanbao.com/preview/3250687