The impact of technology and finance on urban-rural income inequality

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Abstract. Based on the panel data of 30 provinces, cities directly under the jurisdiction of the central government (except for Tibet) and regional autonomous areas from 2011 to 2020, this paper uses the entropy method to measure the index of science and technology finance, and applies the double-fixed model to explore the impact of science and technology finance on urban-rural income inequality. The empirical results show that: (1) Technology finance has a U-shaped influence on rural-urban income inequality. (2) The greater the gap between urban and rural financial development levels will increase urban-rural income inequality; the greater the gap between higher education levels and health care institutions will decrease urban-rural income inequality significantly. (3) There is a heterogeneity in the impact of science and technology financial development on rural-urban income inequality; science and technology finance in the eastern and western areas will have a U-shaped impact on rural-urban income inequality, while science and technology finance in the central area will have an inverted U-shaped impact on rural-urban income inequality. Based on this, this paper offers some suggestions for the development of science and technology finance in China to further reduce rural-urban income inequality.

Keywords: science and technology finance; urban-rural income inequality; entropy method; double-fixed model.

1. .Introduction

1.1 Background:

In March 2022, the Ministry of Science and Technology proposed to carry out the "One Body, Two Wings" action to enhance the innovation capacity of science and technology finance: "In order to thoroughly implement the decision and deployment of the Party Central Committee on promoting the synergistic development of science and technology innovation and modern finance, and accelerate the improvement of the financial support innovation system, the Torch Center and the Bank of China jointly carry out the "One Body, Two Wings" action, with commercial banking services as the main body and integrated services and globalization services as the two wings. Work together to create "four heavy four new" cooperation framework, around key customers, key regions, key parks, key industries, and actively explore new mechanisms for government-bank cooperation, new models, to provide financial services for science and technology enterprises throughout the life cycle, to promote technology, capital, talent, data and other elements of the deep integration, the formation of a more complete system of science and technology financial services, powerful support for high-level science and technology self-sufficiency and high-quality economic development. " 2013 proposed the "One Belt, One Road" to the "Regional Comprehensive Economic Partnership Agreement (RCEP)" that will take effect in 2022. Then, what is the impact of science and technology finance on income inequality in the country's 30 provinces and what differences exist need to be analyzed from the perspective of theoretical and empirical research, which is important to derive guidance of science and technology finance.

1.2 Literature review

Currently, there are three parts of the existing literature on science and technology finance.

1.2.1The concept and definition of science and technology finance

The concept of science and technology finance was first given by Professor Zhao Changwen et al. in the book Science and Technology Finance. Putting aside all that complicated financial language, in layman's terms, he argues that science and technology finance can be simplified as a system of all the multiple resources that serve science and technology enterprises as well as the development and innovation of scientific and technological achievements. Qian Zhixin believes that science and technology finance belongs to the category of industrial finance. Zhang Mingxi et al. continue to explore on the basis of inheriting the theories of their predecessors, arguing that the essence of science and technology finance is both the process of integration of science and technology and economy and finance in the world, but also the advanced form of innovative economy. It is comprehensive, endogenous, dynamic, innovative and social.

1.2.2what is income inequality and how to define it

Kuznets proposed a hypothesis on income inequality, arguing that economic development and income are non-linear, with economic growth varying as the income distribution gap becomes larger at lower income levels, however, when income levels reach a certain level, economic growth is found to be beneficial in alleviating income inequality. Liu Ming [1] studied the impact of public education expenditure on the inequality of income distribution of residents in China from the perspective of education, and the basic conclusion of the study was that strengthening the scale of public education expenditure in high schools and improving the quality of education in China both help to reduce the inequality of income distribution, among which, increasing the scale of public education expenditure has a more significant impact on reducing the inequality of income distribution of residents. Huan Ningning [2] also concluded that the impact of income distribution inequality on economic growth is non-linear, and that in the long run, the rate of economic growth will decline as the income distribution gap widens. K aldor [3] studied the the mechanism by which income distribution affects economic growth through the savings-investment channel. They argued that since the savings rate of the rich is higher than that of other classes and savings and investment originate mainly from the rich, inequality in income distribution helps to increase the savings and investment rates, thus promoting economic growth. In Thomas Malthus' Review of the Principle of Population published in 1798, he argued that overpopulation was the primary factor affecting the distribution of wealth.

1.2.3Analysis of the impact of technology finance and income inequality

Hao, Liang and Liu, Jubiao [4] studied the impact of digital inclusive finance on income inequality, and their study showed that digital inclusive finance can improve income inequality for individuals and groups, and both the breadth of coverage and the depth of use can improve income inequality. Bai Xuejie [5] et al. studied the influence of digital economy development on economic growth and income inequality, and various research approaches showed that increasing individual employment opportunities and raising household income levels are important channels for the digital economy to alleviate income inequality; Chen Wen and Liu Hancheng [6] studied the influence of digital inclusive finance on financial behavior based on the income inequality perspective. Guo Jingxian and Lu Ying [7] conducted a study on whether technology finance can help improve the efficiency of enterprise innovation. Zhang Ying and three others [8] studied the relationship between financial. They first examined the impact of financial openness on income inequality in each country. Bai Wanping and four others [9] studied the industrial structure upgrading effect of science and technology financial development, and the study showed that science and technology finance can significantly promote industrial structure upgrading, and it is more obvious in the less economically developed Western region. In conclusion, few articles have analyzed the impact of technology finance development on income inequality. Based on this, this study adopts the entropy value method to calculate the

technology finance index and uses a double-fixed model to explore the impact of technology finance on urban-rural income inequality in 30 provinces.

2. The basic fundamental of BP neural network

2.1 Fixed effects regression model

This paper focuses on the impact of S&T finance on income inequality, therefore, a time-regional dummy variable λ_t and a time-dummy variable μ_t are added to the baseline model to construct a time-regional bi-fixed model: the

$$y_{i,\ t} = \beta_0 + \beta_1 x_1 + \beta_2 \sum x_{controli,t} + \lambda_t + \mu_i + \varepsilon_{t,t} \tag{1}$$

2.2 Entropy method

Studies have been conducted to explore the application of entropy method in the measurement and evaluation of comprehensive level, and this study adopts this method to measure the science and technology financial index. The indicators involved in this evaluation are all positive. The data are processed according to the entropy value method, and the weights of various indicators are calculated to measure the sample composite index.

$$\begin{cases} Y_{it} = \sum_{j=1}^{n} W_j \times x'_{ij} \\ i = 1, 2\cdots, 11;\ j = 1, 2\cdots, 16; \\ t = 2011, 2012, \cdots, 2020 \end{cases} \tag{2}$$

Y_{it} is the science and technology finance index, x'_{ij} is the standardized value, W is the indicator weight, t represents the year, j represents the indicator, and i represents the 30 sample provinces. The larger the composite index is, the higher the level of science and technology finance is, and vice versa, the lower it is.

2.3 Variable Description

Explained variables

Urban and rural income inequality (urii): Compared by per capita disposable income. We use the method used by Li Maicheng and Li Kaixuan [10] : the ratio of urban average disposable income to rural average disposable income to measure the urban-rural income inequality gap.

Explanatory variables

Technology Finance: This paper selects nine indicators from four dimensions: technology finance resources, technology finance financing, technology finance inputs and technology finance outputs from 2011-2020 provincial panel data to measure the level of technology finance, as follow table 1.

Table 1. Technology finance evaluation system and its indicators

Name	Primary indicators	Secondary indicators	Indicator Properties
Technology Finance Level	Technology Finance resource	The proportion of scientific and technological activities personnel	+
		Number of R & D institutions	+
	Technology finance financing	Ratio of financial institution deposits to technology expenditure	+
		Ratio of loans from financial institutions to technology expenditure	+
	Technology finance investment	R & D funds	+
		Full-time equivalent of R & D personnel in industrial enterprises	+
		Funds to develop new products	+
	Technology finance output	Patent grant	+
		Ratio of Technology Market Turnover to GDP	+
		Industrial enterprises above designated size to develop new products funds	+

Control variables

Higher education level (HEL): The proportion of the number of higher education graduates to the total number of graduates each year. (2) Development of financial institutions (DLFI): The sum of the deposit balance and loan balance of financial institutions is expressed as a proportion of GDP. (3) Year-end permanent population (PPEY): The total number of permanent residents at the end of each province is used as the standard. (4) Medical and health institutions (MAHI): measured by the total number of medical and health institutions in each province.

2.4 Data sources

The author selected panel databases from 30 provinces in China from 2011 to 2020 as samples, and used the entropy method to measure the level of technology and finance. The main data are from China Statistical Yearbook, China Urban Statistical Yearbook, China Science and Technology Statistical Yearbook, National Bureau of Statistics, and Cathay Database.

3. Results

3.1 Regression results

The model used in this part of the study is a double fixed model, which verifies that the urban-rural income gap is affected by the technology-finance pair, which is a significant inverted U-shaped effect and is significant at the 1% level (see column (1)(2)(3) of Table 2 for specific results). This result shows that the current development of science and technology finance level will narrow the income gap between urban and rural areas, but the development of science and technology finance in the future will aggravate the income gap between urban and rural areas, further widening the gap.

At the 1% level, the regression coefficient of higher education level (HEL) on urban-rural income inequality is both negative and significant, suggesting that higher education is a factor in reducing urban-rural income inequality. Consequently, the higher the level of higher education in towns and villages, the more talents will be available, and this will lead to economic development.The greater the development space of rural areas, the higher the per capita disposable income growth rate, thus reducing urban-rural income inequality. This is especially true when compared to towns and cities, where the level of higher education is higher.

At the 1% level, the regression coefficient of (DLFI) on income inequality is both positive and significant, suggesting that the growth of financial institutions will lead to a greater disparity in income between urban and rural areas.The disparity in income inequality is exacerbated by towns having a significantly greater number of financial institutions than villages, and the higher the level of development of these institutions, the more prosperous the economic development, with towns' per capita disposable income growth rate being greater than villages'.

The regression coefficient of year-end permanent population (PPEY) on urban and ural income inequality is negative, but the result is not significant. Theoretically, the larger the population, the faster the economic development, and the industrial shift will occur, which will reduce the gap of income inequality. The regression coefficient of its result, negative and insignificant, implies that the amount of inhabitants at the conclusion of the year has no noteworthy effect on per capita disposable income in both urban and rural areas.

The regression coefficient of medical and health institutions (MAHI) on urban-rural income inequality is positive and significant at the 5% level, indicating that medical and health institutions also widen the inequality gaps. This is because the level of medical care in towns is much higher than that in villages, and the number of medical institutions is also much more than that in villages, even the residents in villages will go to towns to solve their health problems, so the development of medical care level also widens widen the inequality gaps. In Table 2 its regression coefficients with estimated standard errors are magnified 10,000 times.

Table 2. Analysis of the regression results

variable	urii			east	central part	west	2014-2020
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
urii	-0.4028***	-0.8176***	-0.9009***	-0.9050***	4.1921**	-1.6003	-1.0219***
	(0.1212)	(0.2469)	(0.2519)	(0.2458)	(1.8538)	(0.0239)	(0.2259)
$urii^2$		0.5422*	0.7808***	0.6133**	-16.2970**	4.4399	0.8721***
		(0.2817)	(0.2919)	(0.2445)	(7.0036)	(3.8308)	(0.3056)
HEL			-48.6730***	0.0439	-32.9039**	-80.6189***	-30.0035***
			(8.4918)	(9.8528)	(15.4962)	(16.8941)	(9.2725)
DLFI			0.1419***	0.0223**	0.0425*	-0.0137	0.0458***
			(0.0109)	(0.0110)	(0.0235)	(0.0218)	(0.0113)
PPEY			-0.0187	0.0246	0.0074	-0.0715	-0.0542*
			(0.0237)	(0.0203)	(0.0432)	(0.0903)	(0.0309)
MAHI			0.0408**	-0.0064	-0.0075	1.3500***	0.0568***
			(0.0186)	(0.0179)	(0.2720)	(0.0572)	(0.0213)
Fixed time	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observed value	300	300	300	110	80	110	210

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

3.2 Heterogeneity analysis

Columns (4)(5)(6) of Table 2 show the regression results of dividing each prefecture-level city in China into different regions in the east, central and west. Table 2's columns (4)(5)(6) reveal that the regression coefficient for science and technology finance in the east is negative and significant at the 1% count level, while the coefficient for science and technology finance in the central is positive at the 10% level; The estimation coefficient of science and technology finance level in the western region is negative, but the regression coefficient is not significant. This situation shows that the development of science and technology finance can significantly narrow the income gap between urban and rural areas in the eastern region and narrow the income gap. However, from the perspective of social conditions, the level of economic development and infrastructure construction in the eastern region is much higher than that in the central and western regions, and the level of development of science and technology finance is relatively high, so it will be conducive to narrowing the income gap.The eastern region's economic development and infrastructure construction being much higher than that of the central and western regions, science and technology finance development is also comparatively higher, thus aiding in the reduction of income inequality. However, the urban-rural income gap in the central region will be exacerbated due to the fact that it is not as advanced as the eastern region.Moreover, its economic development level is significantly inferior to the east, assuming that its science and technology financial development, then the first thing to promote urban economic development is, but this measure will exacerbate the income gap between urban and rural areas. The western region's economic development appears to be sluggish, and even if science and technology finance were to become more prevalent, there would still be many related technologies and industries lagging behind. This implies that the development of science and technology finance in the west will not have a considerable effect on the income gap between urban and rural areas.

3.3 Robustness tests

In this study, the robustness of the regression results was ensured by shortening the sample year for robustness testing, and the authors changed the study regression year from 2011-2020 to 2014-2020. It is concluded that the regression coefficients of the test results are essentially the same direction, indicating that the results are not accidental, as shown in column (7) of Table 2.

4. Conclusions and Recommendations

4.1 Conclusion

This study analyzes the influence of science and technology finance on the emergence of income inequality using the entropy value method and the time-area bifixed model based on the panel data of 30 provinces from 2011 to 2020, taking into account the heterogeneity of eastern, central, and western regions, and conducting robustness tests. The following main conclusions are drawn.

(1) At the national level, technology finance causes a U-shaped impact on revenue inequality. The current development of technology finance will reduce urban-rural income inequality, but with the gradual development of technology finance, urban-rural income inequality will be further widened.

(2) The greater the discrepancy between urban and rural financial development levels, the greater the discrepancy between higher education levels and health care institutions, the greater the discrepancy between urban and rural income inequality will be significantly reduced.

(3) There is heterogeneity in the effects of science and technology financial development on urban-rural income inequality, with science and technology finance in eastern and western regions causing U-shaped effects on income inequality, and science and technology finance in central regions causing inverted U-shaped effects on income inequality.

4.2 Suggestions

In order to implement the spirit of the 20th Party Congress, implement the strategy of innovation-driven development and the strategy of strong science and technology provinces, increase diversified science and technology investment, accelerate the improvement of the financial support innovation system, better adapt to the needs of science and technology innovation in the new era, effectively solve the problems of financing science and technology innovation, and promote the accelerated development of innovation and entrepreneurship, combined with the results of this paper, the following suggestions are made.

(1) The state should continue to introduce corresponding encouraging and supporting policies to promote the development of science and technology finance in rural areas, and continue to vigorously promote the development of science and technology finance, taking into account the breadth and depth of coverage. It should improve the financial support innovation system, encourage financial institutions to develop science and technology financial products like intellectual property pledge financing and science and technology insurance, and carry out pilot risk compensation for loans for transformation of scientific and technological achievements.

(2) Local governments should actively guide the entry of funds into enterprises to provide comprehensive and specialized science and technology financial services in order to effectively help the growth and development of small and medium-sized start-ups. With the support of central and local policies, each region in China combines policy guidance and local advantages to explore benchmark practices in science and technology finance, gradually improving the development gap between urban and rural income levels and abbreviating urban and rural income inequality.

(3) The technology finance development should take into account the regional heterogeneity and ensure the coordinated and balanced development among regions. By continuously improving the science and technology financial system, continuously improving the science and technology credit services, the policy efforts are appropriately tilted to the regions with industrial structure transformation and relatively slower economic development, and improving the science and technology financial system in the relatively less developed economic regions and rural areas. Local practitioners should continuously increase their awareness of science and technology credit, and provide targeted and characteristic credit services for local science and innovation enterprises by setting up special service organizations such as technology financial centers, technology sub-branches and technology-based microfinance companies, so that science and technology finance can better serve innovation and entrepreneurship. By organically combining the development of science and technology finance with rural revitalization, we can achieve the dual goals of efficiency and fairness in China's urban and rural development by continuously narrowing the income disparity between urban and rural residents, and help China's rural revitalization and high-quality economic growth.

This paper does not analyze the impact mechanism of science and technology finance on urban-rural income inequality, and future related studies can consider the impact of science and technology finance, digital economy on urban-rural income inequality at national, provincial and local level cities.

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