

Sci-tech Innovation, Financial Development and Economy Growth —Empirical Analysis Based on Static and Dynamic Panel Data

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Abstract. The paper makes empirical analysis of the relationship between sci-tech innovation, financial development and economic growth in China's Yangtze river economic belt by building panel data period fixed effect model of 11 provinces and cities in China's Yangtze river economic belt from 2005 to 2015. Static panel analysis results show that financial development and sci-tech innovation in the east, middle and west of Yangtze river economic belt have significantly different effects on economic growth, the performance's ordering of all provinces and cities in Yangtze river economic belt is east>middle>west; In system GMM(one-step),the ranking of financial development's contribution to economic growth is financial development structure>financial development efficiency>financial development scale, financial development scale has lag effect on economic growth, and there is still much room for sci-tech innovation to drive economic growth.

1 Introduction

Sci-tech innovation, financial development and economic growth are important factors in world's development today, financial development is the motive force of economic development, sci-tech innovation is the source of economic growth, positive interaction between them is conducive to country's sustainable development and world's peace and stability. China's economy has entered what is now called a new normal, in which economy has changed from high-speed growth to medium-high growth, paying more attention to quality and efficiency, the epitaxial growth mode which rely on increasing factor inputs has been inappropriate, needs to be transformed into internal growth model driven by financial innovation and technological innovation. The reports of the 19th National Congress of the Communist Party of China make it clear that "We will accelerate the development of industrial system featuring coordinated development of the real economy, scientific and technological innovation, modern finance and human resources ", "deepening reform of financial system and enhancing the capacity of finance serve the real economy." Therefore, analyzing the relationship between sci-tech innovation, financial development and the real economy has very important theoretical and practical significance.

Yangtze river economic belt is the economic circle along the Yangtze river, including Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizho, Yunnan 11 provinces and independent municipalities, which covers an area of about 2.05 million square kilometers, both population and GDP exceeds

40% of China. Yangtze river economic belt straddles China's east, middle and west, is a coordinated development zone of interaction and cooperation between east, middle and west. Since the reform and opening up, Yangtze river economic belt has developed into one of China's regions with the strongest comprehensive strength and the largest role of strategic support. The paper chose Yangtze river economy belt (11 provinces) as samples, and made empirical study on the relationship between sci-tech innovation, financial development and economic growth by panel data model, and put forward the corresponding countermeasures and suggestions, so that Yangtze river economic belt can make full use of finance (the first driving force) to lead the transformation of economic development mode through sci-tech innovation (the first source power), thus promote growth of the real economy.

2 Literature review

2.1 Status quo of overseas research

2.1.1 Economic growth and financial development

Lucas(1988)^[1], Arestis and Demetriades(1997) ^[2] thought there was no necessary and universal connection between financial development and economic growth; Ross Levine(1996) ^[3], Mohsin(2000), King and Levine (1993) argued that there was a positive correlation between financial development and economic growth, Norman(2002), Dimitris K.(2004) believed that financial

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development can promote economic growth, while Robinson Joan(1952) pointed out that economic development contributed to financial development instead of the opposite; Stiglitz J. E. (1985) showed that finance creates new productivity by pooling and distributing savings, Aghion(1992) thought developed financial markets achieve economic growth by increasing savings rates and encouraging technological innovation, Thorsten Beck(2000) believed that financial intermediaries boosted economic growth by influencing total factor productivity.

2.1.2 Financial development and Sci-tech innovation

Hicks, John Richard (1969) discussed the role of finance in scientific and technological innovation in Theory of Economic Development History, believing that the most important condition for industrial revolution is not technology but financial arrangement; Saint Paul (1992), King & Levine(1993), Schwartz (2000) and Stulz(2000) also believed that financial support can promote technological innovation; Consoli (2005), Schinckus (2008), Liao and Rice (2010) and Revilla (2012) emphasized the role of technological progress in promoting financial innovation.

2.1.3 Sci-tech innovation and economic growth

Some scholars have also made beneficial explorations on the relationship between economy and sci-tech innovation. Jeremy Howell (2005) and Jan Fagerberg (2007) showed that technological innovation is closely related to economic growth; Aghion(1992), Grossman(1994), Chris Freeman(1997), Jaffe Trajtenberg and Fogarty(2000), Arash Azdeganan(2011) pointed out that innovation can accelerate economic growth.

2.2 Status quo of domestic research

Jie Hu, Ting An and Xinyu Cao(2013) pointed out that China's economy, finance and sci-tech were developing unevenly, real economy is growing significantly faster than finance and technology, the unbalanced development greatly reduced resource allocation efficiency in the whole economy; Baoli Li and Xueping Hu(2013)^[4] investigated the internal relations among China's economic growth, financial development and technological innovation by building PVAR model, found that economic growth in China had a higher impact on financial development and technological innovation than the latter two on economic growth; Renxiang Wang and Manyang(2015) showed that the coupling coordination degree of technological innovation and financial innovation has a significant positive effect on the improvement of economic efficiency, which is especially true in developing countries; Linzhang(2016) thought that China's real economic growth had significant positive spatial correlation and heterogeneity, both financial development and sci-tech innovation had significantly promoted economic growth in the short and long term, while the integration of financial development and sci-

tech innovation had no significant effect on economic growth.

The relationship between sci-tech innovation, financial development and economic growth has been a controversial hot issue in economics. Foreign scholars have conducted a very detailed study on the relationship between financial development and economic growth, and got many research results, but academia was quite different about the relationship between the two, while the correlation between economic growth and sci-tech innovation was generally agreed upon; Some domestic scholars tried to put sci-tech innovation, financial development and economic growth into a framework for research, and tried to explore the relationship between them. This paper will make an empirical analysis on the relationship between sci-tech innovation, financial development and economic growth in various provinces and cities of Yangtze river economic belt from 2005 to 2015.

3. Variable selection and model setting

3.1 Selection and synthesis of indicators

First, indicators of economic growth. In this paper, GDP growth rate is selected as the index to measure economic growth, which is from China statistical yearbook of 2005-2015.

Second, sci-tech innovation indicators. This paper selects three variables of new product sales revenue, effective invention patents and technology market turnover to measure sci-tech innovation, which is from China science and technology statistics yearbook, and then gets the only sci-tech innovation index by topsis comprehensive evaluation^[5], sorting results are shown in figure 1, 1-11 in the figure correspond to Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizhou, Yunnan respectively, Shanghai had the highest level of Sci-tech innovation in 2005-2010, while it was surpassed by Zhejiang between 2011-2015, and Jiangsu remained in the third place.

Third, financial development indicators. This paper reflects financial development from three dimensions: financial development scale(FIR), financial development structure(FS), financial development efficiency(FE). FIR, FS, FE are calculated by the following formula, $FIR = \text{regional financial industry added value} / \text{regional GDP}$, $FS = (\text{deposits of regional financial institutions} + \text{regional total stock market value} + \text{regional premium income}) / \text{regional GDP}$, $FE = \text{loans from regional financial institutions} / \text{deposits of regional financial institutions}$, most data of regional financial development are from China financial yearbook except that regional financial industry added value are from China statistical yearbook.

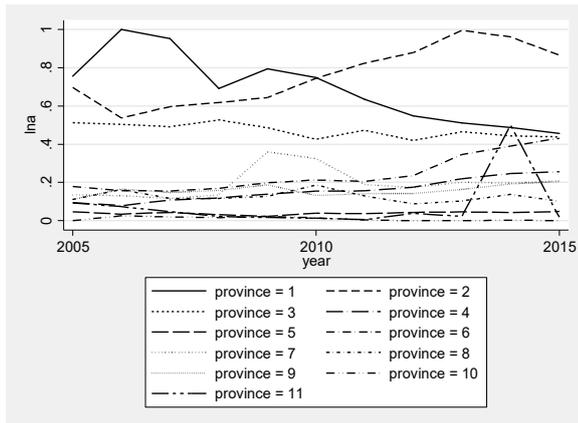


Figure 1. Ranking results of Sci-tech innovation in Yangtze river economic belt

3.2 Data source and processing

According to the above literature review, this paper uses panel data of China Yangtze river economic belt in 2005-2015 to make empirical analysis, then divides 11 provinces and cities into east, middle and west, and the three eastern provinces including: Shanghai, Jiangsu, Zhejiang; the four central provinces include Anhui, Jiangxi, Hubei and Hunan; the four western provinces include Chongqing, Sichuan, Guizhou and Yunnan. All variables are treated with logarithm, in order to reduce heteroscedasticity and enhance the interpretation of the result, the final variable is $\ln Y$, $\ln A$, $\ln FIR$, $\ln FS$, $\ln FE$, meanwhile the uses statistical software of EVIEWS7.0 and STATA13.0 .

4. Empirical analysis

4.1 Static panel analysis

In order to avoid the pseudo-regression phenomenon caused by non-stationary time series data, unit root test of each variable is needed. LLC test, ADF test and PP test are adopted In this paper, and the results are as follows^[6].

Table 1. Smoothness test of variables

Variables	LLC	ADF	PP	Result
$\ln Y$	1.549	9.343	6.837	Unstable
$\ln A$	-2.023*	25.168	24.615	Unstable
$\ln FIR$	-0.676	9.389	8.523	Unstable
$\ln FS$	2.844	3.638	1.458	Unstable
$\ln FE$	-1.046	17.520	18.005	Unstable
$\Delta \ln Y$	-9.728 ***	69.652 ***	67.188 ***	Stable
$\Delta \ln A$	-12.994 ***	86.000 ***	145.648 ***	Stable
$\Delta \ln FIR$	-9.166 ***	61.862 ***	72.754 ***	Stable
$\Delta \ln FS$	-13.525 ***	96.262 ***	143.192 ***	Stable
$\Delta \ln FE$	-10.895 ***	90.162 ***	113.203 ***	Stable

Note: ***, **, * are respectively significant at 1%, 5% and 10%.

Can be seen from table 1, these sequences all have unit root, while their first order difference sequence pass the test at the significance level of 1%, which means panel data is stable, so the next step is co-integration test, carried out by Kao test method, and cointegration test is passed under 5% significance level, namely there is a long-term and stable relationship between these variables, the paper can make parameter estimation by panel model.

Table 2. Panel co-integration test results

ADF	t-Statistic	Prob.
	-2.145	0.016

In the selection of panel model form, F test is firstly used to determine whether mixed effect model or fixed effect model (individual fixed and period fixed), Secondly, Hausman test is used to determine whether random effect model or fixed effect model should be adopted. It can be seen from table 3 that this paper should selects fixed effect model^[7].

Table 3. Panel model type selection test

Statistical method	Alternative hypothesis	P
F test	individual fixed effect model	0.000
	period fixed effect model	0.000
Hausman test	individual fixed effect model	0.026
	period fixed effect model	0.000

Both goodness-of-fit and passing rate of variable significance test of period fixed effects is superior to individual fixed effects after examination (due to space limitations, this part of process is omitted), so period fixed effect will be used to estimate the model.

Table 4. Static panel model (period fixed effect)

Variables	Yangtze river economic belt	East	Middle	West
$\ln A$	-0.035 ***	0.040	0.002	0.019
$\ln FIR$	0.138 **	-0.219 ***	0.081 **	0.151
$\ln FS$	-0.356 ***	-0.087 *	-0.101	0.007
$\ln FE$	-0.189	-0.242 ***	0.171	-0.808 *
R2	0.784	0.985	0.971	0.856
Adjusted R2	0.754	0.973	0.957	0.775
F	26.368	82.597	69.657	10.615

Note: ***, **, * are respectively significant at 1%, 5% and 10%.

It can be seen from table 4, financial development and sci-tech innovation in the east, middle and west of Yangtze river economic belt have significantly different effects on economic growth, and financial development has contributed more to economic growth than sci-tech innovation, because sci-tech innovation have passed variable's significance test only in national model, and the coefficient is negative; financial development scale, financial development structure, financial development efficiency have passed significance test in most models, and the coefficient of financial development scale in Yangtze river economic belt and its' middle is positive,

which means the contribution of financial development scale to economic growth is obvious. In terms of the estimation result of period fixed effect panel model, the performance's ordering of all provinces and cities in Yangtze river economic belt is east >middle >west, the driving role of sci-tech innovation and financial development on economic growth has yet to be improved.

4.2 Dynamic panel analysis

Dynamic panel data generally estimate the parameters of different models by GMM, which can alleviate endogenous problems, including difference-GMM and system-GMM, system-GMM can improve the efficiency of estimation, and GMM can be further divided into one-step and two-step.

Table 5. Dynamic panel model parameter estimation results

Variables	DIF-GMM (one-step)	DIF-GMM (two-step)	SYS-GMM (one-step)	SYS-GMM (two-step)
$\ln Y_{t-1}$	0.670 ***	0.289	0.689 ***	0.248
$\ln A$	0.002	0.002	0.001 *	0.001
$\ln A_{t-1}$	0.001	0.001 *	0.001	0.001 **
$\ln FIR$	-0.419 ***	-0.397 ***	-0.433 ***	-1.675 ***
$\ln FIR_{t-1}$	0.078	-0.107	0.090	1.209 **
$\ln FS$	0.516 ***	0.641 ***	0.522 ***	0.809 ***
$\ln FS_{t-1}$	-0.133	0.207	-0.215 **	-0.169
$\ln FE$	0.646 ***	0.585	0.766 **	-0.423
$\ln FE_{t-1}$	-0.265	-0.024	0.112	-3.785 **
Wald'p	0.000	0.000	0.000	0.000
Sargan'p	0.067	1.000	0.034	1.000
AR (2) 'p	0.214	0.255	0.327	0.142

Note: ***, **, * are respectively significant at 1%, 5% and 10%.

We can know that from table 5, most parameter estimates are more than zero, indicating that it is feasible to set dynamic panel data by introducing lag terms of explained variable. Wald test values is significant at 1% level; The P of AR (2) indicates that there is no second-order autocorrelation, and dynamic panel model is reasonable; The value of Sargan test shows that instrumental variable selected by model is reasonable. Sargan test' P of DIF-GMM (one step) and SYS- GMM (one step) is 0.0672 (>0.05) and 0.0342 (>0.01) respectively, which means the original hypothesis "all instrumental variables are effective" can't be refused in 5% and 1% significance level respectively.

Financial development structure performs the best among various estimation methods, and the coefficient is significantly positive; Then is sci-tech innovation, there are three significant positive coefficients in current value

and lag phase value; The third is the lag phase value of financial development efficiency and economic growth, their coefficient is significantly positive in the two estimation methods; The worst is financial development scale, the coefficient of current value is significantly negative, lag phase value is positive and don't pass significance test, it shows that financial development scale has lag effect on economic growth. The effects of financial development index of three dimensions in dynamic panel on economic growth seems to contrary to static panel, this may be related to the lag effect of explanatory variables in dynamic panel in addition to introducing lagged values of explained variables.

At the same time, it is not hard to see that parameter estimation of system GMM (one-step) is the best, because one-step may be better than two-step with small sample. In system GMM(one-step), the coefficient of GDP growth lagging one period is about 0.69, indicating that the inertial effect of economic growth is strong, which is consistent with the reality.

In addition, current value coefficient of sci-tech innovation, financial development structure and financial development efficiency are significantly positive, and the coefficient of financial development structure and financial development efficiency are about 0.52 and 0.77 , it shows that the role of financial development structure, financial development efficiency in the real economy is played accordingly in Yangtze river economy belt. The coefficient of sci-tech innovation current value is only 0.001, indicating that there is still much room for sci-tech innovation to drive economic growth, which coincides with the analysis of static panel data. The coefficient of financial development scale and financial development structure lagging one period are significantly negative, possible explanation is that if finance develops too much, taking off the reality to the virtual, it will be harmful to the real economy but not beneficial.

5 Conclusions and countermeasures

Financial development and sci-tech innovation in the east, middle and west of Yangtze river economic belt have significantly different effects on economic growth, financial development has contributed more to economic growth than sci-tech innovation , the contribution of financial development scale to economic growth is obvious, the performance of all provinces and cities in Yangtze river economic belt is east >middle >west, the driving role of sci-tech innovation and financial development on economic growth has yet to be improved.

The estimation result of dynamic panel model with lagged variables is improved, the role of sci-tech innovation in economic growth has been preliminarily revealed, the ranking of financial development's contribution to economic growth is financial development structure>financial development efficiency>financial development scale, financial development scale has lag effect on economic growth. Meanwhile, one-step may be better than two-step with small sample. In system GMM(one-step), the coefficient of GDP growth lagging one period is about 0.69, indicating that the inertial effect

of economic growth is strong. The current value of financial development structure and financial development efficiency is significantly positive and big, it shows that the role of financial development structure, financial development efficiency in the real economy is played accordingly in Yangtze river economy belt, The estimated coefficient of sci-tech innovation current value is so small, indicating that there is still much room for sci-tech innovation to drive economic growth.

Based on the empirical analysis of relationship between sci-tech innovation, financial development and economic growth, the following countermeasures and suggestions are proposed: in terms of financial development and the real economy, grasp the essence of financial services to the real economy. First, we need to establish a multi-tiered and all-round financial market system to improve the efficiency of financial services to the real economy; Second, accelerate innovation in financing models and promote the development of multi-tiered capital markets through financial innovation; Third, strengthen financial regulation and ensure financial development and financial stability; Fourth, improve financial regulatory mechanism and ensure that no systemic financial risks occur. In terms of sci-tech innovation and real economy, economy should be continuously boosted by sci-tech innovation. First, increase investment in R&D to enhance the capability of sci-tech innovation in the real economy. Then strengthen conditions construction for innovation and enhance sustained innovation capacity; Then improve the quality of sci-tech innovation and promote high-level industrial development; Finally, improve transformation's ability and promote the commercialization of sci-tech innovation. In short, we should promote deep integration of modern finance and sci-tech innovation actively, make full use of Sci-tech Finance and Fintech to support and lead the transformation of economic development pattern, thus promote the real economy growth.

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