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Empirical Study on the Relationship between Public Finance Technology Input and Independent Innovation in Shanghai

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Abstract – By using dynamic equilibrium analysis method of time series, in this paper, we did cointegration analysis on relevant data variables of public finance technology input and independent innovation capability in Shanghai from 1986 to 2010, established the error correction model between them, revealed dynamic equilibrium relationship between public finance technology input and independent innovation capability in Shanghai. Finally, recommendations and countermeasures are proposed to boost the promotion of Shanghai's independent innovation capability.

Keywords – Public finance technology input; Independent innovation; Cointegration analysis; Dynamic equilibrium

1. Introduction

With the development of globalization, it is increasingly obvious that the scientific and technological innovation can better promote the economic growth. Since the independent innovation is the key to scientific and technological innovation, it's of great significance to do research on independent innovation activities. Investment in science and technology is the foundation of independent innovation activities, in which the government financial investment in science and technology is important component, it plays an important role in creating innovative environment, guiding social capital investment in science and technology, optimizing the allocation of resources of science and technology and strengthening the regional competitiveness etc. China's governments at all levels have constantly strengthened the total amount and intensity of the financial investment in science and technology, in order to focus on promoting independent innovation.

Shanghai as a pearl of China, is one of the most developed provinces in the Mainland, economic development is in a transitional period that from capital-driven to technology-driven, from technology import to independent innovation. In recent years, the Shanghai municipal government has payed more and more attention to financial investment in science and technology, invested a total of 20.203 billion Yuan in 2010, compared with 10.08 billion Yuan in 2000, it has increased 20 times. At the same time, the output of public finance technology input perform significantly, the science and technology thesis, patent, scientific and technological achievements have gradually increased year by year, new and high technology industries have been developing at top speed.

Overview of the existing literature, there are less researches on independent innovation based on the perspective of R&D expenditure and the relationship between public finance technology input and independent innovation of different regional may vary. Based on the above considerations, in this paper, we did empirical analysis on the relationship between public finance technology input and independent innovation in Shanghai.

2. Methodology

2.1. Independent innovation function

From the R&D point of view, independent innovation model can be built as Y=F(X，Z)，Y is the capability of independent innovation, X is the financial investment in science and technology, Z is the corporate and other investment factors. Considering the feasibility of the study, when study the capability of independent innovation, we assume that the corporate and other investment factors constant, only consider the factors of public finance technology input, so we built model Y=F(X), the meaning of the variable as above.

2.2. Stationarity test of time-series variables

The variable stationary test, also known as unit root test. In practice, people usually use ADF test method to do test. The model is as follows:

Model I: $$\Delta y_t = \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

(no constant term, no trend term)

Model II: $$\Delta y_t = a + \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

(constant term, no trend term)

Model III: $$\Delta y_t = a + \beta t + \delta y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta y_{t-j} + u_t$$

(constant term, trend term)

For hypothesis test: H_0: $\delta = 0$; H_1 : $\delta < 0$。If we accept the hypothesis H_0 and reject H_1, it means that sequence y_t exists unit root, and is therefore non-stable. Otherwise sequence y_t does not exist unit root, namely is stable. For non-stable variables, still need to test the stability of the first order difference. If the variable first-order difference is stable, it says the variable is I (1). All variables are the same order difference stability is a necessary condition for cointegration relationship between the variables.

2.3. Cointegration test of time-series variables

Cointegration analysis involves a set of variables, each of them is not smooth, but they drift together. This makes these variables have long-term linear relationship, so that people can study the long-run equilibrium relationship between economic variables. Johansen cointegration test can determine the number of cointegration equation, the number is called the cointegration rank. The hypothesis of cointegration test is:

H_0：there exists none cointegration relationship H_1：there exists m cointegration relationships

Inspection of mark statistics:

$$Q_T = -T \sum_{i=r+1}^{m} \log(1-\lambda_i)$$

Formula λ_i is ranked i in order of size the eigenvalue. T is the total number of the observation period. This is not an independent inspection, but corresponds to a series of tests on the different values of r. The inspection begin from the null hypothesis that there does not exist any cointegration to at most m-1 cointegration relationships. It ha s to do a total of m times inspection, alternative hypothesis is unchanged.

2.4. Error correction model of time-series variables

Cointegration analysis can also be used on short-term or unbalanced estimation of parameter, according to the Granger theorem, if two variable X_t, Y_t are cointegrated, then there is a long-term equilibrium relationship between them. Of course, in the short term, these variables can be non-equilibrium, disturbance item is balanced error ecm_t. The dynamic structure of this short-term non-equilibrium relationship between the two variables can be described by the error correction model (error correction model, ECM). The error correction model that connect the short-term and long-term behavior of two behaviors is given by:

ΔY_t = lagged (ΔY_t , ΔX_t)-**Error! Bookmark not defined.** λecm_{t-1} + V_t

in which Y_t ~I(1), X_t ~I(1), Y_t , X_t ~CI(1，1), $ecm_t = Y_t - \beta_0 - \beta_1 X_t$ ~I(0), V_t is white noise, λ is short-term adjustment coefficient.

2.5. Granger causality test of time-series variables

In the regression analysis, the degree of association between variables can be measured, but the causality cannot be confirmed, identifying causal relationship is an important issue in the study based on inspection. The basic idea of causality test proposed by Granger and Sims are as follows: If the variable X helps to predict the variable Y, that is according to past value of Y on Y for regression, the explanation ability of regression can be significantly enhanced if the past value of X is added, then X is Y Granger reason, otherwise, referred to as non-Granger causality. The process of Granger causality test between variable X,Y is as follows: First of all, test the original hypothesis that "X does not Grange cause Y", estimate the following two regression models:

Unrestricted regression:

$$Y_t = \sum_{t=1}^{m} a_i Y_{t-i} + \sum_{t=1}^{m} b_i X_{t-i} + \mu_t$$

Restricted regression: $$Y_t = \sum_{t=1}^{m} a_i Y_{t-1} + \mu_t$$

Using the RSS of each regression to calculate F statistics, to test whether the coefficients b1，b2，…bm are notable not zero simultaneously. If they are, refuse the original hypothesis. Then test the original hypothesis "Y does not Grange cause X", and do the same regression estimation. But exchange of X and Y, to inspect whether Y lagged items are significant not zero. If they are, refuse the original hypothesis "Y does not Grange cause X".

3. Empirical analysis

3.1. Data

Since patents are new technology schemes that are proposed for a product, a process or an improvement, they can form self-knowledge products. Patent licensing statistical data reflects the quantity and quality of science and technology development and innovation activities that people engaged in a period of time, it can comprehensively reflect the capability of independent innovation, we select patents granted (PL) as a measure of the capability of independent innovation. Although the public finance technology input of China is not all R&D investment in the real sense, as we lack enough R&D expenditure data of long period, here we use fiscal science and technology funds (S) to reflect public R&D input status, PS is the actual value of S after adjustment of the price index P. In order to reduce heteroscedasticity, avoid the volatility of the data, we take the natural logarithm of all variables. Therefore, we select LNPL as an indicator to measure the capability of independent innovation, LNPS to public finance technology input. The specific measurement model is: $LNPL = c_0 + c_1 LNPS + \varepsilon_t$。

Table 1. Relevant data of public finance technology input and independent innovation in Shanghai (1986-2010)

Years	PL	S	P (1978=100)	PS	LNPL	LNPS
1986	220	1.72	782.99	1.23652	5.393628	0.212301
1987	575	1.7	788.12	1.122853	6.35437	0.115873
1988	909	1.85	792.13	1.007625	6.812345	0.007596
1989	957	1.86	784.96	0.867942	6.863803	-0.14163
1990	924	2.44	787.72	1.086376	6.828712	0.082847
1991	1025	2.1	798.13	0.854006	6.932448	-0.15782
1992	1215	2.3	806.91	0.852483	7.102499	-0.1596
1993	2146	2.6	853.11	0.820189	7.671361	-0.19822
1994	1454	3.43	850.04	0.921053	7.282074	-0.08224

1995	1436	5.12	855.72	1.216441	7.269617	0.195929
1996	1610	5.63	851.21	1.274044	7.383989	0.242196
1997	1886	7.65	847.25	1.752176	7.542213	0.560858
1998	2334	8.29	836.21	1.996628	7.755339	0.69146
1999	3665	10.83	733.76	2.680693	8.206584	0.986075
2000	4050	10.08	745.24	2.587933	8.306472	0.95086
2001	5371	12.39	752.26	3.226563	8.588769	1.171417
2002	6695	15.25	792.04	4.023747	8.809116	1.392213
2003	16671	19.84	813.05	5.285029	9.721426	1.664878
2004	10625	39.32	836.87	10.38015	9.270965	2.339895
2005	12603	79.34	863.32	21.06185	9.44169	3.047463
2006	16602	94.89	885.51	25.14308	9.717278	3.224583
2007	24481	105.77	909.08	27.36611	10.10565	3.309305
2008	24468	120.27	1053.24	29.54311	10.10512	3.385851
2009	34913	215.31	1064.42	53.18923	10.46061	3.973856
2010	48215	202.03	1090.76	49.07214	10.78343	3.893291

Note: The data comes from Shanghai statistical yearbook 2011, Shanghai science and technology statistical yearbook 2011, Shanghai national economy and social development of historical statistics 1949-2000.

3.2. Unit root test

In order to test the cointegration relationship between the variables, we did the unit root test to the time series of LNPL and LNPS with ADF test method. Table 2 shows, the ADF value of LNPL and LNPS are greater than the corresponding 10% critical value, indicating that they are non-stationary sequences. While the ADF value of their first difference sequence DLNPL and DLNPS are less than 10% critical value, we determine that LNPL and LNPS are integrated of order 1, that is LNPL～I(1)，LNPS ～ I(1), we can further test cointegration relationship between the variables.

Table 2. Result of stationary test

Series	**Test type (c,t,k)**	**ADF test value**	**1% Critical value**	**5% Critical value**	**10% Critical value**	**Conclusion**
LNPL	(c,t,0)	-3.053758	-4.394309	-3.612199	-3.243079	non-stationary
LNPS	(c,t,0)	-2.063944	-4.394309	-3.612199	-3.243079	non-stationary
DLNPL	(c,0,0)	-6.108429	-3.752946	-2.998064	-2.638752	stationary
DLNPS	(c,0,0)	-3.518378	-3.752946	-2.998064	-2.638752	stationary

Note: (1)In the test type, c and t mean constant term and trend item，k means lag order number; (2)The selection criteria of the lag period of K is based on is based on AIC and SC minimum criterion. In this paper we use Eviews6.0 as the measuring software.

3.3. Cointegration test

Johansen test is a kind of test method based on VAR model, before doing the test, you must first determine the structure of the VAR model. Based on the AIC, SC information criterion, we determined the unconstrained VAR optimal lag period for 2, because the lag period of the cointegration test model is the lag period of first-order differential variable of unconstrained VAR model, so the lag period of the cointegration test was determined for 1. The cointegration equation contains the intercept, but excludes the time trend, the specific test result as shown in Table 3.

Table 3. Johansen cointegration test results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic (Prob.)	λ-max Statistic (Prob.)
None	0.530295	27.24490 (0.0046) *	17.37996 (0.0290)*
At most 1	0.348782	9.864940 (0.0368) *	9.864940 (0.0368) *

Note:* denotes rejection of the hypothesis at the 0.05 level

Table 3 shows that in the 5% significant level, there exists 2 cointegration relationships between LNPL and LNPS, we list the first normalized cointegrating vector given by Johansen test, that's (LNPL, LNPS, C) for (1.0000, -0.6695,- 6.6003), so the long-term equilibrium equation for the original innovation and financial investment in science and technology will be LNPL= 0.6695LNPS+6.6003.

As can be seen from the equation, there is a long-run equilibrium relationship between Shanghai's financial investment in science and technology and independent innovation in 1986-2010. In the long term, the financial investment in science and technology change each 1%, the capability of independent innovation will change 0.6695% in the same direction.

3.4. Vector error correction model

According to the Granger theorem, a group of variables that has a cointegration relationship must have an error correction model expression. Cointegration relationship is merely a reflection of the long-term equilibrium relationship between the variables, error correction model is used to establish a dynamic model of short-term to make up for the deficiency of the long-term static model, it not only reflects the long-term equilibrium relationship of different time sequence, but also reflects the short-term deviation on long-term equilibrium correction mechanism. The error correction model reflects the short-term dynamic equilibrium relationship between LNPL and LNPS is: D(LNPL)=-0.2291*ECM(-1)-0.0951*D(LNPL(-1))+0.1636*D(LNPS(-1)) + 0.1868

In which ECM(-1)= LNPL(-1) - 0.7722*LNPS(-1) - 7.3038

From the error correction model, D (LNPS (-1)) coefficient is 0.1636, can be interpreted as D (LNPL) on the D (LNPS (-1)) short-term elastic coefficient, the value is smaller compared with the long-term cointegration regression equation, it means that in the long term the impact of the financial investment in science and technology on the growth of independent innovation is more significant. The coefficient of error correction term ECM is negative, this accords with reverse correction mechanism, and manifests that the convergence mechanism of deviation of long-term equilibrium trend is:

When LNPL-6.6003-0.6695LNPS> 0, ECM (-1) plays a negative role on the growth of independent innovation; When LNPL-6.6003-0.6695LNPS< 0, ECM (-1) plays a positive role on the growth of independent innovation. The ECM (-1) efficient is -0.2291, indicates that long-term equilibrium error correction term to the growth of independent innovation adjustment range is 22.91%, with strong regulatory role.

3.5. Granger causality test

Cointegration test results show that there exists a long equilibrium relationship between Shanghai's public finance technology input and independent innovation. But whether the equilibrium relationship constitutes a causal relationship still need further verification. According to the relevant data of two, we did Granger causality test, the lag period were taken 1-5, the results were shown in Table 4.

Table 4. Granger causality test results

Lag Period	Null Hypothesis	F-Statistic	Prob.	Decision	Conclusion
1	LNPS≠>LNPL	11.2039	0.0031	rejection	LNPL<=>LNPS
	LNPL≠>LNPS	8.03846	0.0099	rejection	

2	LNPS≠>LNPL	2.00790	0.1632	acceptance	LNPS≠>LNPL
	LNPL≠>LNPS	6.51950	0.0074	rejection	LNPL=>LNPS
3	LNPS≠>LNPL	0.38938	0.7623	acceptance	LNPS≠>LNPL
	LNPL≠>LNPS	8.68803	0.0014	rejection	LNPL=>LNPS
4	LNPS≠>LNPL	0.12377	0.9711	acceptance	LNPS≠>LNPL
	LNPL≠>LNPS	5.16722	0.0118	rejection	LNPL=>LNPS
5	LNPS≠>LNPL	0.20933	0.9501	acceptance	LNPS≠>LNPL
	LNPL≠>LNPS	4.11420	0.0319	rejection	LNPL=>LNPS

We can observe from Table 4: When the lag is 1, financial investment in science and technology promoted the improvement of capability of independent innovation while the capability also contributes to the increase in financial investment in science and technology, they have two-way causality. When the lag is 2-5, the improvement of innovative capability is the cause of the growth of the financial investment in science and technology, while the growth of financial investment in science and technology is not the cause of the improvement of the innovative capability.

Granger test investigates the existence of causal flow in a certain direction between variables from the perspective of statistical significance. Impulse response function and variance decomposition can give a more comprehensive observation to the economic sense contained in VAR model. The impulse response function describes a response generated by an endogenous variable shocked by a unit change of another endogenous variable, it can provide information like the positive and negative direction of the response, adjusting the time delay and stabilizing process.

3.6. Impulse response function

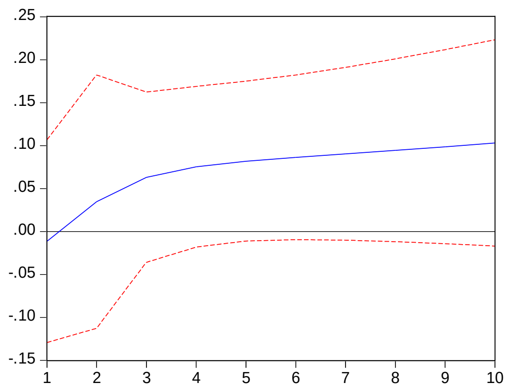

Figure 1. Response of LNPL to Generalized One S.D. LNPS Innovation

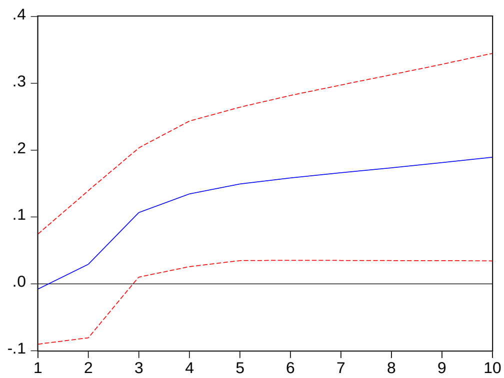

Figure 2. Response of LNPS to Generalized One S.D. LNPL Innovation

As can be seen from the Figure 1, LNPL rises immediately when shocked by generalized one S.D. LNPS innovation, but the rate decreases year by year and tends to be stable. It means the financial investment in science and technology can promote independent innovation, so that the Shanghai local financial investment in science and technology is effective, and has a long continuous effect.

From the Figure 2, we can also find that LNPS rises immediately when impacted by generalized one S.D. LNPL innovation, the rate increases year by year in the first 3years and then gradually tends to grow steadily. This shows that the strengthen of capability of independent innovation significantly promote the Shanghai municipal economic growth, the growth further promotes the increasing of local financial investment in science and technology.

3.7. Variance decomposition

Johansen cointegration test and Granger causality test can only show that the relationship between variables, but can't illustrate the strength of this relationship. Therefore we use previously identified VAR model for variance decomposition analysis. The main idea of the variance decomposition is to decompose the fluctuation of each endogenous variable in the system into m parts that associated with each equation information (random error term), so as to understand relative importance of each equation information on the endogenous variables of the model.

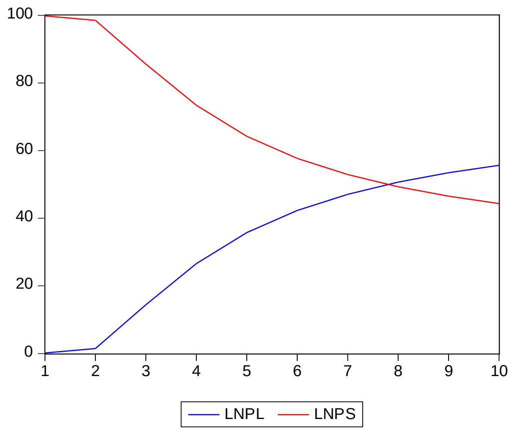

Figure 3. Variance decomposition of LNPL

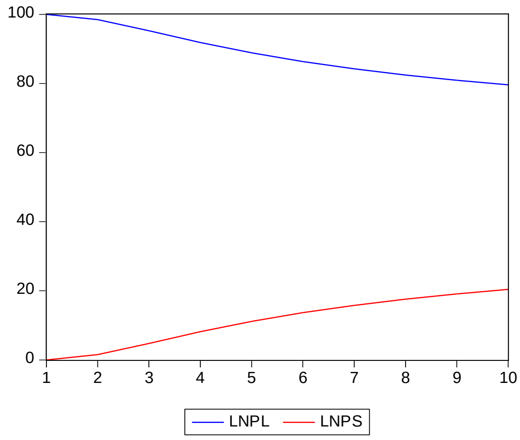

Figure 4. Variance decomposition of LNPS

From the Figure 3, we can see that the proportion of financial investment in science and technology contribute to changes in science and technology innovation rises steadily year by year, but the rate is more slowly. From the Figure 4, we can see that the proportion of changes in science and technology innovation contribute to financial investment in science and technology starts to influence significantly from the second period, with a faster rate.

4. Conclusion and countermeasures

4.1. Conclusion

Through the empirical analysis, we get the following conclusions: (1)There exists a strong relationship between the Shanghai financial investment in science and technology and the capability of independent innovation, although their growth is not stable, but in the long term, they constitute the long-term equilibrium relationship. The long-term elasticity coefficient of LNPL to LNPS is 0.669461, with every 1% of change in the financial investment in science and technology, the capability of independent innovation changes 0.669461% in the same direction. In the short term, the financial investment in science and technology with 1, 2, 3 lag has significant influence to the changes in independent innovation. The equilibrium relationship of public finance technology input and independent innovation has strong self correction ability to current unbalanced error, the adjustment range is 22.9%. (2)When the lag is 1, there is two-way causality between public finance technology input and independent innovation. When the lag is 2-5, the growth of financial investment in science and technology is not the cause of the improvement of the capability of independent innovation. Maybe the effects of financial investment in science and technology of 1lag is significant, in the next few periods, government public finance technology input is not the only source of growth of independent innovation capability. Enterprises as main body of input of independent innovation, their own R&D funding also plays an important role in improvement of capability of regional independent innovation. (3) In the short-term and long-term, there exists continuous bidirectional promotion effect between Shanghai financial investment in science and technology and the ability of independent innovation.

4.2. Recommendations and countermeasures

(1) Increasing financial investment in science and technology. The Shanghai government should give full play to the leading role of financial investment in science and technology, and constantly expand the scale of the

investment, guarantee steady growth level of the investment, ensure the growth of the investment at all levels over the recurring financial income growth, especially increase the proportion of independent innovation funds, strengthen support for independent innovation activities.

(2) Establishing a diversified, multi-channel, multi-level R&D input system. We should encourage financial input of enterprises, social forces, and private capital to the cause of science and technology while increasing financial input.

(3) Improving the government science and technology input mode. Starting from the needs of society and the public safety, give priority to solving the problems of science and technology in a series of prominent contradictions in the social sphere.

(4) Optimizing investment in science and technology management mechanism. Shanghai government and related departments should base on improvement of the efficiency of financial investment in science and technology to innovate financial investment management mechanism and system; establish and improve the performance evaluation system, strive to improve the use benefit of independent innovation funds to make sure that the Shanghai public finance technology input really play a role to support and guide the independent innovation.

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