Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(12):21-26

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

The impact analysis of S & T investment on high-tech industry development

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ABSTRACT

Based on the partial least squares (PLS) method, this article use the Total S&T Personnel, Total Funding for S&T Activities, Total Intramural Expenditures, Full-time Equivalent of R&D Personnel Total and the Total R&D Expenditure as the independent indicators to quantitatively analyze the impact on the high-tech industry development. The results showed that the Total S&T Personnel and Full-time Equivalent of R&D Personnel Total have more intense impact on high-tech industry development, while the total Intramural Expenditures is not obvious to the innovation output.

Key words: S&T Investment, High-tech industry, PLS

INTRODUCTION

The high-tech industry is the key industries which promote industry development and economic growth by technology-driven and the important position of international economic and technological competition[1]. Therefore, developing high-tech industry has an irreplaceable role on facilitating industrial upgrading, promoting economic restructuring, accelerating economic growth and improving labor productivity and economic efficiency. In China, the high-tech industry is an emerging, rapidly growing industry. In the 1995 to 2006, China's high-tech industry added value increased from 108.1 billion Yuan to 1.0056 trillion Yuan, accounting for GDP from 1.78 percent rose to 8%. In support of the local science and technology investment, High-tech companies is now becoming the subject of basic research, an important force of applied research of high-tech cutting-edge exploration, and an important source of technological innovation.

The level of technological development in a country or region largely determines the region's economic development potential and overall competitiveness, and the investment scale, patterns and investment management of government investment in science and technology plays a key role on the development of local science and technology[2]. Science and technology investment, including local financial direct investment, local investment in R & D institutions and enterprises as well as technology investment of local colleges and universities, science and technology investment is not only material and funds support to the development of high-tech industry, it is also the reflect of full emphasis on high-tech industry[3]. However, the financial S&T investment, including many aspects, which will play a more proactive role in promoting high-tech industries development, which will have a weak impact on the development of high-tech industry, this is new problems our each levels government need to be addressed in the new situation. Therefore, using scientific quantitative analysis methods to study the impact of science and technology investment on the development of high-tech industry have important theoretical significance and practical value in government decision-making and the development of high-tech industry.

A PLS model is established in this paper to investigate the relationship of S&T investment and the development of high-tech industry. In addition, the SIMAC-P software is used to deeply analyze the impaction of China’s S&T

investment on high-tech industry development. The research shows that the facilitation of China’s S&T investment to high-tech industry development is rather significant and with the strengthening of the capacity of S&T investment, which has a continuing stimulus in high-tech industry development.

Literature Review

In the impaction study of S&T investment on high-tech industry development, Kortum S., Lerner J（2000), Hagedoorn J., Cloodt M（2003）, Ernst H, Witt P, Brachtendorf G（2005） show that S&T investment has a huge range of effects on industrial innovation and industrial development. Dushnitsky G., Lenox M.J(2006)和 MacMillan I., Roberts E., Livada V., Wang A（2008）investigate the role of venture capital on innovation and high-tech enterprise development, venture capital can be drawn as an important factor to promote industrial innovation and industrial development. Sahaym A., Steensma H.K., Barden J.Q（2009）using econometric models combined with time-series and cross-sectional data, from the industrial level discuss that the R&D investment is the main reason of impacting innovation output of high-tech industries. China scholar Gu Huisan(2004) according to the 1995 - 2001 China's economic statistics, analyze China's high-tech industry science and technology input and high-tech industry development situation and use gray system theory to do association studies of science and technology investment and industrial development. Lu Yongming(2008) using the DEA model to evaluate China's 17 high-tech industry science and technology input-output efficiency from 2002 to 2006 and analyze the industries scale returns situation. Zhao Xiuyu, Guo Chunli, Huang Shichuan (2010) using provincial panel data empirical analyzes the impact of human capital, science and technology investment on the development of high-tech industries. Xu Li, Cui Xuling, Zhao Jianqiang(2011) examine local government's expenses and local industry's expenses in science and technology, as well as the data of high-tech production value. The research verifies this theoretical assumption. At present, government investment in science and technology plays a dominant role in the growth of local high-tech industry. Feng Feng, Zhang Leiyong, Gao Mou, Ma Lei(2011) construct two-stage S&T input-output chain model and studies data of 29 provinces in method of series network DEA, finds that there are differences between provinces or regions, divides all provinces into four categories, draws efficiency map of the two-stage S&T input-output chain, reveals that increase the efficiency of 'Target Stage' can increase efficiency of the S&T input-output chain[3,4,5].

Based on the above overview, we can see that China's current research on the influence of S&T investment and high-tech industries still has a large space, especially the quantitative analysis of related impact. In this paper, on the basis of existing research, the impact relationship between S&T investment and high-tech industry is analyzed quantitatively. The question that what is the key point of S&T investment and if the impact difference is existence of S&T investment on output are also discussed.

EXPERIMENTAL SECTION

A Currently, multiple linear regression models has been widely used in many areas of research, which depend on the variation tendency of multiple variables to explain the variables which are interested. This model method has become a more mature theory. However, despite the multiple linear regression analysis is an effective method, but its application must satisfy certain constraints, such as the independent variables in the set cannot exist the multiple correlation between each other, the sample point size cannot be too small, otherwise it will lead to the model error expansion and regression coefficient estimates changes in the sample data is very sensitive, leading to the regression model unstable. As in the economic and social sciences, variables are often related phenomenon with each other in varying degrees, and because of the conditional limitations, there may be the problem of sample points size insufficient. Therefore, this article uses a new type of multivariate statistical analysis--partial least squares regression (Partial Least Squares Regression)[7,8]. PLS method is an effective method in eliminate the multiple correlation of independent variables. In a complex multi-variable system, the PLS method do not judge the variable accept or reject one by one, but use the idea of information decomposition to make the information recombination of the independent variable systems, to effectively extract the comprehensive variables which have the most explanation of the system, excluding the information interference of overlapping information or non-interpretation meaningful information to solve the negative effects produced by multi-variable correlation in modeling the system, so to get a more reliable analysis results[9]. The biggest advantage of Partial Least Squares Regression model is that it solves the variable multi-correlation in multiple regression analysis and the explanatory variables is more than sample points and other issues.

The original theory model of partial least squares regression is as follows[10]:

There are k dependent variables y, which constitute the dependent variable set $Y = [y_1, ..., y_k]$ and p independent variables x constituting the independent variables set $X = [x_1, ..., x_p]$, in order to study the statistical relationships between dependent variable and independent variables, we observed n sample points and get the $n×(p+k)$ observation matrix resultant constituted by the dependent variable and the independent variables together.

Original regression model is: $Y = X\beta+\varepsilon$

Where β is the $p \times 1$ regression coefficient vector, $X = [x_1, ..., x_p]n \times p$ is the sample observed matrix, ε is $n \times 1$ random error vector, Y is the $n \times k$ dependent variable matrix.

The sample data processing in this paper all use the special processing software--SIMCA-P for partial least squares regression to complete. This software can automatically handle the main components and run the cross-validation method internally to export a reasonable main component finally to interpret the whole model system.

Variables and data selection

In selecting the measure index, this paper chooses the Total S&T Personnel, Total Funding for S&T Activities, Total Intramural Expenditures, Full-time Equivalent of R&D Personnel Total and the Total R&D Expenditure as independent variables to measure the S&T investment. In the selection of the dependent variable for the high-tech industries, the authors use high-tech industry Number of Enterprises, Gross Industrial Output Value at Current Prices, Revenue from Principal Business, Profits and Taxes and Profits as the dependent variable indicators. All the variables data are selected the annual cross-sectional data of all provinces in 2008, (original data root in "Statistical Yearbook 2009, China Science and Technology"). In order to study conveniently, considering that take the logarithm of the sample data will not affect the variables relationship in the future, and the obtained data is easy to get stationary series, we process the each variables data by taken logarithm.

In table 1, the first columns 1-31 sample point are obtained by using the logarithmic transformation transforming of Chinese provinces and municipalities data, the variable y_1 in the first line is the logarithm of high-tech industry Number of Enterprises, y_2 means the logarithm of high-tech industry Gross Industrial Output Value at Current Prices, y_3 accepted that the logarithm of Revenue from Principal Business, y_4 means the logarithm of high-tech industry Profits, y_4 said the logarithm of Taxes and Profits; while x_1, x_2, x_3, x_4, $x_5$respectively mean, the logarithm of the Total S&T Personnel, Total Funding

Tab.1 Logarithmic transformation table

	y1	y2	y3	y4	y5	x1	x2	x3	x4	x5
1	12.94739	16.20323	16.02516	12.15241	15.52089	7.033506	7.990658	8.0653	4.947482	5.312615
2	11.72775	15.00846	14.9287	10.78618	14.25838	6.654153	7.572668	7.583324	4.254051	4.609461
3	11.868	14.4596	14.42094	10.73976	13.90271	5.872118	6.321703	6.290235	4.124712	4.431412
4	11.80238	14.46261	14.42646	10.69163	13.34642	5.003946	5.237718	5.102181	1.83418	2.46215
5	10.77889	13.52838	13.51599	9.812687	12.73361	4.553877	5.235005	5.188447	2.150599	2.587012
6	12.18314	15.07683	15.02367	11.2473	14.45771	6.768493	7.070826	7.020182	4.037951	4.410857
7	11.4861	13.96725	13.89679	10.36505	13.17754	5.983936	6.054463	5.885131	3.480317	3.90076
8	11.65942	14.22564	14.10189	10.83402	13.67279	5.288267	5.65119	5.741945	3.410818	3.827989
9	12.32045	15.58307	15.57386	11.46299	15.08355	7.340836	8.68286	8.710049	4.660037	5.043425
10	13.14544	16.27815	16.23583	12.18246	15.57494	8.385032	9.385166	9.364838	6.532654	6.8319
11	12.93146	15.76545	15.63081	11.98036	15.05264	7.954723	7.901207	7.863382	5.206202	5.57223
12	11.91203	14.73764	14.69957	10.80902	13.79858	6.192362	5.829974	5.796392	3.43431	3.831247
13	11.78003	14.64973	14.55512	10.98986	13.83461	6.517671	7.591221	7.561361	4.681946	4.864684
14	11.25597	13.93896	13.82295	10.24853	13.3558	6.150603	6.373388	6.326436	3.632045	4.174695
15	12.80354	15.84379	15.81673	11.98555	15.28273	7.450661	8.274964	8.258881	5.42301	5.817944
16	12.23804	14.77873	14.71476	11.17737	14.01662	6.444131	6.695787	6.57939	4.312543	4.642466
17	12.12308	14.94787	14.85723	11.1948	14.21419	6.526495	6.742244	6.676756	4.096841	4.494462
18	11.90259	14.58856	14.54102	10.82483	13.93511	6.257668	6.259161	6.209716	3.654288	4.251491
19	13.17586	15.95609	15.94215	12.3829	15.43005	8.639234	9.726183	9.684758	6.28836	6.780149
20	11.11968	13.66555	13.6041	10.05376	12.7017	5.676754	5.491208	5.25243	2.771964	3.266522
21	9.259987	11.89486	11.82974	7.453562	10.41867	4.007333	3.877432	3.790081	2.132982	2.444085
22	11.38469	14.16308	14.12655	10.44642	13.30722	5.537334	5.644952	5.605655	2.696652	3.2312
23	12.30855	15.10068	14.98161	11.37062	14.28713	6.760415	7.247408	7.166027	4.683704	5.153812
24	10.58119	13.14062	13.05925	9.346443	12.15108	4.990433	5.391899	5.217433	2.792391	3.234355
25	11.06252	13.64358	13.57351	9.891111	12.64403	4.990433	4.820765	4.713038	2.695978	3.172203
26	8.174421	10.90314	10.86636	6.453625	9.416134	2.079442	1.757858	1.483875	0.307485	0.71784
27	11.90272	14.78335	14.78562	11.07832	14.17509	5.774552	6.476957	6.414131	3.498022	4.092843
28	10.89731	13.5456	13.34634	9.90937	12.66985	4.26268	4.08732	3.986574	2.2895	2.596746
29	9.29459	12.01708	11.90278	7.824446	10.57367	3.258097	2.697326	2.48574	-0.69315	0.223144
30	9.60103	12.09359	12.09806	8.547334	11.23176	2.833213	3.214064	3.13201	0.444686	0.815365
31	10.43989	13.19748	13.10285	9.083643	11.98364	3.401197	2.97553	2.881443	0.928219	1.305626

Tab.2 Correlation coefficients

	y1	y2	y3	y4	y5	x1	x2	x3	x4	x5
y1	1									
y2	0.961	1								
y3	0.965	0.996	1							
y4	0.992	0.96	0.962	1						
y5	0.959	0.992	0.994	0.967	1					
x1	0.89	0.817	0.844	0.887	0.836	1				
x2	0.808	0.766	0.801	0.823	0.8	0.957	1			
x3	0.812	0.776	0.811	0.827	0.811	0.955	1	1		
x4	0.856	0.827	0.856	0.842	0.83	0.943	0.931	0.93	1	
x5	0.863	0.819	0.849	0.857	0.829	0.963	0.955	0.953	0.994	1

for S&T Activities, Total Intramural Expenditures, Full-time Equivalent of R&D Personnel Total and the Total R&D Expenditure. In other words, there are total five dependent variables (y_1, y_2, y_3, y_4, y_5) and five independent variables (x_1, x_2, x_3, x_4, x_5) in the partial least squares regression original model.

First, according to the above raw data logarithmic transformation table, a correlativity matrix between all variables is obtained, as shown in Table 2. It can be seen from the correlativity matrix that the correlation coefficients between variables are all very high; there is a strong correlation among the variables. To more intuitively observe the explain role of each independent variables on the dependent variable, the regression coefficient vector β of four independent variables will be plotted as the regression coefficient histogram (see Figure 1).

In the regression coefficients Histogram, the variable x1 as the Total S&T Personnel and x4 as Full-time Equivalent of R&D Personnel Total have the greatest impact on the dependent variable. Followed by x2 (Total Funding for S&T Activities) and x5 (Total R&D Expenditure), which impact on the dependent variable is also very obvious. In other word, the impaction of R&D Personnel investment in S&T investment on high-tech industry innovative output can not be ignored. Further analyzing the Figure 1, we can find that x2(Total Funding for S&T Activities) has the most negative impact on high-tech industry, indicating that not all investment need to shift material inputs

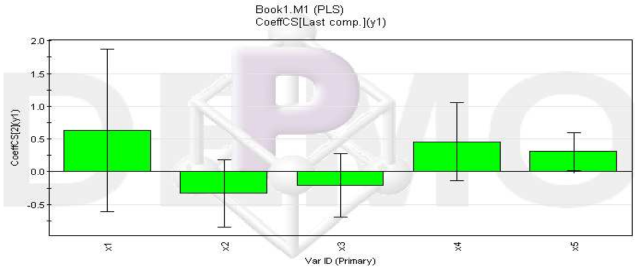

Fig.1 Regression coefficient histogram

Var ID (Primary)		R2VY	R2VY(cum)	Q2VY	Q2 limit	Q2VY(cum)
Total	Comp 1	0.71336	0.71336	0.640875	0.05	0.640875
	Comp 2	0.0325225	0.745883	-0.0928522	0.05	0.60753
y1	Comp 1	0.741998	0.741998	0.711421	0.05	0.711421
	Comp 2	0.0592825	0.80128	0.0229385	0.05	0.718041
y2	Comp 1	0.664977	0.664977	0.544282	0.05	0.544282
	Comp 2	0.0365688	0.701546	-0.112938	0.05	0.49871
y3	Comp 1	0.717535	0.717535	0.604689	0.05	0.604689
	Comp 2	0.0273167	0.744851	-0.148097	0.05	0.565158
y4	Comp 1	0.743834	0.743834	0.719169	0.05	0.719169
	Comp 2	0.0268612	0.770695	-0.0422475	0.05	0.707305
y5	Comp 1	0.698459	0.698459	0.624814	0.05	0.624814
	Comp 2	0.0125834	0.711043	-0.160849	0.05	0.587295

Fig.2 PLS Calculations results

into Intramural Expenditures input. For many high-tech enterprises, more Personnel investment than capital input is more meaningful and have more evident role in improving the innovation output.

The sample data analyses are used SIMPA-P software, which is data analysis software operating in the Windows and developed in 1987 by S. wold and his following team. By a simple operation, you can get the entire PLS analysis process and results, which is easy to use. Figures 2 are PLS calculations results. It can be seen from Figure 2, extracted a PLS components whose cross-validity of total impact on the high-tech industry is 0.640875, and the second component is -0.0928522, so the system only extract one components. The explain ability of the model to the high-tech industry development is 0.640875, reaching a high accuracy.

In addition to the calculation of partial least-squares, SIMCA-P software also provides abundant auxiliary analysis techniques to mine sample data information more comprehensively and more deeply. So next, we will analyze the impaction of S&T investment on high-tech industry in various angles. The first is the correlation analysis between the independent variables set X = [x_1... x_5] and the dependent variable set Y = [y_1... y_5], which illustrate the rationality of linear regression model. Here, we give the t1/u1planar graph (see Figure 4). In the partial least squares regression analysis, the composition of independent variables t1 and the composition of dependent variable u1 have the characteristics of the typical ingredients significantly, so we can use t1/u1 planar graph to give each sample point location [t1(i), u1(i)], if the linear relationship

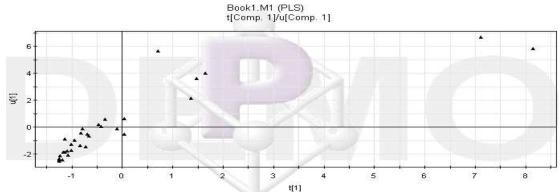

Fig.3 t_1/u_1Planar graph

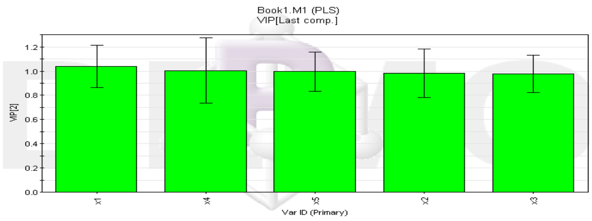

Fig.4 VIP histogram

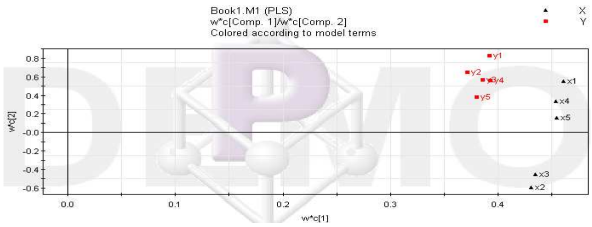

Fig.5 W_1*C_1/W_2*C_2 figure

between t1 and u1 can be clearly observed in the figure, which means that X and Y have a significant correlation relationship. We can see in Figure 3, there is a strong correlation relationship between the independent variables and the dependent variable, in the same time, SIMCA-P software give the correlation coefficient is 0.943482, which indicate that this linear regression model is reasonable, the selected set of independent variables and dependent variable have a significant linear relationship, this conclusion establish the theoretical foundation for the following further analysis.

Followed we analyze the role of single independent variable in explaining the set of dependent variable, that is, whether each S&T investment variables can effectively explain the high-tech industry development. When test the interpretation ability of single independent variables on the set of dependent variable, SIMCA-P software commonly used the indicator VIP(Variable Importance in Projection) to measure. The formula is:

$$VIP_j = \sqrt{\frac{p}{Rd(Y;t_1,t_2)}\sum_{h=1}^{2} Rd(Y;t_1)w_{hj}^2} \qquad (1)$$

Where VIP_j means the projection importance index of the jth independent variables x_j, p is the number of independent variables; w_{hj} is the jth component of w_h, which is used to measure the marginal contribution of x_j to structure the th component. The explain principle of the variable projection importance Indicators is: For p independent variables, if their role of explaining Y are same, all of the VIP values are equal to 1; otherwise, the independent variable whose VIP value is greater than 1 have larger effect in explain the dependent variable. Figure 4 shows the sample VIP histogram.

As shown in Figure 4, in addition to the variable x_1 (the Total S&T Personnel) whose variable projection importance index is more than 1, the other is less than or equal to 1, but not big differences between each other, which indicate that variable x1 has larger role in explaining the dependent variable in the model. This conclusion further validate the results of the previous regression coefficient graph, which shows that the contribution of Total S&T Personnel to high-tech industry Number of Enterprises, high-tech industry Gross Industrial Output Value at Current Prices, the Revenue from Principal Business, Profits and the Taxes and Profits is greatest.

At last, we investigate the structural analysis of correlation between the groups that is the effect role of a single independent variable on a single dependent variable. The previous VIP indicator only shows the impact degree of a single independent variable on the set of dependent variable, the following method can be visually observed the correlation structure of the independent variable Xi for each dependent variable Y_k. In order to research this correlation, SIMPA-P software provides a special method, which is W1*C1/W2*C2 planar graph, shown in Figure 5.

Generally speaking, the closer the position of the independent and dependent variables, the stronger their correlation, although this method is not mathematically rigorous, but it is an effective judging method. In the Figure6, x_2 (Total Funding for S&T Activities) and x_3 (Total Intramural Expenditures) is farthest away from the other variables, that the Total Funding for S&T Activities and Total Intramural Expenditures have not serious affect on the high-tech industry, more funding input will not promote the rapid development of high-tech industry. There is an important finding in W1*C1/W2*C2 planar graph, which is the independent variable x4 (Full-time Equivalent of R&D Personnel Total) has a strong correlation with each dependent variable. This index is rarely mentioned in the previous studies, the study results in this paper show that this indicator variable can measure the impact of S&T investment on the development of high-tech industry commendably, the more the S&T Personnel input, the more abundant of our high-tech industry development, the greater the likelihood of produced revenue, so this variable indicator should be taken seriously.

CONCLUSION

According to quantitative analysis results of the relationship between S&T investment and high-tech industrial development, it show that: the facilitation role of China's S&T investment on high-tech industry is more significant, and with the S&T investment capability strengthening, it has a strong pull function to the development of high technology industry, and this strong pull function has a longer sustained effect.

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