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Empirical study on pharmaceutical economic and investment in research and development based on correlation analysis

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ABSTRACT

The pharmaceutical industry has developed widely in recent years. And the relationship between the economic growth of pharmaceutical industry and the investment in research and development synchronization has been concerned. The application of correlation analysis on it is studied in depth. First, relating researches on investment in research and development of pharmaceutical industry are summarized. Second, basic theory of correlation analysis is studied. Third, analysis on current situation of economic growth of pharmaceutical industry and the investment in research and development synchronization are carried out. Finally, endogenous wavelength and frequency measurement for economic growth of pharmaceutical industry and the investment in research and development synchronization are calculated, results show that the economic growth of pharmaceutical industry and the investment in research and development synchronization is highly consistent.

Keywords: correlation analysis; Pharmaceutical Economic; Investment in Research and Development; endogenous

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INTRODUCTION

The pharmaceutical industry started fairly later in China comparing with foreign countries. However, the pharmaceutical industry developed quickly with support of a series of industrial policy, and the gap between the China and foreign countries in pharmaceutical industry is narrowed. The growth of pharmaceutical economic is closely related to research and development of pharmaceutical industry. Pharmaceutical manufacturing enterprises can develop the patent medicine with sales revenue through investing high capital on research and development, and the monopoly profits can be obtained. The returned money can be injected into research and development of new pharmaceutical technology. In recent years, some pharmaceutical companies have realized the importance of investment in research and development. The economic results of investment in research and development are the most concern when the pharmaceutical companies make research and development investment decision. Therefore it is necessary to analyze the relationship between investment in research and development and growth of pharmaceutical economic. In order to improve the effectiveness of analysis, the correlation analysis method is applied in this research.

In recent years, the researches on economic cycle have been concerned by many scientists, and some achievements have been obtained so far. SM Paul et al. put forward the key to tackling the challenges such issues pose to both the future viability of the pharmaceutical industry and advances in healthcare was to substantially increase the number and quality of innovative, cost-effective new medicines, without incurring unsustainable R&D costs. They presented a detailed analysis based on comprehensive, recent, industry-wide data to identify the relative contributions of each of the steps in the drug discovery and development process to overall R&D productivity [1].

AM McGahan tested the hypothesis that increased patent protection results in greater drug development effort. We find that patent protection in wealthy countries is associated with increases in R&D effort; results showed that the

introduction of patents in developing countries had not been followed by greater R&D investment in the diseases that are most prevalent there [2]. Nicola Dimitri suggested that R&D productivity in the pharmaceutical industry could be strengthened by reducing costs both in the early phase and, mostly, in the clinical phase of drug discovery. And analysis revealed that despite high costs, the clinical phase shows healthy productivity, whereas the early phase, particularly lead optimization, exhibited very low productivity [3]. S Sasidharan applied unbalanced panel data for 1,843 Indian manufacturing firms operating during the period 1994–2005 and corrected for the self-selection problem by using a Heckman-two step procedure. The analysis involving full sample did not give a clear picture of the impact of FDI on the innovation strategies of domestic firms. Interesting results emerge, when analysis was carried out according to different sub-samples based on foreign-ownership and technology intensity of the industry [4]. Jingguo Qu et al. studied the joint influence of the curve radius of curvature, steered angle and the road friction coefficient on the driving speed of the curve and the obtained speed is within the speed limit. Therefore, after improving the overtaking model, the left lane vehicle also applied to the lane-changing rule [5]. So far the empirical study on economic cycle of mainland china and Taiwan is a new field with few academic achievements.

2 Mathematical model of correlation analysis

The correlation analysis can study the relevance between some variables and other variables, which can solve the practical problems of economic cycle.

Set x and y as the p and q dimensional random variables and covariance matrix between x and y is expressed as follows [6]:

$$E(x-E(x))(y-E(y))'=V_{XY} \tag{1}$$

$$V_{YX}=V_{XY}^{'} \tag{2}$$

The variances of x and y are defined as follows [7]:

$$V(y)=E(y-E(y)(y-E(y))'=V_{YY} \tag{3}$$

$$V(x)=E(x-E(x)(x-E(x))'=V_{XX} \tag{4}$$

The projection in linear sub space of y in x is considered, for a element statistic, the random variables z and $x_1,x_2,\cdots,x_p$ are given, if $a_0+\sum_{i=1}^{n}a_ix_i$ make $E(z-a_0-\sum_{i=1}^{n}a_ix_i)$ reach the minimum value, then $a_0+\sum_{i=1}^{n}a_ix_i$ is the projection of z in $x_1,x_2,\cdots,x_p$, which can be denoted by $\hat{z}$, or $\hat{z}=a_0+\sum_{i=1}^{n}a_ix_i$ names as regression function for second type regression problem, therefore $\hat{y}_i$ for y_i of y can be solved based on one statics method, $\hat{y}$ using $\hat{y}_i$ as component can be the projection of y on x. Projection of $\hat{y}$ to x for y is defined by $\hat{P}(y\mid x)$, $y-\hat{y}$ is residual.

There are parts affecting the changes of y, first part is the projection of y on x, that is $V(\hat{y})$, second part is the changes led by $y-\hat{y}$, that is $V(y-\hat{y})$. The correlating coefficient between x and y can be calculated by the following expression:

$$r=[\sum_{i=1}^{n}(x_i-\overline{X})(y_i-\overline{Y})]/\sqrt{[\sum_{i=1}^{n}(x_i-\overline{X})\cdot\sum_{i=1}^{n}(y_i-\overline{Y})^2]} \tag{5}$$

Where $\overline{X}$ and $\overline{Y}$ are the mean value of x and y, x_i and y_i are the observations of x and y.

3 Analysis on characteristic of growth of pharmaceutical economic and investment in research and development

(1) Growth of pharmaceutical economic

Before 2009, the total output of pharmaceutical industry maintained rapid growth, and the compound annual growth rate is 20.8%. The "financial tsunami" hit the pharmaceutical economic in 2009, the increasing rate of total output of pharmaceutical industry drops to 19.9%. Since 2010, with the world economy in better shape, the pharmaceutical industry increases in the speed of 27.48%, which maintains a steady growth trend. The total output of pharmaceutical industry from 2001-2013 is shown in table 1.

Table 1 Total output of pharmaceutical industry from 2001-2013

Year	Total output/ Billion yuan	Growth rate/%
2001	2188	17.01
2002	2517	15.04
2003	3103	23.26
2004	3666	18.01
2005	4628	26.26
2006	5324	15.05
2007	6679	25.50
2008	8667	29.80
2009	10382	21.10
2010	13694	22.95
2011	15694	26.54
2012	18148	20.28
2013	25467	24.71

As from table 1, from 2001-2013, the total output of pharmaceutical industry increasing every year, the output of pharmaceutical industry in 2013 is 11.6 times to that of pharmaceutical industry in 2001. And the increasing rate of pharmaceutical industry is slowed down from 2001 to 2002, from 2002 to 2003, from 2005 to 2006, from 2008 to 2009, from 2011 to 2012.

(2) Investment in research and development of pharmaceutical industry

The investment in research and development of pharmaceutical industry is important for development of it, the total investment in research and development of pharmaceutical industry from 2001-2013 is shown in table 2.

Table 2 Total investment in research and development of pharmaceutical industry from 2001-2013

Year	Investment/ Billion yuan	Increasing rate/%
2001	20.5	28.29
2002	26.3	15.20
2003	30.3	17.50
2004	35.6	21.91
2005	43.4	20.31
2006	52.6	21.20
2007	65.9	20.20
2008	71.6	11.24
2009	78.5	9.56
2010	82.4	8.21
2011	88.7	9.54
2012	91.8	3.48
2013	100.0	8.92

As seen from table 2, the investment in research and development of pharmaceutical industry increases every year from 2001-2013, but the increasing rate is slow down.

And the correlation coefficients between output and investment in research and development of pharmaceutical industry are calculated based on relating theory, which are shown in table 2.

Table 3 Calculating results of correlation coefficients between output and investment in research and development of pharmaceutical industry

Period	Correlation coefficient
2001-2003	0.43
2004-2006	0.53
2007-2009	0.63
2010-2013	0.71

As seen from table 1, since 1996, the correlation coefficients of 2001-2003, 2004-2006, 2007-2009 and 2010-2013 are 0.43, 0.53, 0.63 and 0.71 respectively. The main reason is that the Chinese pharmaceutical companies have a strong research and development ethos, however there are a certain difference between the Chinese companies and multinational pharmaceutical companies in scale, sales volume and profit, then the investment of pharmaceutical industry is relative little.

RESULTS AND DISCUSSION

(1) Definition of indexes

Independent variables are performance index: the performance of pharmaceutical companies can be measured by profitability index, efficiency index and growth index. The profitability index is profit margin of main business, which is the ratio of profit to income of main business. The efficiency index is capital net profit ratio, which is the ratio of net profit to average total capital. The growth index is measured by the year-on-year growth of income of main business.

The independent variable is used as investment in research and development, the investing level in research and development is measured by pockets and human resources.

The index of pockets is research and development strength is the ratio of capital investment in research and development to income of main business. The rate of technicians is ratio of the number of technicians to total number of employees. The relating data is collected from the pharmaceutical company by hand.

The total number of samples of pharmaceutical companies is 320, and the research and development strength of samples are shown in table 3.

Table 3 Research and development strength of samples

Research and development strength	Number of samples
<1%	230
[1%,2%)	58
[2%,3%)	12
[3%,4%)	10
[4%,5%)	6
>5%	4

As seen from table 3, there are 320 pharmaceutical companies with research and development strength of less than 1%, there are only 4 pharmaceutical companies with research and development strength of over 5%, the data shows that the research and development strength of pharmaceutical companies is relative low.

The increasing rate of pharmaceutical economic of samples in period of 2001-2013 is defined by IFP_i, according to correlation analysis, the regression function is obtained as follows:

$$IFP_i = 0.79 \times IFP_{i-1} + 0.042 IFP_{i-2} - 0.237 IFP_{i-3} + 0.203 IFP_{i-4} \quad (6)$$

Then the following regression matrix can be obtained as follows:

$$A = \begin{bmatrix} 0.79 & 0.042 & -0.237 & 0.203 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

The eigenvalues of A are -0.6383, 0.8445, 0.2919 + 0.5398i and 0.2919 - 0.5398i respectively, the endogenous wavelength can be calculated according to the conjugate complex roots, which is 5.8 years, and the frequency is 0.18.

The research and development strength of samples in period of 2001-2013 is defined by RDS_i, according to correlation analysis, the regression function is obtained as follows:

$$RDS_i = 0.173 \times RDS_{i-1} + 0.012RDS_{i-2} - 0.265RDS_{i-3} + 0.360RDS_{i-4} \quad (7)$$

$$A = \begin{bmatrix} 0.173 & 0.012 & -0.265 & 0.360 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

The eigenvalues of A are -0.8362, 0.6997, 0.1547 + 0.7690i, 0.1547 - 0.7690i respectively, the endogenous wavelength can be calculated according to the conjugate complex roots, which is 5.9 years, and the frequency is 0.19.

As seen from the calculating results, the endogenous wavelength and frequency of increasing rate of pharmaceutical economic and research and development strength are highly consistent.

Then the lag coefficient, eigenvalue, endogenous wavelength and frequency for increasing rate of pharmaceutical economic and research and development strength from 2001 to 2013 are calculated based on correlation analysis, the corresponding calculating results are shown in table 6.

Table 6 Calculating results of endogenous wavelength and frequency of growth of pharmaceutical economic and research and development strength

item	eigenvalue		endogenous wavelength		frequency	
	growth of pharmaceutical economic	research and development strength	growth of pharmaceutical economic	research and development strength	growth of pharmaceutical economic	research and development strength
profitability	0.642+0.3984i	0.5	5.2	4.8	0.19	0.21
	0.642+0.3984i	0.35				
	0.116+0.3596i	0.006				
	0.116-0.3596i	0.115				
efficiency	0.89	0.943	4.8	4.6	0.21	0.24
	-0.143+0.72i	-0.812				
	-0.143-0.72i	-0.1.5+0.82i				
	-0.6	-0.1.5-0.82i				

As seen from table 6, the endogenous wavelength and frequency of growth of pharmaceutical economic and research and development strength has small difference, they are also highly consistent. These results show that the growth of pharmaceutical economic and research and development strength have the significant synchronization from 2001-2013.

CONCLUSION

According to the results of regression analysis, the investment in research and development of pharmaceutical industry has positive effect on the growth of pharmaceutical economic. The investment in research and development can be benefit for the development of new pharmaceutical products, and the income of pharmaceutical company get more income. The pharmaceutical company must improve the investment in research and development, and optimize the allocation of research and development resources, then total output of pharmaceutical industry can be improved constantly.

REFERENCES

[1] SM Paul; DS Mytelka; CT Dunwiddie, *Nature Reviews Drug Discovery*, **2010**, 9(3), 203-214.
[2] AM McGahan, *The Review of Economics and Statistics*, **2012**, 94(4), 1157-1172.
[3] Nicola Dimitri, Trends in Pharmacological Sciences, **2011**, 32(12), 683-685.
[4] S Sasidharan, *World Development*, **2011**, 39(7), 1226-1239.
[5] JG Qu; YH Cui; GC Zhou. *Journal of Chemical and Pharmaceutical Research*, **2014**, 6(3), 164-169.
[6] C Laurin, G Lubke, *Multivariate Behavioral Research*, **2013**, 48(1), 165.
[7] DG Western, LP Ketteringham, SA Neild. *Biosystems & Biorobotics*, **2013**, 1(1), 697-702.