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Analysis on innovation capability and influencing factors in Chinese pharmaceutical industry

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ABSTRACT

As a high-tech industry, the pharmaceutical industry in China is uncompetitive and is difficult to go further. By evaluating the innovating capability of different pharmaceutical companies, this paper attempts to find the key factors affecting the innovating ability and provides suggestions for pharmaceutical companies to improve the innovating capability. The research indicates: Independent innovating factor and policy-influencing factor are two factors and the key factors affecting the innovating capacity of different pharmaceutical companies are different; the ability of independent innovation is the key influencing factors to the state-owned pharmaceutical companies, while policy- influencing factor plays a key role in foreign-invested pharmaceutical companies.

Key words: Pharmaceutical Industry, Innovation Capability, Factor Analysis Method, Key Factors.

INTRODUCTION

Since the reform and opening up, China's pharmaceutical industry has maintained a strong and rapid development, but it must be soberly aware that the structural problems caused by extensive development is even prominent. Multinational pharmaceutical giants have seized the market, and facing the increasingly fierce competition, how to enhance the market competitiveness in pharmaceutical industry of china has become a very important issue. Only enhance innovation capability and master the key technology, can they occupy the dominant position. One can see Chinese products anywhere in the world, but it is hard to see the Chinese medicine. It is not matched with China's great power status in Pharmaceutical production and also shows that China is still not a pharmaceutical powerhouse [1]. To be competitive, China's pharmaceutical industry must rely on independent innovation. At present, generic drugs accounts for 90% of China's pharmaceutical market and the market share of innovative drugs is very small, innovation is the only way that Chinese pharmaceutical business can choose to gain sustainable development.

Many scholars have done some research on innovation of pharmaceutical industry, Yong Lan-li(2007) studied the realization mechanism of independent innovation in China's pharmaceutical industry based on the path of innovation and discussed the capability mechanism, guarantee mechanism and independent innovation ability mechanism; Fu Jia-ji divided the innovative forms into three types: cooperation-innovation; imitation-innovation and independent innovation, in his book "Technical Innovation Science", he believed that independent innovation is expected to complete through their own efforts and technological breakthroughs; Dai Yan(2007) described the characteristics of technological innovation in pharmaceutical industry and put forward that we need to integrate the resource to upgrade the innovative path and take Indian mode as a good example to imitate; Tang Dan-lin(2003) analyzed the challenges for pharmaceutical industry from the market share and clinical trial; Li Xue-nong (2006) studied the Current Situation and Countermeasures of R&D on new drugs in Domestic pharmaceutical companies; Liang Danying (2011) discussed the relationship between R&D performance and governmental guiding policy with

analysis model of panel data, the research showed that guiding policy on funds and human resource provided by government do benefit to the enthusiasm of patent application; Song Hui-yong (2013) studied the R&D efficiency changes of pharmaceutical industry by DEA-Malmquist on the basis of the selected panel data from 2002 to 2011, and showed that the technical efficiency and technological progress play different role in TFP growth for different industries. The research methods recommended commonly in evaluation of innovation capability is principal component analysis (CPA) and factor analysis (FA). Based on this, the paper first analyzes the pharmaceutical innovation capability in different types of registration enterprises combined with the data of statistical indicators on technological innovation, and then analyzes the key factors influencing the innovation ability in pharmaceutical enterprises.

EXPERIMENTAL SECTION

2.1 Introduction of Factor analysis method

Factor analysis is a method for investigating whether a number of variables of interest X_1, X_2,…,Xm, are linearly related to a small number of unobservable factors. The basic purpose of factor analysis is to describe relationship between many of the indicators or factors with a few factors, i.e. several closely related variables are grouped into the same class, each class variable becomes a factor, with less factors reflect most of the information of the original data. The core issues of Factor analysis are: First, how to construct a factor variable; second is how to name and explain the factor variables. Therefore, the basic steps and solution of factor analysis is to focus on two issues. Common factors in FA are hard to observe directly but exist objectively，each variable can be expressed as the sum of a linear function of the common factors and specific factors. Factor analysis often has four basic steps: firstly, analyzes the original variables to confirm the suitability for factor analysis; secondly, constructs factor variables; thirdly, factor rotation to assure more interpretable factor variables; lastly, calculate the scores of variable factor.

2.2 Indicators selection and evaluation system

Based on publicly available statistics information and existing results of other scholars on enterprises evaluation, the paper selects representative indexes and establishes evaluation system[2,3], as shown in Table 1, which includes 4 first-level indicators and 15 second-level indicators.

Table1 Evaluation system of innovation capability in different types of registration pharmaceutical enterprises

First level indexes	Second level indexes
Industrial production and investment in Science and technology activities	Total industrial output(X_1)
	Number of R & D personnel(X_2)
	Number of R & D projects(X_3)
	R & D funding(X_4)
	Technological transformation expenditures(X_5)
	Number of R & D institutions(X_6)
Process of technology activities	Number of R & D personnel agency activities(X_7)
	Expenditure on R & D institutions(X_8)
Tax policy	Tax relief on R&D expenditure(X_9)
	tax relief of High-tech enterprise(X_{10})
Outputs of techno logy Activities	Number of new product development projects(X_{11})
	expenditures on new product development(X_{12})
	New product sales revenue(X_{13})
	The number of patent applications(X_{14})
	total of patent possessed(X_{15})

2.3 Basic data in different types of registration enterprise

Distinguished by types of registration, China's pharmaceutical manufacturing enterprises are divided into four categories: state-owned and state-controlled enterprises, domestic enterprises, Hong Kong-Macao-Taiwan invested enterprises and foreign-invested enterprises. Resource allocation of technology activities in different types of pharmaceutical enterprises are shown in Table 2.

On a preliminary statistics analysis of data lists in table 2, we can see that domestic enterprises are much higher in most indicators than other types of enterprises, followed by state-owned and state holding enterprises. This conclusion is in line with the status quo of China's pharmaceutical enterprise, domestic and state-owned enterprises accounts for a large proportion of the total numbers. With the great support of national policy on high-tech industries, there will be more capitals flowing into the domestic pharmaceutical manufacturing, the number of Hong Kong-Macao-Taiwan and foreign pharmaceutical companies will increase gradually.

Table 2 List of resource allocation in four types of pharmaceutical enterprises

Indexes	Types of enterprises			
	State-owned Enterprises	Domestic enterprises	Hong Kong-Macao-Taiwan invested enterprises	Foreign-invested enterprises
X^*_1	17430739	112339293	13291340	23726434
X_2	26722	88317	14369	15872
X_3	3320	10990	2078	1954
X_4	416768	1505888	271812	334761
X_5	190065	626511	80463	82247
X_6	253	1474	168	214
X_7	15737	63137	10115	10707
X^*_8	301116	1043694	208760	243194
X^*_9	59442	115931	25491	19865
X^*_{10}	603801	789002	53080	83483
X_{11}	3478	12313	2091	2036
X^*_{12}	419299	1655169	306962	368588
X^*_{13}	4889998	16774393	2684960	3711082
X_{14}	1024	5470	585	913
X_{15}	1881	7966	1206	1334

(Remark: In table 2, X marked with "" represents its unit of measure is ten thousands YUAN)*

RESULTS AND DISCUSSION

3.1 Analysis on Innovation capability based on Factors Analysis method

First, standardizes the data in Table 2 to obtain the correlation matrix between indicators. As shown in Table 3, all the coefficients are more than 0.7 and the majorities are more than 0.8, there is a strong linear relationship between the indicators and it's suitable for factor analysis.

Table 3 Correlation coefficient matrix between evaluation indexes

Index	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
X_1	1.000	0.983	0.983	0.994	0.974	0.997	0.991	0.994	0.905	0.724	0.985	0.996	0.991	0.997	0.992
X_2	0.983	1.000	0.999	0.998	0.999	0.994	0.998	0.998	0.967	0.829	1.000	0.995	0.998	0.994	0.998
X_3	0.983	0.999	1.000	0.997	0.998	0.994	0.999	0.997	0.965	0.821	1.000	0.995	0.997	0.994	0.998
X_4	0.994	0.998	0.997	1.000	0.993	0.999	0.999	1.000	0.947	0.791	0.998	0.999	0.999	0.999	1.000
X_5	0.974	0.999	0.998	0.993	1.000	0.988	0.995	0.993	0.977	0.852	0.998	0.990	0.995	0.988	0.994
X_6	0.997	0.994	0.994	0.999	0.988	1.000	0.998	0.999	0.933	0.763	0.995	1.000	0.997	1.000	0.999
X_7	0.991	0.998	0.999	0.999	0.995	0.998	1.000	1.000	0.952	0.795	0.999	0.999	0.998	0.998	1.000
X_8	0.994	0.998	0.997	1.000	0.993	0.999	1.000	1.000	0.947	0.790	0.998	1.000	0.999	0.999	1.000
X_9	0.905	0.967	0.965	0.947	0.977	0.933	0.952	0.947	1.000	0.937	0.963	0.937	0.954	0.934	0.948
X_{10}	0.724	0.829	0.821	0.791	0.852	0.763	0.795	0.790	0.937	1.000	0.817	0.771	0.809	0.769	0.789
X_{11}	0.985	1.000	1.000	0.998	0.998	0.995	0.999	0.998	0.963	0.817	1.000	0.996	0.998	0.995	0.999
X_{12}	0.996	0.995	0.995	0.999	0.990	1.000	0.999	1.000	0.937	0.771	0.996	1.000	0.998	1.000	0.999
X_{13}	0.991	0.998	0.997	0.999	0.995	0.997	0.998	0.999	0.954	0.809	0.998	0.998	1.000	0.998	0.998
X_{14}	0.997	0.994	0.994	0.999	0.988	1.000	0.998	0.999	0.934	0.769	0.995	1.000	0.998	1.000	0.999
X_{15}	0.992	0.998	0.998	1.000	0.994	0.999	1.000	1.000	0.948	0.789	0.999	0.999	0.998	0.999	1.000

The second step is to calculate the Eigenvalue and cumulative variance **co**ntribution rates (table 4). Variance contribution rate represents the degree of public factor covering the information amount of original index; while cumulative variance contribution rate reflects the accumulated degree of its covering information amount of original index. The higher the cumulative variance contribution rate, the more common factors represents the degree of information of original indicators. In general, the cumulative variance contribution rate reaches more than 90%, public factor index can reflect the original information more better.

Table 4 Contribution analysis of variance

Ingredient	Initial eigenvalue			Extraction of squares and load			Rotating square and load		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	14.532	96.880	96.880	14.532	96.880	96.880	10.448	69.653	69.653
2	0.453	3.022	99.902	0.453	3.022	99.902	4.537	30.249	99.902
3	0.015	0.098	100．00						

As can be seen from table 4, the cumulative variance contribution ratio of the first two common factors is 99.902%, it is assured to obtain satisfactory results.

The third step, solve the factor loading matrix and rotate variance factor with the Maximum variance method, factor

loading matrix rotated can be seen in Table 5.The following indexes have higher values of load indices in the first common factor: gross value of industrial output (X_1), Number of R&D institutions (X_6),number of patent applications (X_{14}), expenditures on new product development (X_{12}), Expenditure on R&D institutions(X_8), possession of patent (X_{15}), R&D funding(X_4), Number of R & D personnel agency activities (X_7), sales revenue of new products (X_{13}), Number of new product development projects(X_{11}), number of R&D projects (X_3),number of enterprise R&D personnel (X_2), Technological transformation expenditures(X_5) load in the first factor of value.

Table 5 Rotated Factor loading matrix

Indexes	Factors		Indexes	Factors	
	1	2		1	2
X^*_1	0.919	0.39	X^*_9	0.859	0.51
X_2	0.895	0.446	X^*_{10}	0.850	0.525
X_3	0.891	0.453	X_{11}	0.846	0.532
X_4	0.889	0.457	X^*_{12}	0.840	0.542
X_5	0.875	0.483	X^*_{13}	0.816	0.578
X_6	0.875	0.484	X_{14}	0.395	0.917
X_7	0.874	0.485	X_{15}	0.677	0.733
X^*_8	0.870	0.493			

Those indexes reflect that enterprises try to improve their innovation ability through various scientific and technological activities, here named independent innovation factors; Tax relief on R&D expenditure(X_9) and tax relief of High-tech enterprise(X_{10}) have high values of load indices in the second common factor, This shows that the government's tax policy affects enterprise innovation ability, so we names it for policy influence factor

The fourth step is to calculate the scores of all common factors.

Table 6 Coefficient matrix of factor score

Indicators	Factors		Indicators	Factors	
	1	2		1	2
X^*_1	0.255	-0.272	X^*_9	-0.245	0.506
X_2	0.053	0.045	X^*_{10}	-0.617	1.071
X_3	0.067	0.023	X_{11}	0.076	0.009
X_4	0.132	-0.079	X^*_{12}	0.169	-0.137
X_5	0.002	0.125	X^*_{13}	0.097	-0.025
X_6	0.184	-0.161	X_{14}	0.175	-0.146
X_7	0.121	-0.062	X_{15}	0.133	-0.081
X^*_8	0.134	-0.082			

According to the factor score coefficient matrix (Table 6), the score coefficient multiplied by the corresponding standardization value of variable, the comprehensive factor score can be obtained and comprehensive scores combined with rate of variance contribution.

3.2 Innovation capability ranking in different types of pharmaceutical enterprises

According to the comprehensive score formula, the paper evaluates the innovation ability in different types of medicine manufacturing as shows in table 7.

Table 7 Scores of factors and ranking in Innovation capability

Types	F_1 score	Ranking	F_2 score	Ranking	F score	Total ranking
State-owned	-1.027	4	1.0882	1	-0.3862	3
Domestic enterprises	1.371	1	0.6081	2	1.1349	1
HongKong-Macao-Taiwan invested	-0.2418	3	-0.7961	3	-0.4092	4
Foreign-invested	-0.1022	2	-0.9003	4	-0.3435	2

Domestic enterprises and foreign-invested enterprises come in first and second in the total ranking. State-owned enterprises are prominent in policy-influencing factors, but backward in independent innovation factor; on the contrary, the foreign-invested enterprises have a nice score in innovation factor and a bad score in policy-influence factor. This shows that domestic enterprises receive more policy support from government than foreign enterprises.

CONCLUSION

The pharmaceutical industry is an important part of the national economy and a high-tech industry related with people's livelihood [4]. The paper evaluates the innovation capability in different types of pharmaceutical companies

and analyzes the key factors influencing innovation capability.

From a comprehensive perspective, independent innovation factor and policy influence factor are common factors, and independent innovation factor is the key factors of innovation capability. Industrial output、 number of R&D institutes、number of patent application and new product R&D expenditures have greater contribution to independent innovation capability; From a different perspective of registration, China's pharmaceutical manufacturing enterprises are divided into four categories. Firstly, the state-owned and state holding enterprises have the highest score in policy-influence factor, and the lowest score in independent innovation factors. This shows that state-owned enterprises are insufficient in independent R & D investment and need pay more attention to improve its independent innovation capability. Secondly, the foreign-invested enterprises get the lowest score in policy-influence factor. This shows that foreign enterprises receive less policy support from government than other enterprises. Foreign-invested enterprises have high innovation capability and strong finance [5], so policy improvements to foreign enterprise in the future will do benefit to the promotion of its technology innovation ability. Thirdly, domestic enterprises have higher score in two common factors. The enhancement of independent research and national policy for the domestic high-tech enterprises preferential, are stimulus to domestic pharmaceutical enterprises maintaining a good momentum of development.

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