The Industrial Difference in the Technological Innovation of Beijing Industrial Enterprises

—Empirical Analysis of the Cross-section Data Based on 606 Large and Medium-sized Industrial Enterprises

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Abstract: Based on the cross-section data of technological innovation activities of large and medium-sized industrial enterprises in 2007, this study analyses the industrial difference in the technological innovation of Beijing industrial enterprises, and draws the conclusion that, of the 34 large and medium-sized industries in Beijing, there is strong sense of innovation in hi-tech industries, but with their innovation level not high enough; in low-tech and middle and low tech industries, technological innovation activities are not well carried out, with a comparatively low innovation efficiency.
Key words: ***innovation efficiency, Industries, Beijing***

I. Foreword

The concept of "innovation" is firstly put forward by economist Joseph Alois Schumpeter, in his book "Theory of Economic Development" in 1912. Under the background of economic globalization and knowledge economy, the enhancement of innovation ability of enterprises has become the key in sustainable economic development in China.

The factors that influence enterprise innovation fall into two types. One is the factor at the corporate level, such as enterprise size, and structure of property right, etc. The other is the factor at the industrial level, like market concentration, industry characteristics, and so forth. Since Schumpeter put forward in his famous hypothesis that "large enterprises have stronger innovation ability than medium and small-sized ones, because the former enjoys comparative advantages in scale economy, risk sharing and financing channel, etc.", both Chinese and foreign scholars have studied the influence of industry size and FDI (foreign direct investment) on innovation ability of enterprises in succession. This text will firstly, at the industrial level, study the industrial difference in innovation ability of large and medium-sized enterprise in Beijing, and then, at the corporate level, discuss the innovation efficiency of different industries and the problems existing in them, using innovation efficiency model. On the principle of Integration of Subjectivity and Objectivity, all the data come from "The Survey on Innovation of Large and Medium-sized Enterprises in Beijing in 2007" and "Annual Report on Science and Technology Advancement of Industries in Beijing in 2007."

II. Industrial Difference in Independent Innovation of Large and Medium-sized Industrial Enterprises in Beijing in 2007

By the end of 2007, there had been 606 large and medium-sized industrial enterprises altogether in Beijing. Of which, 28.7% had scientific & technological institutions, becoming the carrier and platform for enterprises' independent innovation; there were 29140 R&D professionals, accounting for 4.3% of the total employed persons; R&D expenditure reached 6100 million RMB Yuan, with an input intensity of 0.76%; the number of patent applications was 2462, of which, 58.3% ware patents of invention; sales of new products was 234.59 billion RMB Yuan, accounting for 29.3% of the total sales income of products. In the following, we will analyze the industrial difference in innovation ability of large and medium-sized industrial enterprises in Beijing, from the angles of both input and output of innovation.

1. In view of the R&D input strength, heavy industries are stronger than light industries, while skill intensive industries are superior to labor intensive industries.

R&D strength include both R&D expenditure level and R&D input strength, which shows the condition of science and technology in an area or an enterprise, an important indicator for measuring the strength and ability of innovation. It shows that the overall level of R&D input expenditure and input strength in heavy industries is higher than that of light industries. The top seven industries in terms of R&D expenditure are all heavy industries, such as manufacture of telecommunication equipment, computers and other electronic equipment(2100 million RMB Yuan, accounting for 1/3 of the total), manufacture of transport equipment (778 million RMB Yuan),manufacture of special purpose equipment(399 million RMB Yuan). Of the six industries with input strength over 2%, only artwork and other manufacturing are enterprises in light industry.

R&D strength of skill intensive industries has a lead over that of labor intensive industry. As for pharmaceutical industry, processing of petroleum, coking, processing of nuclear fuel, manufacture of measuring instruments and machinery for culture activity and office work, and the three industries mentioned above, are all hi-tech industries. Their R&D expenditure level and input strength are all superior to that of labor intensive industries which are represented mainly by textile, furniture, manufacture of textile wearing apparel, foot ware and caps.

2. In view of R&D human capital, skill intensive industries are dominant, but the upstream fundamental industries are short of innovative talents.

We measure the quality and potential capacity of human capital for innovation input, by means of patio of R&D to employed persons, the ratio of scientists and engineers to employed persons, respectively. The data demonstrates skill intensive industries characterized by hi-tech industries enjoy prominent advantages in human resource, for example, in the manufacture of measuring instruments and machinery for culture activity and office work, R&D persons account for 12.38% of the total employed persons, scientists and engineers 16.27%, well over that of labor intensive industries.

In the upstream industries as fundamental industry, R&D human resources are comparative insufficient. In ferrous metals mining and dressing, production and distribution of gas, production and distribution of water, there are no R&D personnel and no scientists and engineers, and in production and distribution of gas, and production and distribution of water, the two indicators are maintained at a comparatively low level of 2%-4%.

3. In view of technology innovative products, the innovation output is rather low in parts of basic upstream industries and capital intensive industries.

New product development is the main form of innovative output of enterprises. Therefore, we choose the proportion of the two indicators, output value of new products, and the ratio of sales income of new products to sales income of new products, to sales income of products, for measuring innovation output. In ferrous metals mining and dressing, some basic upstream industries such as production and distribution of electricity and heat, and capital intensive industries, there is no new product, due mainly to their own industrial characteristics. Besides, in capital intensive industries, owing to their characteristics of numerous technical equipment, huge investment, slow capital turnover, and slow investment effectiveness, the innovation output is hardly to embody in a short time, for example, in extraction of petroleum and natural gas.

4. In terms of number of patent applications, traditional industries like heavy industries are in an absolute predominant position, and patents are concentrated in downstream industries and skill intensive industries.

Number of patent applications is also a general indicator for appraising ability and result of independent innovation of enterprises. It shows in Table 7 that heavy industries enjoy more patents, this reflects, to some extent, the different intention of different industries, and verifies Scherer's idea that "in traditional industries, such as industrial and civil equipment, building stone, clay, glasswork, etc., there are more patents." [1] The top three are all heavy industries, with the number of patent applications of 1657, accounting for 67.3% of the total of the whole 34 industries.

Manufacture of communication equipment, computers, and other electronic equipment, manufacture of special purpose equipment, manufacture of transport equipment, manufacture of measuring instruments and machinery for culture activity and office work, are both skill intensive industry, and downstream industry, therefore, most of the patents are concentrated in there industries. For example, the number of patent applications in manufacture of communication equipment, computers, and other electronic equipment is 1308, accounting for 53.1% of the total. The sum of the number of patent applications in the four industries accounts for 67.9% of the total.

5. In view of sense of innovation and innovation desire of entrepreneurs, and excitation mechanism for employees, entrepreneurs in heavy industries and labor intensive industries appear to be more initiative and active.

The capacity of innovation input and output is influenced directly by the sense of innovation of entrepreneurs. According to the data from "Survey on innovation of large and medium-sized industrial enterprises in Beijing in 2008", when asked about "role of innovation in the existence and development of enterprises", 63.4% entrepreneurs in light industries believe that innovation will play an important role, while 82% of entrepreneurs in heavy industries believe that innovation will play an important role, an 19 percentage points higher than the former; 50.8% of entrepreneurs in labor intensive industries believe innovation will play an important role, whereas 82% in skill intensive industries believe so, a 31 percentage points higher than the former.

When asked about "measures taken by enterprises to encourage workers to innovate", 43.1% of entrepreneurs in light industries prefer to money award or percentage deduction, while entrepreneurs in heavy industries who do the same way account for 66.8%, 23 percentage points higher than the former; 29.2% of the entrepreneurs in labor intensive industries prefer to raising job wage, 27.7% of them prefer to money award or percentage deduction, whereas entrepreneurs in skill intensive industries prefer to the two ways mentioned above account for 64.4% and 77.0%, respectively, 35 percentage points and 49 percentage points higher than the former.

The conclusion mentioned above comes from comparison of innovation input and output between 34 industries, from different dimensions of industrial division. It is necessary to employ innovation model to study the actual innovation efficiency of individual industry.

III. Empirical Analysis of Technological Innovation Efficiency by Sector

(I) Model of Appraisal

The basic train of thought of efficiency appraisal, is to measure the outcome resultant from unit input, more exactly, by defining the input of corresponding resources and the output of different outcomes, and through comprehensive comparison, analyzes finally the configuration efficiency of resources. This text defines technological innovation efficiency of industries as the following model:

$$E_i = C_i / T_i$$

Of which， $C_i = \lambda_1 C_{i1} + \lambda_2 C_{i2} + \cdots + \lambda_j C_{ij}$； $T_i = \theta_1 T_{i1} + \theta_2 T_{i2} + \cdots + \theta_k T_{ik}$. C_i is the comprehensive indicator value of S & T output of Industry i, C_{ij} is the output value of "j"th term, technological innovation Industry i, $j = 1,2,3\ldots$， $\lambda_1, \lambda_2, \ldots, \lambda_j$ is the weight of "j"th term, output indicator; T_i is comprehensive indicator value of technological innovation input of Industry i, T_{ik} is the comprehensive indicator value of “k”th term, technological innovation input of Industry i, $j = 1,2,3\ldots$, $\theta_1, \theta_2 \ldots, \theta_k$ is the weight of “k”th term, input indicator. The bigger E_i is, the better the resource configuration will be.

Before calculation, it is necessary to conduct dimensionless standard processing of both input and output indicators.

$$L_R = (L - L_{\min}) / (L_{\max} - L_{\min})\text{。}$$

Of which, $L_{\max}$ and $L_{\min}$ stand for Maximum and Minimum of that indicator respectively. L stands for real value of that indicator.

By means of factor analysis model, more input and output indicators of enterprise technological innovation can be divided into a number of main effect-factors; meanwhile, depending on the degree of contribution of individual main factors to the general objective, its relative importance can be settled. The weight set by factor loading is the internal structural relationship between indicators, based on data analysis, which is not influence by objective factors, with a better subjectivity, and the relationship between the comprehensive indicators obtained is independent, reducing repetitions and overlap of information.

(II) Index Selection and Data Source

Level of industrial technological efficiency is decided by technological innovation efficiency of enterprises in an industry, and technological innovation efficiency is the ratio of input to output of technological innovation resource. Technological innovation input includes tangible factors (people, money and equipment) and intangible factor (innovation objective, strategy, management and the four sources, etc.). The output form of technological innovation is diversified, and some output and their result can not be quantified easily, which is one of the nuts to crack in this study. Ordinary studies evaluate technological innovation output in view of product sales income, technological development programs, patent of invention, profit and tax of new products, and science and technological thesis. As this text preferentially discusses economic result of enterprise technological innovation, measurement is conducted by means of tangible monetary indicators, and numbers of scientific and technological thesis published, collected according to industry, is not available. Theory, R&D personnel and R&D expenditure are finally set as input indicators, and output of new products, sales of new products, and number of patent applications as output indicators, covering main tangible and intangible factors of innovation input and output.

This text depends mainly on the industry classification standard for Chinese industry, employed by the Standard and Catalogue for Second National Economic

General Survey. In this standard, there are 39 industries altogether. Since five of them are absent in Beijing, data of large and medium-sized industrial enterprises in the field of the rest 34 industries in 2007 are used as study samples. The original data of indicators and the result of standard processing for them will not be shown in the text.

(III) Result of Appraisal

Using KMO and Barylett roundness check for testing the original data, the KMO value is 0.72, so the factor analysis is feasible. By analyzing the rotated factor matrix of technological innovation input and output, meaning and relative weighting of its factors are sorted out and induced, and then the score of weighted input and output is calculated according to the variance contribution ratio of individual main factors, and finally the technological innovation efficiency ratio of individual industries are obtained.(See the table)

Table Rankings of technological innovation of large and medium-sized industrial enterprises in Beijing in 2007

Industry	Input Factor	Output Factor	Efficiency Ratio
Manufacture of Communication Equipment, Computers and Other Electronic Equipment	**1**	**1**	**1**
Processing of Petroleum, Coking, Processing of Nuclear Fuel	**0.1302**	**0.1063**	**0.82**
Manufacture of Artwork and Other Manufacturing	**0.0846**	**0.0544**	**0.64**
Manufacture of Raw Chemical Materials and Chemical Products	**0.0657**	**0.0288**	**0.35**
Manufacture of Electrical Machinery and Equipment	**0.207**	**0.0645**	**0.31**
Manufacture of Textile	**0.0349**	**0.0092**	**0.26**
Smelting and Pressing of Non-Ferrous Metals	**0.0125**	**0.0033**	**0.26**
Manufacture of Non-Metallic Mineral Products	**0.1027**	**0.0272**	**0.26**
Smelting and Pressing of Ferrous Metals	**0.3766**	**0.0867**	**0.23**
Manufacture of General Purpose Machinery	**0.2523**	**0.0591**	**0.23**

Manufacture of Special Purpose Machinery	**0.2875**	**0.0658**	**0.22**
Manufacture of Transport Equipment	**0.5041**	**0.1037**	**0.21**
Processing of Food from Agriculture Products	**0.0332**	**0.0064**	**0.19**
Manufacture of Metal Products	**0.09**	**0.0175**	**0.19**
Manufacture of Beverages	**0.1069**	**0.0171**	**0.16**
Manufacture of Foods	**0.0149**	**0.002**	**0.13**
Manufacture of Medicines	**0.1848**	**0.0236**	**0.13**
Manufacture of Measuring Instruments and Machinery for Culture Activity and Office Work	**0.1495**	**0.0201**	**0.13**
Manufacture of Plastics	**0.0126**	**0.0013**	**0.1**
Manufacture of Chemical Fibers	**0.009**	**0.0009**	**0.09**
Manufacture of Rubber	**0.0031**	**0.0003**	**0.08**
Extraction of Petroleum and Natural Gas	**0.0208**	**0.001**	**0.05**
Production and Distribution of Electric Power and Heat Power	**0.0262**	**0.0005**	**0.02**
Manufacture of Tobacco	**0.1983**	**0.0046**	**0.02**
Manufacture of Furniture	**0.0024**	**0.00003**	**0.01**
Printing, Reproduction of Recording Media	**0.0015**	**0**	**0**
Manufacture of Articles For Culture, Education and Sports Activity	**0.006**	**0**	**0**
Mining and Washing of Coal	**0.0426**	**0**	**0**
Production and Distribution of Gas	**0.0026**	**0**	**0**
Production and Distribution of Water	**0.0074**	**0**	**0**
Manufacture of Paper and Paper Products	**0**	**0**	**No Innovation Activity**
Manufacture of Textile Wearing Apparel, Foot ware and Caps	**0**	**0**	**No Innovation Activity**
Processing of Timber, Manufacture of Wood,	**0**	**0**	**No Innovation**

Bamboo, Rattan, Palm and Straw Products			**Activity**
Mining and Processing of Ferrous Metal Ores	**0**	**0**	**No Innovation Activity**

1. There is strong sense of innovation in hi-tech industries, but with an overall level of innovation not enough. In 2007, the industries ranked the top three according to their R&D expenditure of large and medium-sized enterprises in Beijing are telecommunication equipment, computers, and other equipment manufacture, transportation equipment manufacture, and special purpose equipment manufacture. The R&D expenditure of the three industries mentioned above amounted to 3.28 billion RMB Yuan, accounting for 53.5% of the total R&D expenditure of large and medium-sized industrial enterprises. In view of technological innovation efficiency, however, only telecommunication equipment, computers, and other electronic equipment manufacture enjoyed relatively high efficiency ratio of 1.0, ranked the first of all industries; efficiency ratios of transport equipment manufacture and special purpose equipment manufacture were relatively low, they were 0.21 and 0.22 respectively.

The input and output values of those two industries were relatively high, while the efficiency ratios were comparatively low, showing that there was improper use of innovation resource input.

2. The innovation activities in middle and low-tech industry were carried out relatively poorly, with a relatively low efficiency. It can been seen from the table, that the efficiency ratios of manufacture of chemical fibers, manufacture of metal products were generally under 0.2,with an insufficient innovation input and a somewhat low innovation efficiency. Some of those industries are in such a condition that they suffer from surplus production capacity and the aging of products. Generally speaking, those industries are large, but not powerful enough. There are seldom high-grade, precision and advanced technique and important technical equipment that embodies competitiveness.

3. There was no innovation activity in most low-tech industries, such as processing of timber, manufacture of wood, bamboo, rattan, palm and straw products, manufacture of textile wearing apparel, foot ware and caps, etc. This conceals from one respect that as main exporting industries, they have a low added value of products, which is just the reason that they are situated in the lower link by international division of labor. Although those industries hold a very big share in the international market, and enjoy a powerful competition in price, still, they are situated in a weak position in terms of high-end and brand products. It is an important way for raising added value of products, to improve production technology and equipment by means of technological innovation.

（Ⅳ）Conclusion

This study conducts the analysis on the industrial difference in the innovation activities of 34 industries, and also conducted the empirical analysis on the technological innovation efficiency of industries, based on the data of innovation survey and annual report on science and technology advancement. It is concluded that there was significant positive correlation between technological innovation efficiency and technical content in industrial enterprises in Beijing. Generally speaking， innovation level of large and medium-sized enterprises in Beijing needs further improvement. Sense of innovation in hi-tech industries is strong, and innovation input is sufficient; while sense of innovation in low-tech and medium low-tech industries is weak. For scientific and technological innovation level of industry in Beijing, there is still much room for lifting. Hi-tech industries, especially, should make full use of their advantages in technology, market and capital, make further step forward, for lifting the level of innovation efficiency.

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