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Measurement of Innovation Efficiency of Logistics Enterprises in China

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ABSTRACT

With the change of the principal contradiction in Chinese society and China's economic development entering a new stage, high-quality development has now become the theme of China's economic development. innovation has become the key to China's economic development. It is also of great significance for the development of Chinese logistics industry enterprises.

innovation and development of China's logistics industry enterprises, This paper takes China's logistics industry listed enterprises as the main research object, Combined with the display significance of previous research and innovative development, Established a new evaluation index of innovation efficiency, A dea network model was developed, And select the new innovation efficiency influencing the new factor system, To measure the innovation efficiency of 2013 to 2020 listed enterprises , In combination with the current development of China's logistics industry, put forward suggestions, In order to facilitate China's logistics industry enterprises in the future more efficient innovation and development.

KEYWORDS: *Logistics enterprise; Innovation efficiency measurement*

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1. INTRODUCTION

With the development of science and technology, new technologies are constantly being applied to logistics enterprises, and the logistics industry is also constantly developing continuously. So Chinese logistics industry should also closely follow the pace of The Times. And at present Chinese logistics enterprise profit margin is relatively low, development mode and business model is relatively backward, need to improve, the emphasis of innovation and development and investment intensity, basic rely on capital accumulation, the company business strategy problems, and specifically for the Chinese logistics industry enterprise innovation efficiency research is less. Therefore, it is urgent to improve the innovation efficiency of Chinese logistics enterprises, and of great significance to the research on the innovation efficiency of Chinese logistics enterprises。

This paper takes China's logistics industry listed companies as the research object, establishes a new index system, adopts the network DEA model, and refines the innovation and development status of enterprises at each stage, and compared with the technological innovation and development status of listed companies in other industries, measure the technology innovation efficiency of Chinese logistics industry companies and other industry companies, and provide reference for the innovation and development of Chinese logistics enterprises.

2. Enterprise innovation efficiency and its measurement method

Innovation efficiency, in essence, refers to the output ratio of these inputs used by producers under certain resource inputs. Koopmans[1] first proposed the definition of technology effectiveness in the 1950s, and noted that technology effectiveness means that a company has no way to produce the best product without additional other investments; According to Afriat[2],innovation efficiency refers to the distance between innovation output and the optimal productivity at a given input.

Nowadays, the main innovation efficiency measurement methods mainly include two categories, one is the parameter measurement method, which is to use the form of random error allocation form of the new established random frontier production function and other relevant assumed preconditions to calculate the input parameters of innovation and calculate the innovation efficiency[3],The other type is the non-parametric measurement method. The main method is to adopt the established innovation efficiency evaluation index, and use the principal component analysis and cluster analysis to measure the innovation efficiency of the evaluation unit[4],Among them, the more mature methods in parametric method include solo model and DEA model, while the more classical method in non-parametric method includes exponential method and SFA method.

DEA is a non-parametric effectiveness comprehensive evaluation method for multi-index input and multi-index output. Because DEA does not require specific production functions, nor does it take into account parameters in advance, it has unique advantages in avoiding subjective factors and reducing bias. From the perspective of industrial comparison, Sun[5] studied the overall technical efficiency of Korean industry by using DEA method, and the results show that there is technological progress between high-tech industries and low-technology industries. Raab[6] studied the high-tech industrial technology efficiency in 50 states in 2002 from the perspective of regional gap. By analyzing the data of 21 emerging strategic industries in China, Qiaoling Luo[7] has proved that policy support and scale effect have a certain positive impact on the innovation efficiency of different industries. Arif Umaima[8] calculated manufacturing plants in 16 Asian countries from 2006 to 2016 and showed that infrastructure was an important factor in their innovation efficiency, with transportation infrastructure being more important for low-technology-intensive industries and power infrastructure being more important for high-tech-intensive industries. Su Hongwei[9] refers to the production of 29 provinces from 1999 to 2017, and verified that regional market integration and economic opening have a positive impact on the productivity of all provinces. The Furceri Davide[10] calculates a sample of 24 industries from 18 developed economies, from 1970 to 2014.It was found that the deep decline led to a permanent deterioration of total factor productivity levels due to improper allocation of resources among different sectors. The DEA model includes CCR, BCC, SBM, EBM, ultra-efficiency DEA and other models.

Based on the EBM model proposed by Tone and Tsutsui in 2010, the EBM model considering the undesired output can be expressed as:

$$r^* = \min \frac{\theta - \varepsilon^- \sum_{i=1}^{m} \frac{w_i^- s_i^-}{x_{i0}}}{\varphi + \varepsilon^+ \left(\sum_{r=1}^{s} \frac{w_r^+ s_r^+}{y_{r0}} + \sum_{p=1}^{q} \frac{w_p^{u-} s_p^{u-}}{u_{p0}} \right)}$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \\ \sum_{j=1}^{n} y_{rj}\lambda_j - s_i^+ = \phi y_{r0} \\ \sum_{j=1}^{n} u_{pj}\lambda_j + s_p^- = \phi u_{p0} \\ \lambda_j \geq 0, s_i^-, s_r^+, s_p^- \geq 0 \end{cases} \quad (3\text{-}20)$$

$$i = 1,2,...,m; r = 1,2,...s; p = 1,2,...,q$$

In the formula, w_i^-, w_r^+, w_p^{u-} satisfied $\sum_{i=1}^{m} w_i^- (w_i^- \geq 0), \sum_{i=1}^{m} w_r^+ (w_r^+ \geq 0), \sum_{i=1}^{m} w_p^+ (w_p^+ \geq 0)$

The hyper efficient network EBM model considering undesired output is shown in equation (3-21):

$$r^* = \min \frac{W_h(\theta - \varepsilon^- \sum_{i=1}^{m} \frac{w_i^- s_i^-}{x_{i0}})}{[\varphi + \varepsilon^+ \left(\sum_{r=1}^{s} \frac{w_r^+ s_r^+}{y_{r0}} + \sum_{p=1}^{q} \frac{w_p^{u-} s_p^{u-}}{u_{p0}} \right)]}$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \\ \sum_{j=1}^{n} y_{rj}\lambda_j - s_i^+ = \phi y_{r0} \\ \sum_{j=1}^{n} u_{pj}\lambda_j + s_p^- = \phi u_{p0} \\ Z^{(k,h)}\lambda^h = Z^{(k,h)}\lambda^k (\forall k,h) \\ \lambda_j \geq 0, s_i^-, s_r^+, s_p^- \geq 0 \end{cases} \quad (3\text{-}21)$$

$$i = 1,2,...,m; r = 1,2,...s; p = 1,2,...,q$$

In the formula, while $r_h^* = 1$ the stage h DEA valid. Sub-stage efficiency is shown in formula (3-22):

$$r^* = \min \frac{\theta - \varepsilon^- \sum_{i=1}^{m} \frac{w_i^- s_i^-}{x_{i0}}}{\varphi + \varepsilon^+ (\sum_{r=1}^{s} \frac{w_r^+ s_r^+}{y_{r0}} + \sum_{p=1}^{q} \frac{w_p^{u-} s_p^{u-}}{u_{p0}})} \quad (3\text{-}22)$$

W represents the stage h weight, and the efficiency of stage h relative to the the importance of the whole

$$\sum_{h=1}^{H} W_h = 1, W_h \geq 0 (\forall h),$$

decision unit, and the decision unit is overall effective if and only if all stages are valid。

This paper intends to measure the innovation efficiency of China's logistics industry from the perspective of Chinese logistics industry. In terms of methods, because the production function of the logistics industry is unknown, this paper adopts the mature DEA-Malmquist index method, which is highly recognized in academia, to measure the innovation index of Chinese logistics industry enterprises. Because the EBM model is more suitable with the investment and radial and non-radial production in the actual production, and also to more carefully reflect the production process in the technological innovation activities, therefore, this paper will introduce the network EBM model containing non-expected co-output to realize the two-stage evaluation of technology enterprises.

3. Measurement and analysis of innovation Efficiency of logistics Enterprises

3.1. Index selection

In the research on the innovation efficiency of logistics enterprises, it is necessary to select appropriate indicators according to the characteristics of logistics enterprises. business ability, efficiency level, so as to promote the company overall economic benefits, so people in the study of logistics enterprise innovation performance generally did not choose the new commodity sales, new commodity update cycle, and more choose company profits, main business income and other indicators.

According to Porter (1985), the production activities of enterprises can be divided into multiple value creation links, and the overall value enhancement of the enterprise can be realized through the cooperation of multiple links. Hansen and Birkinshaw (2007) distinguish the value creation process of company technology into two different stages according to the enterprise technology innovation value chain, which are the technology innovation stage and the achievement transformation stage. The technological innovation stage mainly includes the enterprise invests development funds and research talents and other technological innovation resources in the new system developed, and then obtains the technological innovation results such as invention patent; the achievement transformation stage of achievements is mainly the commercial transfer stage of the previous stage. Through investment in labor and capital, the new technology developed into products, and finally provides commercial value for the company[99][100]. By learning from the above ideas, this paper divides the company's technological innovation process into two stages of technology development and achievement transfer, As shown in Figure 5-1.

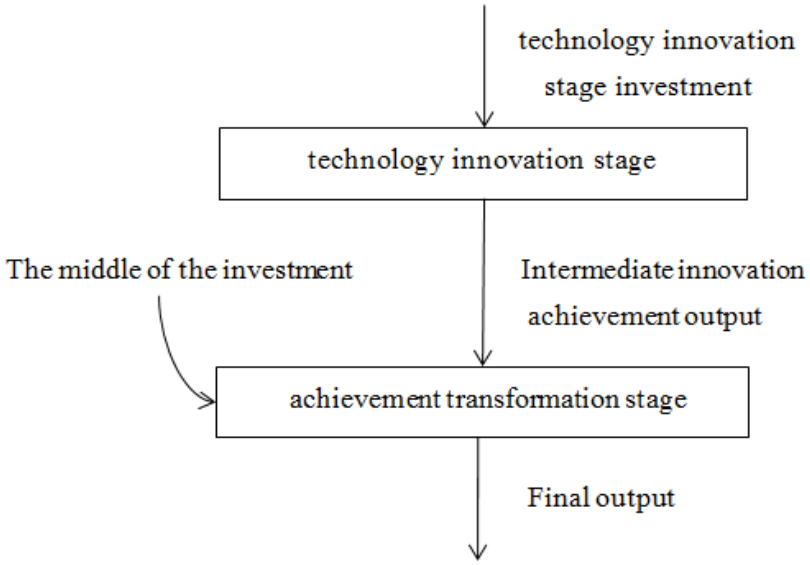


Figure 4-1 Schematic diagram of the two stages of enterprise innovation

This paper refers to the index system formulated by predecessors, and selects the indicators suitable for the actual development of China's logistics industry to formulate the innovation efficiency evaluation indicators suitable for logistics enterprises and listed enterprises in other industries, as is shown in Table 4-1 below. In order to further promote the innovative development of China's logistics industry.

Table 4-1 Innovation efficiency evaluation index of enterprises

stage	level 1 indicators	level 2 indicators
technology innovation stage	R & D phase investment	Number of R & D personnel
		R & D investment amount
		Number of valid patents
	intermediate variable	Patents Application
	Undesired output in the development stage	Patents Termination and rejection
achievement transformation stage	Commercial stage investment	Total employees
		total assets
	Commercial stage output	income from main business
		retained profits

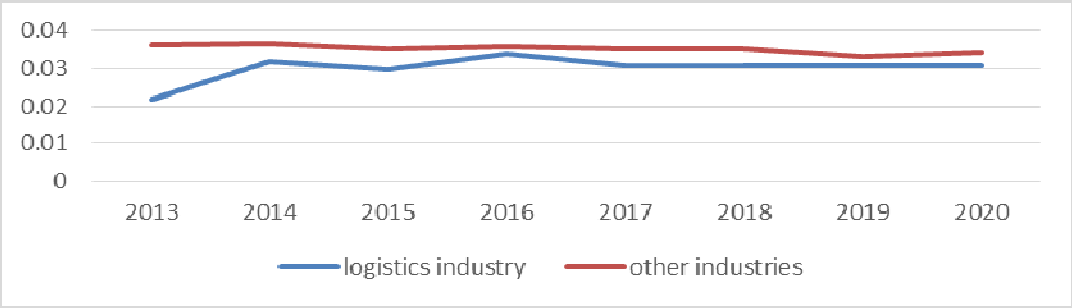
3.2. Data selection

Due to Chinese small and medium-sized enterprises general have many problem such as facilities are not perfect, the information level is low, the professional talent serious shortage, the management system is not perfect, more difficult to carry out innovation activities, therefore, this paper selects Chinese listed logistics enterprises as the research object.

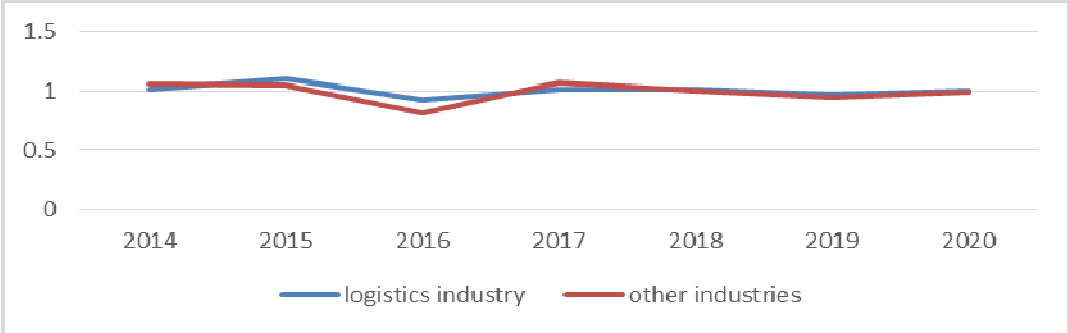
The data of Chinese listed companies adopted in this paper are all obtained from the CSMAR database, Since the relevant data of enterprise research and development was less disclosed in the annual reports of listed companies before 2013, in order to ensure the continuity and integrity of the data, this paper selects the data from 2013 to 2020 and removes the data with missing values and more outliers.

3.3. The two-stage innovation and innovation efficiency and decomposition in China's logistics industry and listed enterprises in other industries, the two-stage innovation and innovation efficiency and decomposition

As can be seen from Figures 4-1 and Figure 4-2,the innovation efficiency of China's logistics industry is steadily upward, but slightly lower than other industries, while the pure technology efficiency is basically the same compared with other industries, therefore, the reason why the innovation efficiency of Chinese logistics enterprises is lower than the average efficiency of other industries is that the scale effect has not been fully played ,Therefore, the reason why the innovation efficiency of Chinese logistics enterprises is lower than the average efficiency of other industries is that the scale effect has not been fully played.



Graph 4-1 The average total innovation efficiency of Chinese enterprises

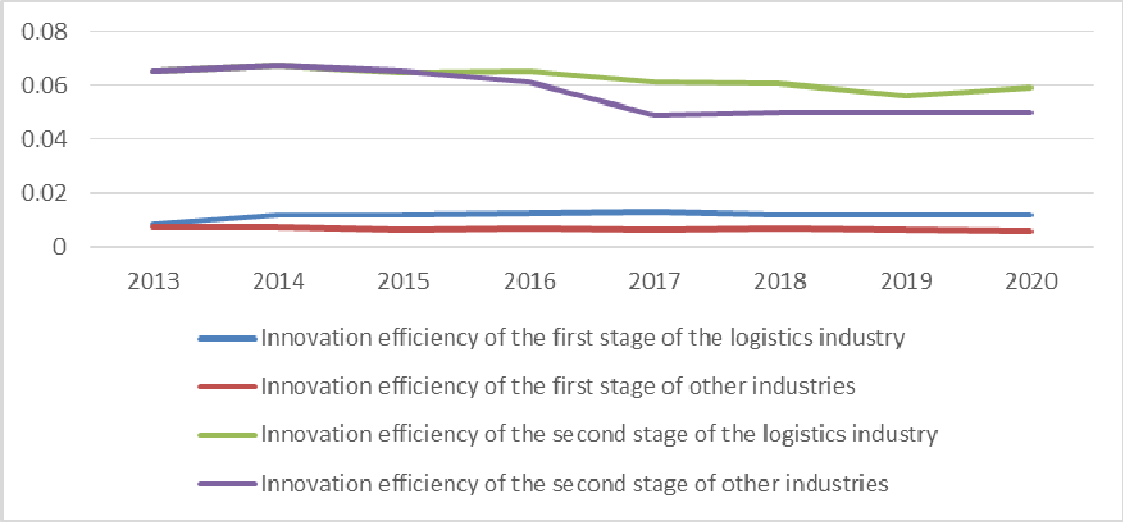


Graph 4-2 Average pure technology efficiency of Chinese enterprises in all industries

At present, there are still many small and medium-sized logistics enterprises in China. If large enterprises can continue to expand their scale and acquire other small and medium-sized enterprises, they can give full play to the scale effect of enterprises, improve the overall innovation efficiency of enterprises, and then promote the innovation and development of enterprises. The steady improvement of innovation efficiency of Chinese

logistics enterprises may be related to the strategy of Chinese logistics enterprises to expand their production scale in recent years.

As can be seen from Figures 4-3 and Figure 4-4, the overall innovation efficiency of China's logistics industry in both stages is slightly higher than that of enterprises in other industries, which shows that the overall innovation and development of China's logistics enterprises is good. In addition, the innovation efficiency of Chinese logistics enterprises in the first stage is relatively stable, but the innovation efficiency in the second stage has decreased. The pure technical efficiency of Chinese logistics enterprises is slightly higher than that of the second stage, while in other industries, the pure technical efficiency of the second stage is higher than that of the first stage. This shows that the first stage of the innovation process of China's logistics industry is still relatively good, and if the key to improve the innovation efficiency of China's logistics industry lies in the second stage of the innovation process. Finally, the second stage of the pure technical efficiency of the logistics industry enterprises fluctuates greatly and is relatively unstable.



Graph 4-3 The first-stage and second-stage innovation efficiency of Chinese enterprises in various industries

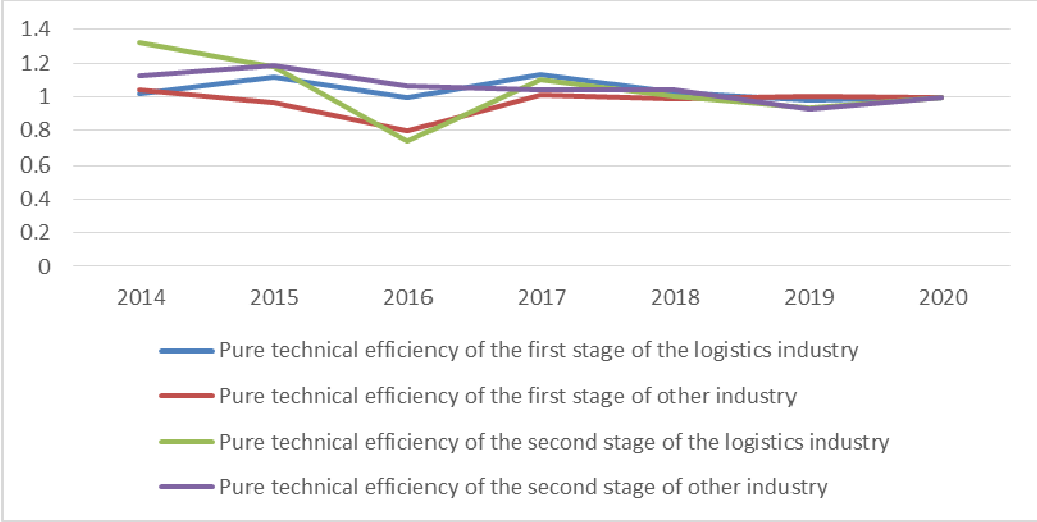


Figure 4-4 First-and second-stage pure technical efficiency of Chinese enterprises in various industries

4. Conclusion and suggestion

1. Because the scale effect of Chinese logistics enterprises has not been fully played, so enterprises can expand their scale, acquire small enterprises, and improve the scale effect of enterprises.
2. The current problems in the innovation and development of Chinese logistics enterprises appear in the second stage. Therefore, Chinese logistics enterprises can focus on improving the efficiency of bringing economic benefits from the innovation results in the first stage to enterprises.
3. Because at the present stage, the first stage of China's logistics industry enterprises has obvious advantages over the second stage, Therefore, enterprises need to strengthen the existing research and development results of enterprises to improve the economic benefits, enterprises can also consider applying for more invention patents to rent to enterprises in other industries, so as to

make use of the advantages of the first-stage innovation efficiency of logistics enterprises to bring more profits to Chinese logistics enterprises, strengthen the investment in innovation and development, expand the scale, and further promote the development of enterprises, a virtuous cycle

4. Because the efficiency of pure technology innovation in the second stage of China's logistics is relatively unstable, so if the innovation achievements of enterprises cannot effectively bring economic profits to the enterprise for the time being, it may just be the fluctuation of positive production. It is suggested that enterprises should not lose confidence in the innovation ability of enterprises and adhere to the investment in technological innovation and development.

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