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# Evaluation and Analysis on Textile Industry Technological Innovation Ability based on DEA

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**Abstract—**With economic development, China has become one of the largest textile producer in the world. In the international market, China's textile and apparel products have obvious advantages in price, capabilities of production and export continue to increase; but the product value-added and technology content are low, lacking seriously in the self-owned brands, which earns the least part of the processing costs in the international value chain, So it is very important that improve China's technical innovation capability of textile and apparel industry, and rely on innovation to improve the operational capabilities of the whole industrial chain. In this paper, DEA method applied to analyze the technological innovation of China's top ten textile and apparel provinces in goods exported, and propose the countermeasures to improve the efficiency of input and output in technological innovation.

**Keywords**-technological innovation ability；DEA； textile and garment industry； industry value chain

## 1. Introduction

China's textile and apparel exports in 1978 was only $ 2,431,000,000 and in 1985 to $ 6,440,000,000, an increase of only 1.65 times in 7 years, 1986, China's textile and apparel exports less than 100 billion dollars, exports in 1987 exceeded 100 billion dollars, In 1991 exports over 20 billion dollars, China's textile and apparel exports in 1993 compared with 1986, an increase of 2.17 times, which show China's textile and garment production and export capacities continue to increase, China's textile and apparel exports in 1994 reached 35.55 billion dollars, The proportion of the global textile and apparel accounted for 13.2%, and become the world's largest exporter of textiles and clothing. Particularly during the period 2002-2004 over 10 billion dollars per year, the size of the increase reached 60 billion, 80 billion and 90 billion dollars, 2004compared with 1994 increased by 1.74 times, the average annual growth rate of 15.8%. 2005 exceeded 100 billion dollars, 2005-2007, 3 years, china's ascending scale of textile and apparel exports over 20 billion dollars annually, which reached 115.03 billion dollars in 2005, 143.97 billion dollars in 2006, 171.21 billion dollars in 2007. The same period, Chinese textile and garment export growth maintain a high level of 18.12% in 2005, up to 25.16% in 2006, and18.92% in 2007.

As China's economic development, China has become the world's textile producer. In the international market, China's textile and apparel products have a clear price advantage, production capacity and export capabilities continue to increase, but the product value-added and technology content is low, a serious lack of own brands. Recent years there is rapid expansion of textile and garment production capacity, but the extensive growth mode is still the main mode, trade is still processing trade and OEM trade. Back in 1994, China had become the world's largest supplier of textiles and clothing, but exports of textile and apparel industry production chain is basically embedded in the global value chain, focusing on the production of finished products, and chemical fiber raw materials, textile machinery major dependent on imports, operational capacity with high value-added fashion design and brand are weak, and less involved in the design

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and marketing areas with higher profit. This division status, determine the profitability of most textile enterprises' profit will not exceed 5% and apparel business is difficult to over 10%.

The research of modern Industrial value chain shows that the profit chain presents a "V" shape, in this curve, the two tilt is the R&D and marketing of high value-added, industry profit margins of 20% to 25%; intermediate droop is the production of low value-added, profit margin is only 5%. In the international labor division of textile and garment industry, China's enterprises in the smile curve exactly the most low-end, earning at least that part of the production is the processing fee, to be known as the public opinion and experts and scholars in the international industrial chain, "International migrant workers. " Today, the competitive advantage is not only products, but the whole industry chain. To enhance the competitiveness of the industrial chain, china's textile and garment industry must work hard and improve the operational capabilities of the whole industry chain, must rely on innovation, improve the technical innovation of textile and garment industry.

## 2. Method and Model

DEA is more effective and convenient way in the existing models of efficiency evaluation to solve the timing problem of multiple input and output. It is proposed by well-known operations researchers, Charnes, Cooper and Rhodes, from the United States in 1978, which is a decision-making method, to analyze relative efficiency about DMU which all kinds of multiple inputs and multiple outputs. This model CCR as the evaluation method selected, the relevant model is as follows:

$$\begin{aligned} &Min \quad \theta \\ &\text{s.t.}\begin{cases} \sum_{\mathrm{j}=1}^{\mathrm{n}} \lambda_{\mathrm{j}} x_j + s^- = \theta x_{j_0} \\ \sum_{j=1}^{n} \lambda_j y_j - s^+ = y_{j_0} \\ \lambda_j \geq 0;\ \mathrm{j}=1,2,\cdots,\mathrm{n};\ \mathrm{s}^- \geq 0;\ s^+ \geq 0 \end{cases} \end{aligned}$$

where, $\theta$ is the competitiveness evaluation index, $x_j = \{x_{1j}, x_{2j}, \cdots, x_{mj}\}^T$ and $y_j = \{y_{1j}, y_{2j}, \cdots, y_{sj}\}^T$, $j = 1,2,\cdots,n$ mean vector of $n$ decision making units with $m$ inputs and $s$ outputs, $\lambda_j$ are the parameters to be estimated, $s^+, s^-$ are the slack variables. Use $DEA$ evaluate the ability of technological innovation of the textile and garment cities, provinces and municipalities as each $DMU$, obtain results of the effectiveness of technological innovation about textile cities solved by linear programming.

According the value of $\theta, s^-, s^+$ to divide the decision-making unit is into three categories:

(1) $\theta_0 = 1$ and $s_0^- = s_0^+ = 0$, so $DMU_0$ is called $DEA$ effective, that the decision-making unit $DMU_0$ on the basis of the original investment $x_0$ has maximum output, resources can be fully utilized.

(2) $\theta_0 = 1$ and $s_0^- > 0$ ($s_0^+ > 0$), so $DMU_0$ is called $DEA$ weakly effective, that as the decision-making unit $DMU_0$, input $x_0$ can be reduced $s_0^-$ while maintaining the same outputs $y_0$; or in the case of constant input $x_0$, output can be increased $s_0^+$.

(3) $\theta_0 < 1$, $DMU_0$ is called $DEA$ non-effective, in other words, for decision-making unit $DMU_0$, inputs $x_0$ can be reduced to the ratio $\theta_0$ of original through a combination of inputs while maintaining the original outputs $y_0$ not-reduced.

Select the year 2009 the amount of textile and apparel exports as the top 10 provinces and cities as decision-making units in Table 1, to analyze evaluation of technical innovation.

TABLE I. PROVINCIAL STATISTICS OF CHINA'S EXPORT VALUE OF TEXTILE AND APPAREL IN JANUARY-DECEMBER 2009

Data Source: China Textile Industry Association

| Rank | Province Name | Export value (billion dollars) | Growth Rate |
|---|---|---|---|
| 1($DMU_1$) | Zhe Jiang(ZJ) | 39.76919 | -5.90% |
| 2($DMU_2$) | Guang Dong（GD） | 30.99162 | -9.19% |
| 3($DMU_3$) | Jiang Su（JS） | 26.72338 | -8.53% |
| 4($DMU_4$) | Shang Hai(SH) | 15.29429 | -7.96% |
| 5($DMU_5$) | Shan Dong(SD) | 14.20456 | -8.65% |
| 6($DMU_6$) | Fu Jian(FJ) | 9.46270 | 18.62% |
| 7($DMU_7$) | Xin Jiang(SJ) | 4.96153 | -53.68% |
| 8($DMU_8$) | Liao Ning(LJ) | 3.76723 | -1.08% |
| 9($DMU_9$) | He Bei(HB) | 2.92943 | 7.80% |
| 10($DMU_{10}$) | Si Chuang(SC) | 2.34025 | 10.26% |

## 3. Evaluation Index System of Technological Innovation

Different scholars and experts on the technological innovation capability definition is different, foreign scholars Seven Maller consider that technological innovation is the integrated embodiment of product development, improving production technology, reserves, production, and organizational capacity, technological innovation is showed by the R&D capabilities, production preparation, marketing capability, management capability and contains more extensive content, so setting up the technological innovation ability evaluation system is a more complex process, indicators should be representative, integrity and systematic, specially comprehensive should be highlighted; in the choice of specific indicators must be given to common indicators of content among all types of enterprises, the same statistical methods, in order to facilitate comparison, the selection of indicators to consider the to quantification of indicators and the ease and reliability of data collection, make the best use of available statistics and the normative standards , which will help to grasp and operate. This paper fully considered the characteristics of the textile and garment industry to meet requirements of the mathematical model and references to technological innovation ability evaluation index system of the domestic and foreign experts and scholars, from the perspective of input and output, design evaluation index system as following:

TABLE II. TECHNOLOGICAL INNOVATION ABILITY EVALUATION INDEX SYSTEM OF TEXTILE AND GARMENT INDUSTRY

| | | | |
|---|---|---|---|
| **Input Indicators** | Innovation Input | The total funding for technological innovation(million yuan) | Quantity of innovative investment funds |
| | | R&D Funds(million yuan) | Quantity of R & D Funds |
| | | The proportion of scientific and technical personnel (%) | Total number of science and technology personnel / total number of employees |
| **Input Indicators** | Innovation Input | Patents with service | Number of patents with service |
| | | The proportion of international advanced level equipment (%) | Number of international advanced level equipment / device number |
| | Product Marketing | Product marketing costs (million yuan) | Total investment cost of product marketing |

| | | | |
|---|---|---|---|
| | Capability | The proportion of product marketing personnel (%) | Number of Product marketing personnel / total number of employees |
| **Output Indicators** | Innovation Output | New product return rate (%) | New Net income / total revenue sales |
| | | Market share of new products (%) | New product sales / total sales of the commodity market |

TABLE III. VALUES OF TECHNOLOGICAL INNOVATION ABILITY EVALUATION INDEX IN TEXTILE AND APPAREL INDUSTRY

| **Indicators** / **City** | **Input Indicators** | | | | | | | ***Output Indicators*** | |
|---|---|---|---|---|---|---|---|---|---|
| | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $Y_1$ | $Y_2$ |
| ZJ | 959.227 | 599.517 | 4.4 | 21.0 | 37.3 | 4383.125 | 23.3 | 18.0 | *26.7* |
| GD | 888.431 | 511.138 | 4.1 | 19.0 | 35.5 | 3927.467 | 24.6 | 16.6 | *22.3* |
| JS | 923.468 | 477.751 | 4.0 | 16.0 | 34.3 | 4311.453 | 22.3 | 17.0 | *22.1* |
| SH | 431.426 | 169.425 | 3.9 | 16.0 | 32.1 | 3677.018 | 21.8 | 18.0 | *24.7* |
| SD | 890.123 | 442.877 | 3.5 | 14.0 | 31.9 | 4215.604 | 22.5 | 16.4 | *23.5* |
| FJ | 974.621 | 576.892 | 3.3 | 11.0 | 30.2 | 4621.567 | 21.9 | 19.3 | *25.9* |
| XJ | 723.143 | 347.805 | 3.4 | 10.0 | 25.9 | 3003.451 | 19.7 | 16.0 | *19.3* |
| LN | 9017.806 | 425.767 | 3.2 | 12.0 | 27.8 | 3241.566 | 20.0 | 16.2 | *18.9* |
| HB | 789.432 | 389.955 | 2.8 | 10.0 | 25.1 | 3677.894 | 19.8 | 18.2 | *23.5* |
| *SC* | *680.038* | *202.733* | *2.6* | *11.0* | *26.1* | *4467.790* | *21.3* | *17.3* | *20.2* |

Note: The Evaluation System used all the data from the 2009 "China Science and Technology Statistical Yearbook", "Statistical Yearbook of the textile industry", and according the Chinese Bureau of Statistics website, the China Textile Economic Information Network, the State Council Development Research Center of Information Network and State Intellectual Property Office released data processing to organize and access.

## 4. Calculation and Analysis

Start *MyDEA* software, load the data shown in Table 3, select the CCR-I analysis (output unchanged, input smallest), running evaluation results are shown in Table 4. The output shows that: the effective number *DMU10* for the DEA; and *DMU9*, *DMU7*, *DMU6* and *DMU4* is weak DEA efficient; and *DMU1*, *DMU2*, *DMU3*, *DMU5*, *DMU8* non-effective for the DEA.

TABLE IV. THE RESULTS OUTPUT

| ***DMU*** | $S_1^-$ | $S_2^-$ | $S_3^-$ | $S_4^-$ | $S_5^-$ | $S_6^-$ | $S_7^-$ | $S_1^+$ | $S_2^+$ | **Efficiency value V** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50012 | 41274 | 0.00 | 4.40 | 0.04 | 58060 | 0.01 | 0 | 0 | 0.97 |
| 2 | 30393 | 24641 | 0.00 | 2.29 | 0.01 | 0 | 0.01 | 0 | 0 | 0.85 |
| 3 | 2921 | 3250 | 0.01 | 3.97 | 0.05 | 14373 | 0.00 | 0 | 0 | 0.84 |
| 4 | 43142 | 16942 | 0.04 | 16.00 | 0.32 | 367701 | 0.22 | 0 | 0 | 1.00 |
| 5 | 0 | 314 | 0.00 | 2.34 | 0.03 | 4852 | 0.00 | 0.02 | 0 | 0.89 |
| 6 | 12796 | 16175 | 0.00 | 0.00 | 0.02 | 79683 | 0.00 | 0 | 0 | 1.00 |
| 7 | 72314 | 34780 | 0.03 | 10.00 | 0.26 | 300345 | 0.20 | 0 | 0 | 1.00 |
| 8 | 829351 | 24916 | 0.00 | 0.00 | 0.03 | 28002 | 0.03 | 0 | 0 | 0.96 |
| 9 | 78943 | 38995 | 0.03 | 10.00 | 0.25 | 367789 | 0.20 | 0 | 0 | 1.00 |
| 10 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 1.00 |

## 5. Conclusion

China's technological innovation of textile and apparel is uneven in the ten provinces and cities above, which is due to the integrated efficiency of textile and garment industry is different all over the country, from the angle of effectiveness input-output to analyze, many areas affected by the level of technique, environment,

management and other effects, can't get corresponding desired output when invested, there are some room for growth. There is weak DEA efficient and non-effective in China's technological innovation capability of textile and garment industry, and the main factors is:

(1) low level of technology and R & D capabilities, most companies do not have their own R & D Centre，and lack of strong awareness linking with the research institutes, universities and other research institutions, so that the enterprise is not only lack of internal sources of technology but also lack of external technology sources.

(2) The relatively outdated technical equipment, large-scale textile and garment equipment rely on import basically. Currently, the textile industry is still a labor-intensive industry in China, there are a large number of SMEs, to these enterprises, there is huge sunk cost when they eliminate the relatively outdated equipment, most of them can not afford.

(3) Marketing information is relatively outdated areas, there are a lot of inputs of product marketing costs, poor ability to respond to the market, unable to respond rapidly to adapt to the complex and volatile market environment.

For the problems in technology innovation of China's textile and garment industry, proposed recommendation to increase the ability of competitiveness and innovation, and make input and output reasonably and effectively.

(1) Follow the road of combining Production, learning and research, take full advantage of internal and external resources for enterprise development for support.

(2) Encourage enterprises' development to the Scale and the Group, speed up the pace of industry concentration, increase their scale effect, form industry cluster advantages, further change industrial structure, form the regional characteristics economy.

(3) Attention to personnel training, make the design and marketing become a pillar, rather than manufacturing, OEM and sample processing.

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