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Chinese and Foreign Sports Industry Development TFP Analysis and DEA Approach Applied Research

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Abstract: TFP analysis was conducted on Chinese and foreign sports industry by applying DEA approaches to detect TFP fluctuation. The research highlighted the influence factors to analyse the overall TFP index description process from year the year 2010 to 2013. The results indicated that Puma, Adidas, and Nike experienced relatively rapid increase in TFP in these four years and the main factors that affected the Chinese sports product industry were observed to be investment in human resource, in research as well as in machinery and equipment.. Foreign business proportions and enterprises bearing increase in tax also have certain impacts on the TFP of sports industry. Finally, the paper also gives relative suggestions to provide theoretical basis for Chinese sports product industrial development.

Keywords: DEA model, Sports health, Sports industry, TFP analysis.

1. INTRODUCTION

Sports industry plays an important role in the field of sports. Improvement in people's living standards is of importance to enterprise development. Especially after the successful hosting of Beijing Olympic Games, sports product industry has experienced rapid development, therefore this research will contribute to the industrial development of Chinese sports products [1].

Regarding sports products industry research, former researchers such as Wei De-Xiang *et al* made many efforts, and achieved some results [2]. These researches attempted to list companies' operations, through analyzing nine Chinese and foreign sports goods companies and declared financial data from the year 2008 to 2010. Finally, overall comprehensive efficiency mean values were obtained showing a rising trend, in which technical progress showed incomparable effects. [3] Li Xun-Jin in his scientific research on Chinese and foreign sports targeted the functioning of domestic and foreign governments , funding sources, contents, sports research system and prospects of scientific researches on sports thereby making comparative analysis, and finally put forward relevant opinions [4].

The paper targeting hinese and foreign sports product industry provided detailed analysis and finally proposed that Chinese government should encourage international high-end sports products development in China, promote scientific research on sports product, and form a perfect sports products service system for changing the international status of Chinese sports products [5].

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2. DEA MODEL ESTABLISHMENTS

DEA model is a data envelopment analysis approach that uses the available model to obtain corresponding product frontier to evaluate DMU (decision unit) with its input and output. In DEA, the enterprises' relative efficiency is distributed between 0 and 1, with the enterprises' efficiency value in efficiency frontier being 1. Its advantages are numerous such as: DEA can conduct actual value and target value efficiency analysis, sensitivity analysis and comparative analysis. In DEA, model weight is mainly generated according to data being free of human factor influence, and its unit has indeformable characteristics. To measure TFP development of Chinese and foreign sports products industry , the paper adopted Malmquist exponential equation set by Fare and others to establish its exponential models, whose basic form is:

$$M_0\left(y^{t+1},x^{t+1},y^t,x^t\right)=\left[\left(\frac{d_0^t\left(x^{t+1},y^{t+1}\right)}{d_0^t\left(x^t,y^t\right)}\right)\times\left(\frac{d_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{d_0^{t+1}\left(x^t,y^t\right)}\right)\right]^{\frac{1}{2}} \quad (1)$$

In the above formula, product input and output amount of t+1 period and t period are $\left(x^{t+1},y^{t+1}\right)$ and $\left(x^t,y^t\right)$ respectively, and the t period and the t+1 period distance functions are represented as d_0^t and d_0^{t+1} respectively. For the i+1 and the i period output and input ratio geometric mean, if the value is less than 1, then it implies that sports products industry is experiencing a decline while , if the value is above 1, then it implies that sports product TFP is increasing . Malmquist index can be divided into two kinds; one of them is technical progress index and the other is decomposable technical efficiency variability index. Technical variability index is responsible for the distance between product leading surface and effective leading surface. Specific conditions are as follows:

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Table 1. DEA index-based sports goods manufacturing industry factor system table.

First Grade Factor	Second Grade Factor	Definition of Factors
Input indicator	Main business cost	Represent economic resources consumption conditions in enterprises' operation
	Total assets	Enterprises-controlled, monetary measurement-adapted, representative of enterprises scale capital input conditions
Output indicator	Basic earnings share	One of comprehensive reflection of enterprises profitability indicators
	Income from main business	Main business regular basic income, represents enterprises operational abundant ability
	Net margin	Comprehensive reflect enterprises operational final results, represents operational efficiency conditions
	Net assets income rate	Comprehensive reflect enterprises profitability, net margin owner's right

Table 2. Year 2010-2013 Chinese sports product industry overall TFP index and decomposition index table.

Year	Technical Progress	Scale Efficiency	Pure Technical Efficiency	Technical Efficiency	Total Factor Productivity (TFP)	TFP Growth Rate (%)
2010	0.988	0.955	1.000	0.955	0.944	-5.6
2011	1.072	1.047	0.996	1.052	1.123	12.3
2012	1.184	0.991	0.985	1.006	1.173	17.3
2013	1.111	0.991	1.002	0.989	1.101	10.1
Mean value	1.087	0.995	0.995	1.000	1.082	8.2

$$M_0\left(y^{t+1},x^{t+1},y^t,x^t\right)=\frac{d_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{d_0^t\left(x^t,y^t\right)}\times\left[\left(\frac{d_0^t\left(x^{t+1},y^{t+1}\right)}{d_0^{t+1}\left(x^{t+1},y^{t+1}\right)}\right)\times\left(\frac{d_0^t\left(x^t,y^t\right)}{d_0^{t+1}\left(x^t,y^t\right)}\right)\right]^{\frac{1}{2}} \quad (2)$$

In the above formula, $\frac{d_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{d_0^t\left(x^t,y^t\right)}$ represents sports product technical efficiency variation function relations from i+1 to i, and the above right side $\left(\frac{d_0^t\left(x^{t+1},y^{t+1}\right)}{d_0^{t+1}\left(x^{t+1},y^{t+1}\right)}\right)\times\left(\frac{d_0^t\left(x^t,y^t\right)}{d_0^{t+1}\left(x^t,y^t\right)}\right)$ represents measured sports product industry development conditions from the t period to t+1 period technical aspect.

In order to compare the TFP differences of Chinese and foreign sports products industry, the paper selected the TFP of sports product industry of three internationaly listed famous brands of nine countries as key points of research. The selected twelve brands yearly data reported that Chinese and foreign sports product industry's turnover is basically consistent.

Twelve kinds of international and state level famous enterprises were listed which highlighted consistent data. The paper selected output items and input items and all the indicators are shown in the following Table **1**.

According to all the factors, the paper analyzed the annual report of twelve sports companies from 2010 to 2013. After sorting out the data, all enterprises' input and output data were obtained related to all items, with

3. CHINESE AND FOREIGN SPORTS PRODUCT INDUSTRY TFP EVALUATION

Based on the year 2010 to 2013, sports industry's overall TFP index and decomposition index as well as individual TFP index and its corresponding decomposition index were verified step by step using, DEAP software to carry out objective evaluation.

The paper established a Chinese and foreign sports product's overall TFP index and corresponding decomposition dynamic table as shown in Table **2**.

In order to more clearly show mutual relations, the study gave a bar figure as shown in Fig. (**1**).

Chinese and foreign sports product's overall dynamic decomposition table is shown in Table **3**.

In order to more clearly show the relationship of the above indicators , the paper presented a bar figure as shown in Fig. (**2**).

Tables **2** and **3** provide Chinese and foreign sports product industry's overall TFP index and decomposition index with dynamic situations from 2010 to 2013 of four years. Based on this data, the paper analyzed Chinese and foreign sports product industry's technical progress, scale efficiency, TFP, technical efficiency and other aspects.

In real production, foreign technical efficiency has not shown its technical potentials and resourceful utilization. It mainly suffers from the influence of pure technical efficiency index, while in the domestic enetrprises four

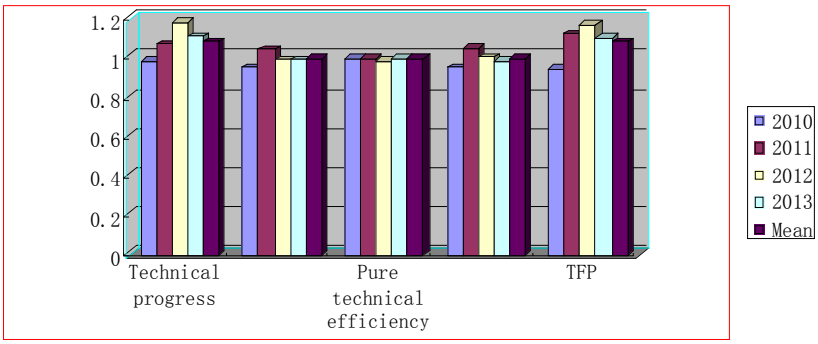

Fig. (1). 2010-2013 China sporting goods industry as a whole decompose TFP index map.

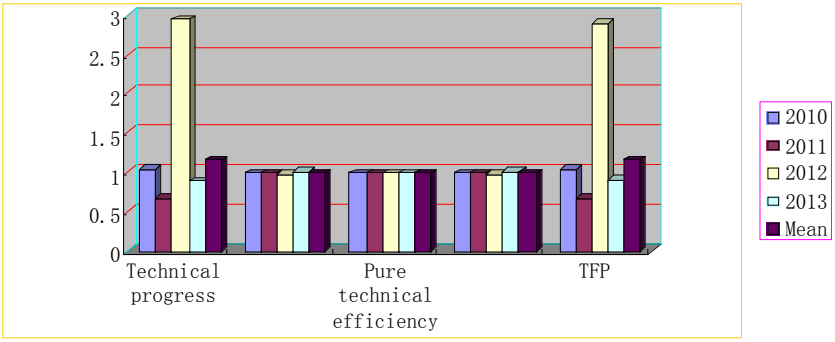

Fig. (2). 2010-2013 overall foreign sporting goods industry exploded TFP index map.

Table 3. Year 2010-2013 Chinese and foreign sports product industry overall TFP index and decomposition.

Year	Technical Progress	Scale Efficiency	Pure Technical Efficiency	Technical Efficiency	Total Factor Productivity (TFP)	TFP Growth Rate (%)
2010	1.047	1.002	1.000	1.002	1.049	4.9
2011	0.682	0.999	1.000	0.999	0.681	-31.9
2012	2.958	0.984	1.000	0.984	2.912	191.2
2013	0.898	1.017	1.000	1.017	0.913	-8.7
Mean value	1.173	1.001	1.000	1.001	1.174	17.4

years' comparison is not ideal in pure techniques that shows negative growth rate t leading to technical efficiency reduction.

Based on the above analysis results, domestic powerful enterprises have started focusing on relevant problems discussed in the research. For instance, Li Ning company established a research and development center, Anta established a sport biomechanics laboratory, and 361 companies have also developed research and development center, human engineering laboratory and product laboratory. But China has still not reached to the level of foreign countries due to limited technical developments.

3. CHINESE AND FOREIGN SPORTS PRODUCT INDUSTRY TFP INDIVIDUALS AND DECOMPOSITION INDEX EVALUATION

In the analysis, the paper listed four years' TFP of seven sports product companies and corresponding decomposition index with dynamic situations as shown in Table **4**.

From the above Table **4**, it is clear that TFP of Chinese sports product industry in 2011 was high , especially for 361, X-step international holdings and Anta sports, which experienced a boom due to the impact of international market in 2011, while domestic and overseas sports product industry experienced a downfall . From the table, it can also be seen that since 2011, technical input and technical progress led to increase 361 and X-step international holdings TFP , while domestic reduction in Anta and Li Ning due to extrusion of TFP storage volume. Foreign sports products industry, due to economic recovery of America and other developed countries, like Nike, experienced a decline while Puma and Adidas, due to economic advancement in Germany and other countries , experienced TFP growth of above 20%.

The paper compared Chinese and foreign sports product industry TFP not just for testing the decomposition index but mainly for examining its influence factors to make Chinese sports product industry play a positive role in future

Table 4. Year 2010-2013 Chinese and foreign sports product listed companies TFP decomposition index table.

Company Name	Year	Technical Progress	Technical Efficiency	Pure Technical Efficiency	Scale Efficiency	TFP	TFP Growth Rate (%)
Li Ning	2010	0.939	0.991	1.000	0.991	0.959	-4.1
	2011	0.979	1.116	1.000	1.116	1.092	9.2
	2012	0.964	1.006	1.000	1.006	0.970	-3
	2013	0.886	1.000	1.000	1.000	0.886	-11.4
	Mean value	0.887	1.000	1.000	1.000	0.887	-11.3
361 degree	2010	1.183	1.000	1.000	1.000	1.183	18.3
	2011	0.910	0.972	1.000	0.972	0.993	-0.7
	2012	0.957	1.028	1.000	1.028	0.984	-1.6
	2013	0.881	1.000	1.000	1.000	0.881	-11.9
	Mean value	0.983	1.000	1.000	1.000	0.983	-1.7
X-step internation-al holdings	2010	1.384	1.036	1.025	1.011	1.434	43.4
	2011	0.745	1.003	1.000	1.003	0.747	-25.3
	2012	1.816	1.000	1.000	1.000	1.816	81.6
	2013	0.904	0.855	0.865	0.989	0.773	-22.7
	Mean value	1.205	0.985	1.000	0.985	1.187	18.7
Anta sports	2010	0.606	0.879	0.980	0.896	0.533	-46.7
	2011	0.913	1.093	0.994	1.100	0.998	-0.2
	2012	1.637	1.041	1.027	1.014	1.704	70.4
	2013	1.850	1.000	1.000	1.000	1.850	85
	Mean value	1.138	1.000	1.000	1.000	1.138	13.8
Puma	2010	0.919	1.000	1.000	1.000	0.919	-8.1
	2011	0.832	0.998	1.000	0.998	0.830	-17
	2012	1.132	0.963	1.000	0.963	1.090	9
	2013	0.953	1.041	1.000	1.041	0.991	-0.9
	Mean value	0.889	1.000	1.000	1.000	0.889	-11.1
Adidas	2010	1.017	1.007	1.000	1.007	1.024	2.4
	2011	0.936	1.000	1.000	1.000	0.936	-6.4
	2012	1.542	1.000	1.000	1.000	1.542	54.2
	2013	0.886	1.000	1.000	1.000	0.886	-11.4
	Mean value	1.296	1.002	1.000	1.002	1.299	29.9
Nike	2010	1.228	1.000	1.000	1.000	1.228	22.8
	2011	0.989	1.000	1.000	1.000	0.789	-1.1
	2012	1.284	0.991	1.000	0.991	1.214	21.4
	2013	0.964	1.009	1.000	1.009	0.973	-2.7
	Mean value	1.201	1.000	1.000	1.000	1.201	20.1

Table 5. TFP technical efficiency and technical progress influence factors analysis table.

Independent Variable	Dependent variable				
	TFP	**Technical Progress**	**Technical Efficiency**	**Pure Technical Efficiency**	**Scale Efficiency**
EI	0.1256*** (7, 512)	0.0978*** (5.431)	0.1023*** (2.315)	0.1084*** (6.310)	0.1015*** (2.533)
Human	0.1726** (3.098)	0.1150*** (2.351)	0.2224*** (9.295)		0.1063*** (5.526)
R&D	0.1454*** (2.765)		0.1472*** (20.627)	0.0718*** (5.835)	0.0702*** (10.452)
POE	0.0201*** (4.364)	0.0114*** (11.432)		0.0021** (2.115)	
Scale	0.0151** (3.743)	0.0078** (2.608)		0.0012*** (8.051)	
NC	0.0752** (10.456)			-0.0034*** (-5.002)	0.108*** (2.690)
SOE			0.1450*** (8.179)	-0.1400*** (-3.268)	
AR(1)	0.0988*** (2.365)	0.0226** (5.648)			0.0509*** (-1.980)
Tax	-0.1246** (-1.1992)	-0.1175*** (-2.363)	-0.0057** (-4.403)	-0.0025** (-2.701)	
CR4	-0.2338*** (-3.449)		0.2101*** (2.929)		0.7199*** (15.538)
R^2 After adjustment	0.7526	0.6640	0.6900	0.7128	0.5269
F statistics	109.4850	503.64	269.06	457.65	388.34
D.W value	1.9443	2.2630	2.3731	2.3570	2.278

*It represents to arrive at significant correlation in the level 0.01;**It represents to arrive at significant correlation in the level 0.05;***It represents to arrive at significant correlation in the level 0.10;

development to improve Chinese sports product industry's TFP. According to former researches , the paper adopted various influence factors , which mainly include enterprise tax burden, enterprise concentration ratio, new product ratio, average size of enterprises, domestic business ratio, foreign business ratio, human capital, investment in research and development as well as investment in mechanical equipment. For possible hidden serial correlation and heteroscedasticity problems in panelling data, the paper employed stata software's least square method to analyze, and obtain results as shown in Table **5**.

From the above Table **5**, it was observed that:

1) Enterprise scale efficiency is positively related to enterprise scale and enterprise concentration ratio, from which the most important influence factor is the enterprise scale. However, enterprise scale efficiency is positively related to enterprise's human resource, investment in research and development, as well as investment in mechanical equipment;

2) Enterprises shows a positive relation of human resource and equipment investment. and is the main influence factor, enterprise new product investment is bigger and then pure technical efficiency will be lower, while enterprise scale becomes bigger than pure technical efficiency accordingly will be lower. Therefore it proves the causes for current China sports product industry constantly appear new products, but pure technical efficiency is still low;

3) Enterprise technical efficiency show a kind of positive relations with mechanical equipment, human capital investment, research and development investment and new product ratio, from which minimum influence belongs to enterprise concentration ratio and enterprise scale, while the maximum influence belongs to scientific research investment, therefore it can prove enterprise scale and enterprise technical efficiency are not in a proportional relationship, it is mainly up to technical factors;

4) Investment in research and development as well as in mechanical equipment are important factors to drive

technical progress, on which the impacts of human resource are not obvious. It is because that the relative contribution rate of Chinese and foreign business ratios is greater in technical progress. In addition, increased tax will play an important role in enterprise's technical development.

5) Mechanical equipments research and development as well as human resource driving TFP are the greatest influencing factors of an enterprise, having the highest impact on TFP. TFP growth and improvement in domestic business contribution rate are obviously lower than that in the overseas, while sports enterprise's contribution to TFP is adequate, implying that the larger the sports product industry, the larger the TFP.

CONCLUSION

By analysing the overall TFP index description from 2010 to 2013 of Chinese and foreign sports product industry, and combining the data shown in the tables, it can be observed that Puma, Adidas and Nike as overseas sports product industries experienced rapid TFP development in these four years, with an average growth rate of 17%. Meanwhile, although overall sports product industry experienced development , but compared to overseas, its overall development has been slower, from year 2010 to 2013. Overseas sports product industry's technical efficiency index increased by 0.1 percentage, and technical progress showed 17% growth rate, which is mainly because overseas techniques are still more advanced than domestic. Domestic sports products industry's technical progress rate remained 8%, because technical efficiency did not increase but dropped, and the 8% growth rate in TFP was actually lower than the overseas.

The main influencing factors affecting Chinese sports products industry are investment in human resources, investment in research and development and investment in mechanical equipment, and the ones positively contributing to Chinese sports product industry development are mainly regional concentration and production scale. Foreign business ratio, and increased tax burden on enterprise still have certain impact on the TFP of sports products industry.

Based on the conclusion, the paper put forward following suggestions in order to modify Chinese sports product industry's international status. China's government should play a major role in this process. It should encourage the development of international high-end sports products in China, and introduce sports product scientific research development.. It can introduce advanced techniques and equipment as well as management staff and scientific researchers by taking assistance from famous foreign brands enterprises and should also develop relevant industries by optimizing development environment, to establish a perfect sports products service system.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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REFERENCES

[1] P. Chen, Z. Qin, Y. Yin, and C. Xia, "Correlation analysis of current situation of regional athletics sports development and society population structure in China," *Journal of Beijing Sport University*, vol. 30, no. 12, pp. 1610-1613, 2007.

[2] H. Li, H. Xue, and W. Feng, "Sociological analysis of comparison of chinese population with the sports population of chinese," *Journal of Xi'an Institute of Physical Education*, vol. 24, no. 4, pp. 25-28, 2007.

[3] Z. Miao, and C. Qin, "Sociological analysis of contemporary Chinese sports population structures," *Journal of Physical Education*, vol. 13, no. 1, pp. 119-121, 2006.

[4] H. Xiao, Z. Weng, and Y. Chen, "Basic characteristics of social and sports population structures of contemporary China," *Journal of Shanghai Physical Education Institute*, vol. 29, no. 2, pp. 10- 14, 2005.

[5] J. Xue, and J. Wang, "Analysis on development level of competitive sports of eastern china in the "eleventh five-year" Period," *Bulletin of Sport Science & Technology*, vol. 19, no. 4, pp. 57-59, 2011.

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