The Influence Factors and Efficiency Variance in Transportation Equipment Manufacturing Industry

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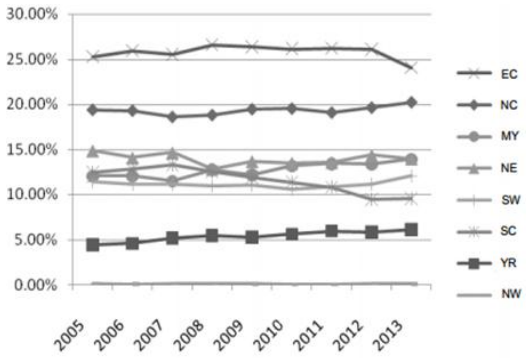
***Abstract*—The current economic development cannot simply rely on manpower and capital investment, because it had turned into new normal trends which depend on the overall increase in total factor productivity. Transportation equipment manufacturing industry as the basis of the national economy tries to improve its total factor productivity in order to lead industries to upgrade. Applying Malmquist-DEA model and 2005-2013 periods' development data to analyze efficiency variance from time dynamic dimension, the regional dimension and ownership organization dimension, points out that creative destruction environments and technological progress, technical efficiency improvement are the main ways to enhance the industry. This is undoubtedly an important reference for the manufacturing sectors when they had to enhance overall performance.**

***Index Terms*—Malmquist-DEA model, influence factors, efficiency variance, TFP.**

I. Introduction

The introduction of "National new urbanization plan (2014-2020)" brings a new manufacturing development space. At the same time, "One Belt and One Road" as the Chinese new international strategic framework will also lead the entire Asian economies to take off and achieve the overall balance of the domestic industry at the same time. Our economic development has been constrained by geographical factors, natural resources and basic infrastructure, showing an overall "East fast-West slow" development pattern. "New urbanization" and "One Belt and One Road" policies will vigorously promote the urban agglomeration and regional bodies to achieve coordinated development, focusing on infrastructure interoperability, committing regional economic integration. Under the current domestic and international development theme, we should depth profiling analyze the TFP structure of transportation equipment manufacturing industry in order to find out the root cause of promoting or restricting its development, and then find ways to vigorously promote the development of transportation equipment manufacturing industry and the national economy, which will bring a good opportunity for the development of the transportation equipment manufacturing industry.

In recent years, China's rapid development economy promotes the transportation equipment manufacturing industry to grow exponentially, showing a fleet growth trend. The total sales value and total profit of transportation equipment manufacturing industry is 1.56 trillion RMB and 66.4 billion RMB in 2005, and 7.53 trillion and 615.86 billion respectively in 2013, with an average annual growth rate of 21.7% and 32.1%. Fig. 1 shows the output value of the northern and eastern coastal areas accounted for almost half of the country in recent years, the development of transportation equipment manufacturing industry in the country's eight major economic regions shows a relatively stable but uneven development trend. The data of recent ten years shows the industrial sales value difference between different ownership is large, although the private sector accounts a smaller percentage, but its average annual growth rate is 27.92 percent, far higher than the whole average growth rate, while the annual growth rate of the state-owned and state-controlled is only 17.62% and foreign (including Hong Kong, Macao and Taiwan) investment is 21.81%. Thereby, the three dimensional (time, space, ownership) development of transportation equipment manufacturing is still quite different; in order to clearly analyze the industry growth drivers of this industry we should deconstruct the TFP.



(Note: EC represents east coastal region, NC represents north coastal region, MY represents Middle Yangtze region, NE represents northeast region, SW represents southwest region, SC represents south coastal region, YR represents middle reaches of Yellow River, NW represents big northwest region, the same below)

Fig. 1. The ratio of the eight economic area's industrial sales value.

How to promote transportation equipment manufacturing industry to achieve coordinated regional development will be an important topic during the "Thirteen Five" period. With the help of Malmquist-DEA model , this paper do some heterogeneity analysis of China Transportation Equipment Manufacturing development from time, space and ownership angles to provide more theoretical basis for the development of the industry. How to act a basic industry for the development of national economy during "Thirteen Five" period under the "one belt one road "and "new urbanization" strategies and how to promote the development of the industry in Midwest regions to act as a new economy growth pole require us to do some depth

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research of TFP. Input-driven turning to factor productivity-driven mode is a new widespread development normal, thus increasing total factor productivity of the industry will be critical for the transportation equipment manufacturing industry and even China's future economic growth.

II. Literature Review

Currently there is a lot of efficiency evaluation research about transportation equipment manufacturing industry, but they varied with different research content and research methods.

In terms of the contents, the majority of those researches are about sub-sectors and enterprises from the microscopic point, and still some are about organization structure from the perspective of industrial organization etc. [1]-[4]. In terms of the methods, parts of the literature are using parametric methods [5]-[7]; a part of the literature is using non-parametric methods [8]-[11]. Among the non-parametric literature, few literature aggregates time series dimension and regional economic dimension, expect that there are little research on TFP of different ownership. And there is much research from the view of Provincial or Urban Agglomeration [12], [13].

This paper estimates the value of the provincial dynamic efficiency from 2006 to 2013 with Malmquist-DEA model, and on this basis do some dynamic evaluation about the efficiency of various ownership from 2006 to 2013,providing a useful way of thinking about improving and upgrading the overall efficiency of the manufacturing industrial.

III. Efficiency Measure

A. The Introduce of Malmquist-DEA Model

Charnes presented the data envelopment analysis (DEA) to evaluate the relative efficiency of each object [14], and then it got widely used in the practice evaluation. Compared with other methods, the advantage of Malmquist index method is that it relies on data envelopment analysis, without requiring pre-set specific form function or distribution hypothesis to restrict frontier function and it has an easier access to the inputs and outputs data with different units. In view of these advantages, it is very suitable for comparing the efficiency of different time, regions and ownership. Therefore, this article selects Malmquist index to compute the dynamic efficiency of the transportation equipment manufacturing operation of different regions, different times and different ownership, trying to explore average change efficiency of the manufacturing sector. Malmquist productivity index equation is defined by the following by Färe *et al.* [15]:

$$M_0\left(X^{t+1},Y^{t+1},X^t,Y^t\right)=\left[\frac{D_0^t\left(x^{t+1},y^{t+1}\right)}{D_0^t\left(x^t,y^t\right)}\times\frac{D_0^{t+1}\left(x^{t+1},y^{t+1}\right)}{D_0^{t+1}\left(x^t,y^t\right)}\right]^{1/2} \quad (1)$$

Currently Malmquist-DEA method and decomposition of TFP have been used very popularly, so here we do not give unnecessary details.

We treat the development of transportation equipment manufacturing industry of 30 provinces, eight regions and three ownerships as production decision making unit (DMU). Malmquist-DEA method can do an effective decomposition to TFP growth, through technological progress, technical efficiency; scale efficiency indicators reflecting the real economy, this paper can act as realistic basis for TFP theory.

B. Indicators and Data Description

TABLE I: Input and Output Indicators

Indicators	Sub-indicators	Symbol	Unit
Input indicators	The average annual number of employees	X1	Thousand people
	Total fixed assets	X2	Billion RMB
	Main business cost	X3	Billion RMB
	Management cost	X4	Billion RMB
Output indicators	Total industrial output value	Y1	Billion RMB

While selecting input and output indicators, we consider the indicators within the input and output group are not linear correlated and the indicators among those two groups are linear correlated. This article draws the general provisions of indicators of Cooper, Charnes [16], [17] and the existing mature research [18], [19], at the same time gets reference from the corresponding data availability of Statistical Yearbook. Specific indicators are shown in Table I.

Referring from studies of Gong, Fan [20], [21], we analyze efficiency variance of different ownership with the same input and output indicators of Table I.

The data of this paper are from the "China Industrial Economy Yearbook (2006 to 2014)," which is statistics data of 30 provinces from 2005 to 2013; and the corresponding price index data are from the "China Statistical Yearbook (2006 - 2014)."

Due to the dynamic comparison of different years, the computing process includes the factors of price changes of many years and does not accurately reflect the amount of increase or decrease in actual physical changes, so we need to do deflating process to indicators which contain price factors. Referring to some proven practices [22]-[24], we use fixed-asset investment price index (specific operation: treat the data of 2005 as the base 100, and then convert the data of 2006 to 2013 with the data of 2005 as a base period deflator, the below are same as here.).We do price deflator to total fixed assets, with the use of the producer price index to industrial output value, the use of industrial producer price index to the main business cost, and the use of the consumer price index to management cost.

IV. Preliminary Test of Production Function

Based on many literatures and production function relationship, we treat the annual average employees number (PERSON), fixed assets total (ASSET), the main business cost (COST), administrative expenses (MANAGEMENT) as input factors, the industrial output (Y) as an output

obtained by the above-mentioned input elements. We construct multiple linear regression model, and then use eviews8 to do coefficient estimates and Wald test. According to usual practice, we do a double logarithmic transformation to the production function.

$$\ln Y = \ln A + \alpha \ln ASSET + \beta \ln COST + \gamma \ln PERSON + \lambda \ln MANAGEMENT + \mu$$

The follow table is the result of regression analysis.

TABLE II: THE RESULT OF REGRESSION ANALYSIS

Dependent Variable: LOG(Y)				
Method: Least Squares				
Date: 08/25/15 Time: 18:43				
Sample: 1 270				
Included observations: 270				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.309411	0.090281	3.427181	0.0007
LOG(ASSET)	0.217018	0.040295	5.385717	0.0000
LOG(COST)	0.788525	0.030076	26.21734	0.0000
LOG(PERSON)	-0.115856	0.025421	-4.557457	0.0000
LOG(MANAGEMEN)	0.095062	0.037702	2.521380	0.0123
R-squared	0.993610	Mean dependent var		6.115048
Adjusted R-squared	0.993513	S.D. dependent var		2.154550
S.E. of regression	0.173525	Akaike info criterion		-0.646641
Sum squared resid	7.979427	Schwarz criterion		-0.580004
Log likelihood	92.29657	Hannan-Quinn criter.		-0.619883
F-statistic	10301.38	Durbin-Watson stat		1.746053
Prob(F-statistic)	0.000000			

So, the sample regression equation is:

$$\ln \hat{Y} = 0.309 + 0.217 \ln ASSET + 0.789 \ln COST - 0.116 \ln PERSON + 0.095 \ln MANAGEMENT$$

（3.42）（5.39） （26.22） （-4.55） （2.52）

$$R^2 = 0.994, \bar{R} = 0.994, F = 10301.38$$

The fit of the model is good, under the condition of significance level 0.01, every coefficient pass the T-test.

$\bar{R} = 0.994$ shows that 99.4% of change of the industrial output can be interpreted by the log of the above-mention inputs, the remaining 0.6% can be interpreted by other factors, this influence is small. From the regression result, we also see that the sum of the coefficients of ASSET and COST is approximate to 1, that is to say, the sum of the output elasticity of this two important input factors is 1, which shows that this two key inputs is in constant return to scale.

TABLE III: THE RESULT OF WALD-TEST

Wald Test:			
Equation: Untitled			
Test Statistic	Value	df	Probability
t-statistic	0.138794	265	0.8897
F-statistic	0.019264	(1, 265)	0.8897
Chi-square	0.019264	1	0.8896
Null Hypothesis: C(2)+C(3)=1			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
-1 + C(2) + C(3)		0.005543	0.039937
Restrictions are linear in coefficients.			

We do Wald-test to constraint relations.

From the corresponding probability, we accept the null hypothesis, two key inputs is in constant return to scale. This result can act as a basis for the following discussion.

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V. MEASUREMENT RESULTS AND ANALYSIS

In this paper, we use the basic tools DEAP2.1 software to measure dynamic efficiency values of China's 30 provinces from 2006 to 2013. We drill heterogeneous decomposition from time, space, ownership angles in order to deconstruct "growth effect" (technological progress) and "level effect" (technical efficiency).

As can be seen from Table IV, the nationwide time series data show that total factor productivity growth over the past decade is relatively stable, TFP change during "the Eleventh Five-Year" period is small, indicating that the reform and opening-up policies and some other basic industry policies improve market economy gradually. But during the first two years of "the Twelfth Five-year " the TFP witness a large increase, and later appears a lowest value of the last decade, which is related with the economic adjustment since the second half of 2011. The average growth rate of TFP from 2005 to 2013 is 3.0%, this high growth mainly due to great technological progress. In recent years intensified competition in international market and the global financial crisis has brought a greater impact to the economic development of the transportation equipment manufacturing industry, which to some extent hinders the further improvement of the total factor productivity levels.

TABLE IV: TFP DECOMPOSITION OF EIGHT REGIONS WITH DIFFERENT INVESTMENT FROM 2006 TO 2013

Year	Effch	Tech	TFP	Prov.	Effch	Tech	TFP
2006	1.059	0.970	1.027	NC	1.004	1.034	1.038
2007	0.960	1.091	1.048	NE	0.995	1.033	1.032
2008	0.932	1.097	1.022	EC	1.007	1.029	1.0369
2009	1.063	0.967	1.028	SC	0.999	1.018	1.0169
2010	1.004	1.018	1.022	YR	1.001	1.010	1.0108
2011	0.955	1.105	1.055	MY	1.011	1.032	1.0429
2012	0.868	1.240	1.076	SW	1.005	1.026	1.0312
2013	1.231	0.785	0.966	NW	1.005	1.027	1.0329
Mean	1.004	1.026	1.030	Mean	1.004	1.026	1.0302

From the Table IV, we also draw the conclusion that the TFP change of northwest region is greatest from 2005 to 2013, while the other seven regions are of a slight concussion with little volatility. The TFP of Northeast, north coast, east coast, the middle reaches of the Yangtze River and southwest areas of the industry is relatively high, which is consistent with the development status of these areas, but TFP differences among those regions are not very significant. Technology spillovers of the industry can give a rational interpretation, while industrial transfer leds to the transfer of appropriate knowledge and technology. In addition, as a capital-intensive industry, capital investment has a great effect on TFP increase. The needs of the industry and the development of a national strategy will promote its

development, so the state and the corresponding provinces should invest heavily and advocate more research about its development.

TABLE V: TFP DECOMPOSITION WITH DIFFERENT INVESTMENT

Type	Effch	Tech	TFP
State-owned	0.995	1.105	1.099
Privately-operated	1	0.96	0.96
Foreign investment	1	1.052	1.052
Mean	0.998	1.012	1.010

As can be seen from Table V, the average growth rate of the total TFP is 1.0%, the average growth rate of technical efficiency index is -0.2% and the average growth rate of technological progress index is 1.2%.Before 2005, most large state-owned enterprises through restructuring changed into Limited enterprises, although still acted as state-controlled enterprises, but they had been integrated into market-oriented mode with great increasing total factor productivity, but the effect of this restructuring change after 2007 is not very clear. TFP index of private enterprises from 2005 to 2013 decreased by 4%, with almost no technical efficiency changes over the period, that is to say "horizontal effect" is almost zero, but the "growth effect" brought by technological progress index demonstrates ups and downs .The average TFP growth rate of Hong Kong, Macao, Taiwan and foreign invested enterprises is 5.2% from 2005 to 2013, which has almost no change in technical efficiency.

V. CONCLUSION AND ADVICE

Leading by the current "New Urbanization" and "One Belt and One Road " development strategies, transportation equipment manufacturing industry still need to transfer the overseas and home high-tech achievements into productive forces, increase the total factor productivity gradually, which can act as the industrial base of future national economic development for a long time. Transportation equipment manufacturing industry needs urban agglomeration as the main platform, breaking the administrative barriers and monopoly, promoting the factors of production to flow within the industry freely and optimized, accelerating industrial upgrading and transferring and co-building infrastructure to promote cross-regional coordination of joint industrial development. Under the new normal economy, with the help of the promotion of technology, the improvement of organization management and the integrity of institutional systems, we hope to improve the level of total factor productivity to further adjust the industrial structure and establish the innovation system and achieve rapid economic growth finally [25].

East coast, north coast, northeast area should act as the industry's leaders, at the same time they should continue to accelerate technological innovation to support the industry to upgrade and improve the level of global industry division. The middle parts of the Yangtze River should improve their industry openness, optimize the development system of the industry, play a gradient effect, and enhance mobility and clustering of factors and the technological innovation and absorptive capacity. During technical progress and technical efficiency improvements process, the industry should do some preparation for regional transition. South coastal region and middle reaches of the Yellow River should improve the markets function, economic strength and cooperation to achieve intensive development and linkage type.

Reform of state-owned enterprises has injected fresh blood into the development of enterprises, but this power has been exhausted during the development process, so we need to promote enterprise development with the use of technology efficiency. Private enterprise is difficult to form a joint force under the vagaries of the external environment, which eventually lead its technological progress index volatile. The increase of TFP of foreign investment and Hong Kong, Macao and Taiwan investment enterprises relied on the technical efficiency with the technological progress installed. Foreign direct investment enterprises absorb advanced technology globally, but the use efficiency of its technology should improve, which shows foreign direct investment companies need to adapt the local market and culture during the operation and management actively and effectively. At present our overall market environment is difficult to stimulate enterprises to invest in the initiative to do the technological innovation, but long-term use of cheap labor input instead of investment in technology is bound to cause a decline in the level of technology.

Overall, the increase in TFP includes three aspects, technological progress, improvements of technical efficiency and increase of investment scale. Technological progress and enhance of technical efficiency should act at the same time, alternating improvement of those two aspects is useless, even a huge waste of resources. Alone rely on the capital investment to promote economic development is not particularly sustainable. Transportation equipment manufacturing industry as a capital-intensive industry, if in a more relaxed macroeconomic policy environment, enterprises especially private enterprises will have no power to transfer the input driver into TFP driver.

REFERENCE

[1] Y. J. Zhang, C. H. Gan, and R. G. Zheng, "Endogenous and correlation effects of producer services and manufacturing sectors-an empirical research based on structural decomposition technique of input-output model," *Industrial Economics Research*, vol. 06, pp. 81-90, 2014.

[2] X. H. Sun, Wang, "The Influence of firm size on productivity and its difference-based on the empirical test of industrial firms in China," *China Industrial Economics*, vol. 05, pp. 57-69, 2014.

[3] Y. Luo and L. L. Cao, "A positive research on fluctuation trend of China's manufacturing industrial agglomeration degree," *Economic Research*, vol. 08, pp. 106-127, 2005.

[4] S. B. Xu, "The correlation research about Beijing municipal transportation equipment manufacturing industry," *Economic Research Guide*, vol. 11, pp. 55-56, 2013.

[5] S. C. Hao, J. F. Tian, and T. Hu, "An industry inspection on the efficiency of state-owned industrial enterprises," *China Industrial Economics*, vol. 12, pp. 57-69, 2012.

[6] D. R. Yang, "Study on the total factor productivity of Chinese manufacturing enterprises," *Economic Research*, vol. 02, pp. 61-74, 2015.

[7] H. H. Nie and R. X. Jia, "China's manufacturing business productivity and resource misallocation," *The Journal of World Economy*, vol. 07, pp. 27-42, 2011.
[8] Y. S.Chen, "A methodology to evaluate and improve performance of automobile manufacturing industry using DEA," *Journal of Technological Economics*, vol. 06, pp. 53-58, 2013.
[9] Y. T. Chang, N. Zhang, D. Danao *et al*., "Environmental efficiency analysis of transportation system in China: A non-radial DEA approach," *Energy policy*, vol. 58, pp. 277-283, 2013.
[10] Y. Hu, X. Wang, and L. Yang, "Assessment of intellectual capital efficiency in China transportation equipment manufacturing companies: Using DEA," *Advanced Technology in Teaching. Springer Berlin Heidelberg*, pp. 405-412, 2013.
[11] C. Hsieh and P. J. Klenow, "Misallocation and manufacturing TFP in China and India," *Quarterly Journal of Economics*, vol. 124, no. 4, pp. 1403-1448, 2009.
[12] Z. Y. Hu, P. Li, and Y. W. Liu, "The evaluation of the construction of urban infrastructure investment and financing in China based on the CCA-DEA model," *Soft Science*, vol. 04, pp. 7-11, 2013.
[13] H. J. Li and S. H. Li, "Research on efficiency of urban agglomeration based on DEA model - An empirical study of the pearl river delta city group," *Soft Science*, vol. 05, pp. 91-95, 2011.
[14] Charnes, W. W. Cooper, and E. L. Rhodes, "Measuring the efficiency of decision making units," *European Journal of Operational Research*, vol. 2, no. 6, pp. 429-444, 1978.
[15] R. Fare and C. A. K. Lovell, "Measuring the technical efficiency of production," *Journal of Economic Theory*, vol. 19, no. 150-162, 1978.
[16] W. W. Cooper, L. M. Seiford, and K. Tone, "Data envelopment analysis: A comprehensive text with models, applications, references and DEA-solver software," *Springer Science & Business Media*, 2007.
[17] A. Charnes, W. W. Cooper, A. Y. Lewin, and L. M. Seiford, "Data envelopment analysis: Theory, methodology, and applications," *Springer Science & Business Media*, 2013.
[18] Y. Y. Zhen and B. Xu, "Capital measure in the study of economic growth," *The Journal of Quantitative& Technical Economics*, vol. 07, pp. 14-27, 1992.
[19] X. P. Li and Z. L. Zhu, "The Calculation of China's industrial sector total factor productivity," *Management World*, vol. 04, pp. 56-64, 2005.
[20] G. Gong, G. L. Hu, and L. Chen, "The analysis of total factor productivity difference between China's state-owned and non-state-owned manufacturing enterprises," *Industrial Economics Research*, vol. 01, pp. 93-100, 2015.
[21] J. Fan, B. J. Yan, and J. Liang, "Industrial enterprises of different ownership dynamic comparative study on total factor productivity-take Nanjing as an example," Social Science in Nanjing, vol. 01, pp. 113-121, 2008.
[22] J. Zhang, S. H. Shi, and S. Y. Chen, "The industry reform and efficiency change in China: Methodology, data, literatures and conclusions," China Economics Quarterly, pp. 38, 2003.
[23] S. Y. Chen, "Reconstruction of sub-industrial statistical data in China (1980-2008)," *China Economics Quarterly*, pp. 42, 2011.
[24] H. Y. Xia, C. Dong, and C. X. Xu, "The compare of several common price index of measuring the rate of inflation," *Statistics& Information Tribune*, vol. 03, pp. 31-33, 2000.
[25] F. Cai, "How China's economic growth change to total factor productivity-driven mode," *Social Sciences in China*, vol. 01, pp. 56-206, 2013.

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