

# Research on total factor productivity of manufacturing enterprises in the Yangtze River economic belt

Hua Yuan<sup>a</sup>, Yun Zhang<sup>b\*</sup>, Hongzhong Zhao<sup>a</sup>

<sup>a</sup>Wuhan University of Technology, Wuhan, Hubei, China

<sup>b</sup>Wuhan Donghu University, Wuhan, Hubei, China

\*Corresponding author: Yun Zhang, Doctor of Economics, 2280727@qq.com

## Abstract

Manufacturing, the important industries in the Yangtze River Economic Belt, is a hot issue for many scholars to study. In this paper, Data Envelopment Analysis(DEA) method is used for calculating the total factor productivity (TFP) of enterprises in the Yangtze River Economic Belt. The results show that TFP of manufacturing enterprises in these areas has gone through four stages of development: steady decline--decline--fast rise--maintenance from 2005 to 2014. As for industrial sectors, seven sectors including tobacco, textiles, leathers, furs, feathers, shoemaking and medicine manufacturing showed rise in TFP, and TFP of high-tech manufacturing enterprises increased while low or medium-tech declined.

**Key words:** *the Yangtze River economic belt; total factor productivity; data envelopment analysis; manufacturing enterprises; industrial sectors*

## 1 Introduction and literature review

The Yangtze River Economic Belt, west from Guizhou and east to Shanghai, is the most economically advanced area in the Yangtze River Basin. Manufacturing industry, which is a pillar industry in the national economy, plays an important role in the Yangtze River Economic Belt. Thus, it is of theoretical and practical significance to study the total factor productivity (TFP) of manufacturing enterprises in the Yangtze River Economic Belt.

Considering existing literatures, the literatures studying TFP are primarily classified into three types:(1) overall research on TFP of manufacturing industry;(2) research on TFP of regional manufacturing industry, and (3) research on TFP of subdivided manufacturing sectors. As for overall research on TFP, *R. Yang*<sup>1</sup> utilized enterprise data, by employing OP, LP methods to calculate TFP at the enterprise level, discovered that the growth rate of overall TFP of manufacturing industry in China ranged from 2% to 6%, with an average annual growth rate reach to 3.83%, which features great fluctuation. In terms of research on TFP in regional manufacturing industry, *Liu, Yu Lin and T. W. Chen*<sup>2</sup> found out regional differences of the relations between foreign trade dependence and TFP after analysing the panel data of China's provinces from 1993 to 2007. *W. U.Hao, and L. I. Zheng*<sup>3</sup> analyzed regional differences of TFP and the components by applying the non-parametric model of DEA. The research points out that eastern coastal areas has the highest growth of regional TFP, whereas the northeast is

the lowest. *A.Cieślik, et al.*<sup>4</sup> found the empirical results show some degree of heterogeneity across Ukrainian macro-regions. As for research on TFP in subdivided sectors, *F.Aiello et al.*<sup>5</sup> found the results that firm TFP increases when it belongs to more innovative sectors.

## 2 Research methods and data selection

### 2.1 Research methods

The method for calculating TFP can generally be classified into two types: parametric and nonparametric methods. The parametric methods need to estimate the parameters by choosing different forms of production functions under different assumptions, including C-D production function regression method, stochastic frontier production function(SFA) and Solow's residual method. Non-parametric methods are not required to make pre-assumption of specific forms of production functions, including algebra index method and data envelopment analysis (DEA). This paper selects DEA to measure TFP of manufacturing industry in the Yangtze River Economic Belt. The Malmquist index and its decomposition are calculated in order to measure TFP.

The expression of the Malmquist index is as follows:

$$M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \left[ \frac{D_0^t(x_{t+1}, y_{t+1} | C, S)}{D_0^t(x_t, y_t | C, S)} \times \frac{D_0^{t+1}(x_{t+1}, y_{t+1} | C, S)}{D_0^{t+1}(x_t, y_t | C, S)} \right]^{\frac{1}{2}} \quad (1)$$

When the index is more than 1, it indicates that the TFP is increasing from t to t+1, and when the index is less than 1, which shows that TFP has decreased from t period to t+1 period.

### 2.2 Data selection

Considering data accuracy and availability, this article selects data of manufacturing enterprises in 9 provinces and 2 municipalities included in the Yangtze River Economic Belt from 2005 to 2014 as a research subject. All the data come from 2006-2012 China Industrial Economy Statistical Yearbook, 2013-2015 China Industry Statistical Yearbook, and China Compendium of Statistics 1949-2008 and statistical yearbooks of provinces and municipalities.

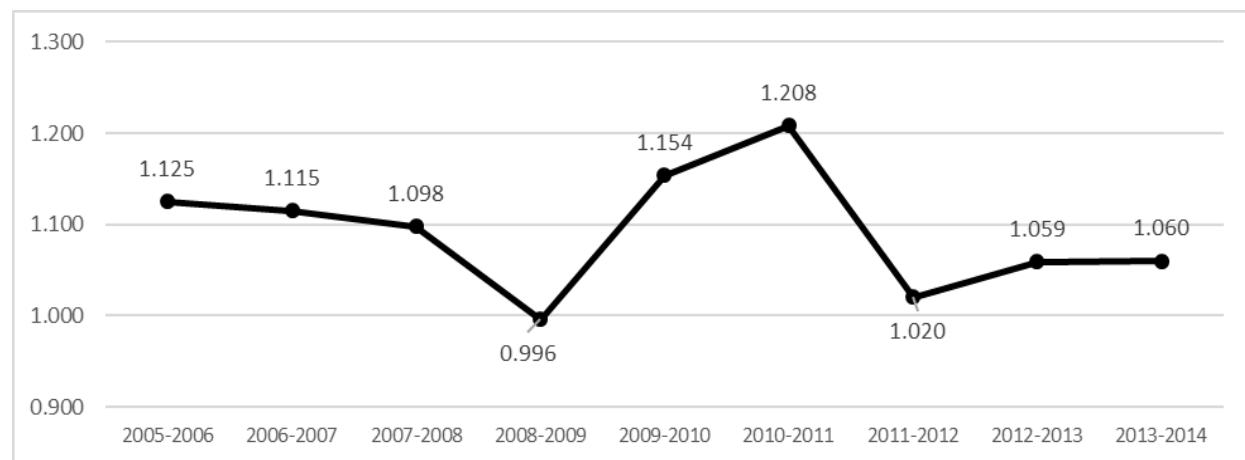
Measuring TFP needs to set output index and input index. Total enterprise production value of 9 provinces and 2 municipalities are chose as output index. Input index includes labour input and capital input. Labour input is the number of employees in manufacturing industry in these provinces and municipalities from 2005 to 2014; while enterprise liabilities and owner's equity capital are selected as capital input. The cause for choosing these two indexes to sum up lies in that by definition of economics, capital could bring in value from surplus value, thus all assets input for enterprise operation, including enterprise's own accumulation should be termed as enterprise capital. While by accountancy, the capital is defined as enterprise capital=paid-in capital=capital fund. Meanwhile, the capital fund of enterprise mainly comes from two sources, one of which is enterprise's own operation accumulation, and the other of

which is debt. The enterprise's own operation accumulation can be measured by owner's equity, while the capital acquired in the form of debt can be measured by enterprise's liabilities.

### **3 Overall analysis of TFP of manufacturing enterprises in the Yangtze River Economic Belt**

The results of change of TFP of manufacturing enterprises in 9 provinces and 2 municipalities included in the Yangtze River Economic Belt from 2005 to 2014 are shown in Fig.1.

*Fig.1 –TFP index of manufacturing enterprises in provinces and municipalities in the Yangtze River Economic Belt*



The measuring results illustrate that from 2005 to 2014, the TFP of manufacturing enterprises generally can be represented in four stages. The first stage, before 2008, showed steady growth, which was stable despite slow in rise. The second stage, from 2008 to 2009, showed decline, which was due to influence on markets for manufacturing enterprises by global financial crisis. The third stage, from 2009 to 2011, the rise of TFP of manufacturing enterprises accelerated, which was due to the investment expanding in manufacturing enterprises caused by stimulus of the 4 trillion-yuan plan. The fourth stage, TFP of manufacturing enterprises grow slightly from 2012 to 2014. TFP of manufacturing enterprises is further analysed year by year, and the measuring results as shown in Table 1:

Table 1 shows common trend featuring four stages: steady decline--decline--fast rise--maintenance, but the value of these provinces shows different characteristics. In general, during the period from 2005 to 2014, the growth of TFP of manufacturing enterprises in downstream area of the Yangtze River Economic Belt is the lowest, where the growth rates of TFP in Shanghai, Jiangsu and Zhejiang are respectively 7.6%, 7.2% and 4.6%, while the rise of TFP of manufacturing enterprises in middle and upper middle and upstream of the Yangtze River Economic Belt was relative smooth, at round 10%.

**Table 1 –TFP index of manufacturing enterprises in provinces and municipalities in the Yangtze River Economic Belt**

Region Year \ Region	SH	JS	ZJ	AH	JX	HN	HB	CQ	SC	YN	GZ
2005-2006	1.128	1.083	1.042	1.112	1.212	1.065	1.145	1.107	1.124	1.239	1.138
2006-2007	1.104	1.068	0.996	1.138	1.124	1.128	1.120	1.126	1.127	1.204	1.144
2007-2008	1.066	1.076	1.000	1.125	1.197	1.080	1.149	1.115	1.081	1.102	1.095
2008-2009	0.958	0.979	0.946	1.001	0.925	1.045	0.984	0.997	1.121	0.989	1.031
2009-2010	1.209	1.086	1.107	1.164	1.135	1.266	1.229	1.162	1.070	1.163	1.124
2010-2011	1.163	1.158	1.188	1.285	1.171	1.211	1.309	1.258	1.185	1.191	1.183
2011-2012	0.970	1.059	1.044	0.995	1.022	0.985	1.018	1.010	0.959	1.040	1.125
2012-2013	1.059	1.085	1.053	0.949	1.053	1.034	1.059	1.056	1.132	1.015	1.173
2013-2014	1.056	1.064	1.055	1.246	1.002	1.021	1.000	1.087	1.089	1.021	1.040
2005-2014	1.076	1.072	1.046	1.107	1.089	1.089	1.108	1.099	1.097	1.104	1.116

#### **4 The industry analysis of TFP of manufacturing enterprises in the Yangtze River Economic Belt**

Furthermore, TFP of manufacturing enterprises with respect to sectors is calculated through using the data of 31 sectors of manufacturing industry in these provinces and municipalities from 2013 to 2014. The results are demonstrated in Fig.2.

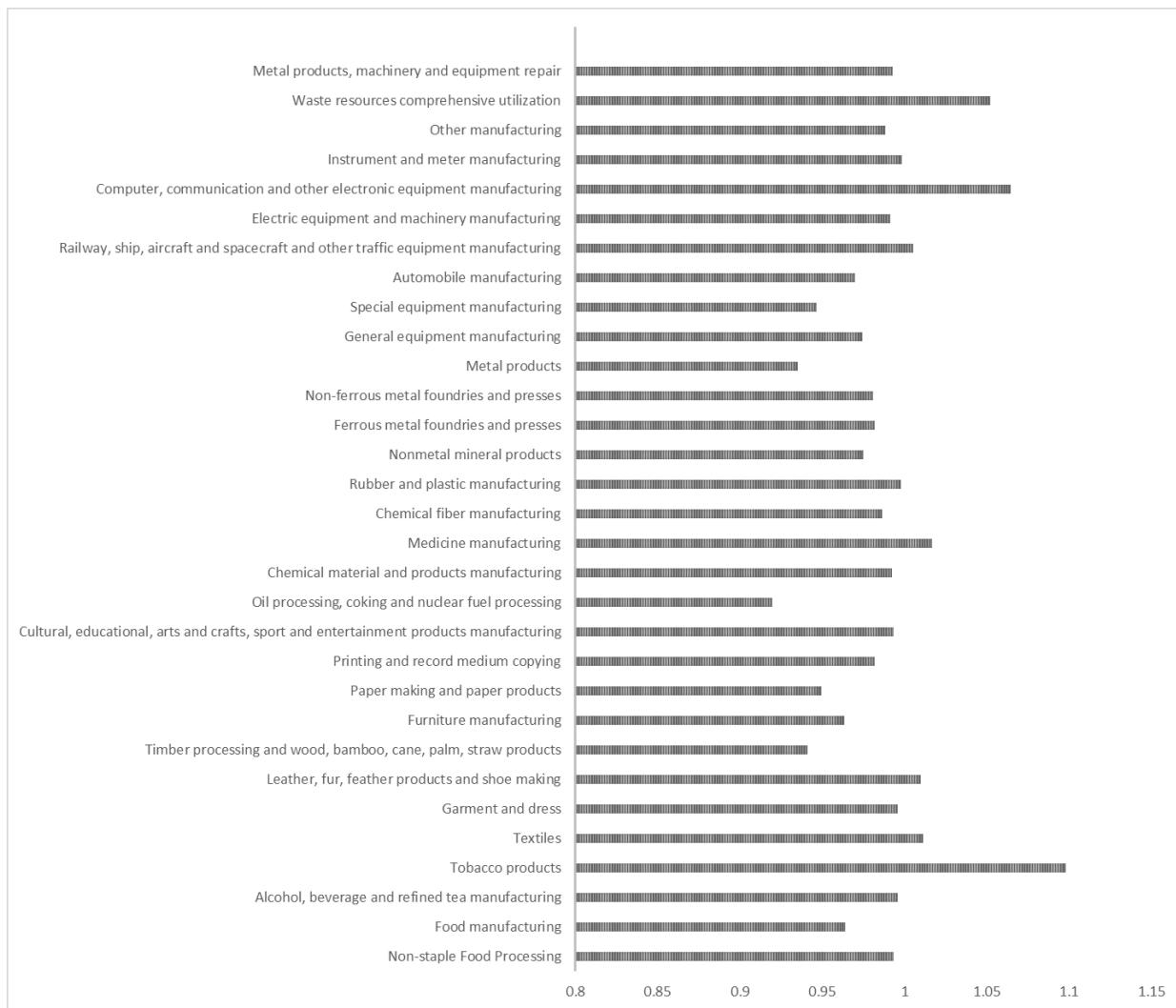
The results indicate that among 31 sectors in manufacturing industry, there are seven sectors have growth in TFP of manufacturing enterprises in the Yangtze River Economic Belt, only accounting for 22% of whole industry, which are respectively the sectors of textiles; leather, fur, feather products and shoe making; medicine manufacturing; railway, ship, aircraft and spacecraft and other traffic equipment manufacturing; computer, communication and other electronic equipment manufacturing; waste resources comprehensive utilization. Sector of tobacco products shows greatest rise, which is determined by nature of monopoly of sector of tobacco products. The growth in TFP of enterprises from two sectors (medicine manufacturing and computer, communication and other electronic equipment manufacturing) indicates that the manufacturing industry in the Yangtze River Economic Belt was marching into high-tech development. While the growth in TFP of textile enterprises indicates that traditional sectors also developed when the high-tech sectors were developing.

On basis of survey reports from Organization for Economic Cooperation and Development (OECD) and Development Research Center of the State Council, this paper, according to technology-intensive degree, classifies the sectors in manufacturing industry into three types: high-tech sectors, medium-tech sectors and low-tech sectors. Table 2 shows the differences of

high-tech and medium and low-tech enterprises.

TFP of high-tech manufacturing enterprises in the Yangtze River Economic Belt is 1.0266, while TFP for medium-tech manufacturing enterprises and low-tech manufacturing enterprises are respectively 0.9807 and 0.9915. These results imply that from 2013 to 2014, the TFP of high-tech manufacturing enterprises increased, while the TFP of low-tech and medium-tech decreased. There is substantial difference between high-tech sectors medium and low-tech sectors

*Fig. 2 –TFP for sectors in manufacturing industry*



## 5 Conclusions and policy suggestions

From above analyses, it can be concluded that:(1) the TFP of manufacturing industry has some fluctuation from 2005 to 2014 with respect to time, which shows the trend of steady decline--decline--fast rise--maintenance; (2) in terms of regions, there is great differences in TFP of manufacturing industry among the regions, TFP grows rapidly in the west than in the east; (3) as for sectors of manufacturing industry, the TFP of monopoly sector enterprises saw

obvious growth, the growth of TFP in high-tech sectors was faster than medium and low-tech. The following policy suggestions can be implied from conclusions of empirical research: (1) national policies already have great influence on the manufacturing enterprises in the Yangtze River Economic Belt, and the government should plan and facilitate the coordinated development of the Yangtze River Economic Belt through "Top-level Design" and authoritative system arrangement. (2) Governmental cooperation between provinces should be strengthened. The regional gap in TFP of manufacturing enterprises in the Yangtze River Economic Belt should be narrowed through providing support by government for coordinated development of the Yangtze River Economic Belt. (3) The variance between sectors in manufacturing sector should be reduced through industrial restructuring. To create conditions for the development of high-tech industries by improving the level of scientific and technological progress. Meanwhile, to improve the level of innovation in traditional industries by promoting the technological transformation and technological investment.

*Table 2 –TFP index of manufacturing industry according to classification based on technology-intensive degree*

	N	Mean value	Standard deviation	Standard error	Minimal	Maximum
					value	value
Low-tech sectors	12	0.9915	0.04053602	0.01170174	0.9413	1.0982
Medium-tech sectors	16	0.9807	0.03012588	0.00753147	0.9199	1.0521
High-tech sectors	3	1.0266	0.03405721	0.01966294	0.9986	1.0645
Total	31	0.9893	0.03625027	0.00651074	0.9199	1.0982

## References

1. R.Yang , Study on the Total Factor Productivity of Chinese Manufacturing Enterprises, Economic Research Journal,2 (2015) 61-74.
2. Y. L.Liu, T. W.Chen, Regional Differences in the Effects of Foreign Trade Dependence on Total Factor Productivity(TFP)——based on inter-provincial data in China, Journal of Chongqing University of Technology 4(1) (2010) 34-40
3. W. U.Hao, Z L. I.heng, Regional Differences of TFP and the Plight of Economic Transformation in China. Commercial Research 5(2016) 9-16.
4. A.Cieślik, J. J.Michałek, I.Nasadiuk, The Regional Heterogeneity of Productivity Determinants: Evidence from Ukrainian Firms. Miscellanea Geographica 21 (1) (2017) 44-50.
5. F. Aiello, V.Pupo,F.Ricotta, Firm heterogeneity in TFP, sectoral innovation and location. Evidence from Italy. Mpra Paper 29 (5) (2013)1-29.