Is China's Manufacturing Technical Efficiency Cost-push?*

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Abstract:
Do rising factor prices promote technical efficiency (TE) in China's manufacturing sectors? This topic has not yet been thoroughly studied in any literature. Using panel data from 1993 to 2007 of Chinese provinces' manufacturing industries, this paper calculated the TE by data envelopment analysis (DEA). The result shows that China's manufacturing TE remained stagnate in the mid- and late-1990s and increased after 2000. Using a Pooled Regression Model, Fixed-effects Regression Model and Panel Corrected Standard Error (PCSE) to obtain robust parameters and the standard error, we find that rising factor prices have an obvious positive effect on the TE of the manufacturing industry and that this effect reaches its peak three to five years later. Therefore, the assumption of a "cost-push TE" in China's manufacturing sectors can now be statistically proven. It has verified the significance of reforming China's factor price system. Governments should value resource-allocating efficiency, implement policies that promote industrial transition and upgrading and transform the economic development pattern through technical innovation.

Key words:
factor price, data envelopment analysis, technical efficiency

I. Introduction

While rising factor prices are becoming increasingly heavy burdens on China's manufacturing industry, they are objectively helping to speed up industrial transition and upgrading. Although reform of China's price system has not yet been entirely completed, especially in the fields of energy and resources, the current bout of rises in factor prices will fundamentally impact the transition, upgrading and location of China's manufacturing sectors. Theoretically, when the cost of labor rises, enterprises tend to replace labor with capital, in an effort to employ innovative techniques to maintain product competitiveness. This way, the overall technical level will be lifted across the industry. So can rising factor prices really force enterprises to improve their TE to hedge against soaring costs? If the answer is yes, then how rising factor prices affect the TE in manufacturing becomes an important issue that needs further study. This paper aims at filling in the holes in this field of study in China by providing facts that can help shape industrial upgrade policies. Furthermore, this paper also helps in finding out the intrinsic relationship between reforming the factor price system and transforming the economic development pattern.

Productivity or the production efficiency is an important measurement of a country or region's industrial economic growth quality. It can also be used by economists to analyze industrial performance and its trend.

Zhang Jun, Shi Shaohua and Chen Shiyi (2003) once pointed out that China's industrial reform provides rich insights for economists to study how the reform policy uniquely affects enterprises of various forms of ownership in regards to changes in their productivity. China's industrial productivity or production efficiency has long been studied in lots of empirical research literatures[1], namely the calculation, decomposition and influencing factors of China's Total Factor Productivity (TFP). There are mainly two types of researches. The first involves the calculation and decomposition of TFP. Commonly used calculating methods include parameter estimation (such as the Stochastic Frontier Model and the Translog Model) and non-parameter estimation such as the Malmquist Index. Such research has been done by Tu Zhengge and Xiao Geng (2006), Li Lianshui and Zhou Yong (2006), Gong Juntao, Sun Linyan and Ligang (2008), Zhu Zhongdi and Li Xiaoping (2005). The second approach is to calculate the productivity and to study its relationship with other economic variables as done by Lin Qingsong (1995), Wang Zhipeng, Li Zinai (2003), Wu Lixue and Fu Xiaoxia (2008), etc. The TE can be calculated using data envelopment analysis (DEA), Bootstrap-DEA and the Malmquist Index, etc.

Most scholars use data from the *China Statistical Yearbook* and the *China Industry Economy Statistical Yearbook* to calculate Chinese industrial productivity and the production efficiency. Only a very few scholars such as Tu Zhengge and Xiao Geng (2006) have employed micro-level data of enterprises; Jefferson *et al*. (1992), Zheng Jinghai and Liu Xiaoxuan (2002) used business survey data. According to existing literatures, we can find a clear research trend. Early studies mainly surveyed national-level industrial performance and measured TFP using the Solow Residual. Later studies encompassed the following features: First, they used new methods to study the same issue such as the Malmquist Index, Stochastic Frontier Function and Bootstrap-DEA; second, they used micro data instead of macro data; third, the research perspective shifted from being nationwide to region- or enterprise-focused. Cai Zhixian, Huang Zuhui (2008), Gong Juntao, Sun Linyan and Li Gang (2008) employed the Malmquest Index to analyze the TFP trend of provincial enterprises. Fourth, they added input and output variables to calculate the efficiency by sectors. Referring to foreign studies, Wang Bing (2008), Yang Wenju (2009), Yue Shujing and Liu Fuhua (2009) included environmental variables, most notably, the industrial pollutant discharge index into input or output variables. This method is more practical. Although different methods and data have been used, scholars have reached relatively consistent conclusions. "The finding that China's economic reform has positively affected industrial efficiency has virtually been accepted" (Zhang Jun, Shi Shaohua and Chen Shiyi, 2003).[2] Selin Ozyurt (2009) studied the changes in the TFP of Chinese enterprises since the founding of the new China in 1949, and reported findings that the TFP has experienced an obvious upward trend and has evidently positively affected economic growth after the reform and opening-up. But has China's industrial growth performance really been as great as these economists have imagined it to be? Some hold a dissenting view, questioning whether the positive effects efficiency has had on China's state-owned enterprises. But one point has been commonly recognized, i.e., productivity growth in state-owned enterprises has been slower than in non-state-owned enterprises.

During econometric analysis on the factors which influence productivity and productive efficiency, researchers normally select a wide variety of variables, including the factor resource-allocating efficiency (Lin Qingsong, 1995), the role of foreign funds (Wang Zhipeng and Li Zilai, 2003), the ownership structure (He Cong and You Ruizhang, 2008) and the agglomeration economy (Wu Lixue and Fu Xiaoxia, 2008), etc. However, there have been almost no domestic scholars who have looked into the impact factor input costs have on the TE, i.e., do micro economic entities experience an upgrade in their technical R&D capabilities, organization and management and specialization level against a backdrop of prevalent factor price rises? In other countries, some scholars have begun to focus on this question. Pol Antras and Hans-Joachim Voth (2003) used factor prices instead of factor inputs to measure the TFP trend of British industries; K. Obeng and R. Sakano (2002) studied whether government subsidies aimed at reducing factor input costs in the public transportation sector can affect its TE. Their finding is that by reducing the inefficiency of subsidies, the TE in the transportation sector can be improved. This is called the "subsidies-induced technical change." However, their research only looked at the current impact without taking into account the lagging effect of factor prices. Such research is still an under-researched field in China; hence, this paper presents a goosd opportunity for the authors to make a far-reaching contribution to this field of study.

This paper's pioneering work is mainly reflected in the following three aspects. First, the authors analyzed the relationship between factor price rises and the manufacturing TE using panel data and verified whether or not China's manufacturing TE is cost-push. This fills in the gap of domestic studies in this field. Second, the authors stress the robustness of their results. While measuring the impact factor prices have on China's manufacturing TE, they used the Pooled Regression Model, Fixed-effect Regression Model and Panel Corrected Standard Error, etc. and selected the lag order prudently to ensure robustness of the estimation coefficient and errors. Third, the authors made an effective use of statistics and constructed 1993-2007 panel data from manufacturing industries in various Chinese provinces. These data come from authoritative state statistical departments and cover a long time span, a wide range of sectors and complete indexes.[3]

The paper is organized as follows. Section II attempts to calculate China's manufacturing TE; Section III introduces the model, variables and data; Section IV attempts to study results of the econometric analysis; Section V provides conclusions and enlightenments which can be inferred from this paper, including major findings, policy implications and issues that need to be addressed.

II. Calculating the TE of manufacturing industries

(I) Introduction to methodology and data processing

Data envelopment analysis (DEA) is often used to calculate the TE[4]. An advantage of this method is that it can directly work out the manufacturing TE of all provinces (autonomous regions and municipalities directly under the central government) during 1993-2007. And unlike other indexes, it does not require the assumption that the TE of economic entities is always effective. Also, DEA avoids specific assumptions of the productive function distribution and form, in contrast to parameter methods. Farrell (1958) proposed to estimate the production frontier by constructing a non-parameter linear convex; Shephard (1970) proceeded to propose that the input distance function can be taken as a method of efficiency evaluation. But this method relies on the construction of a production possibility set. Charnes *et al.* (1978) established the DEA model with constant return to scale (CRS) that constructs the production possibility set using the linear programming method, the first to do so, thus realizing the calculation of Shephard's distance function. After constructing the production possibility set, we can arrive at the production frontier by directly connecting its outermost points. Points above the production frontier stand for effective technical production, whereas those below it refer to ineffective technical production. By using the distance function, we can figure out the efficiency of these points.

Based on the output-oriented DEA method, the authors used the distance function Shephard defined to estimate the TE of manufacturing industries. As stated above, DEA does not necessitate a specific form of the production function. Statistics software can construct the production possibility set by directly using the linear programming method, which can eliminate the researcher's subjectivity. The DEA method involves the issue of returns to scale. In Timothy J. Coelli's *et al.* (2004) literature, he pointed out that when the assumption that all enterprises are operating at the optimal scale is not met, using the CRS-DEA setting will confuse TE with scale efficiencies (SE). He also stated that the CRS-DEA –based result is actually a generalized TE (including "pure" TE and SE), whereas the VRS-DEA-based result is the "pure" TE (TE_{VRS}). The relationship between the two can be described as: TE= TE_{VRS}×SE.

We assume there are I economic entities, data of the N×I input matrix X and the M×I output matrix Q, where λ stands for the constant vector of I×1. The input and output of the i[th] entity are denoted by column vectors x^i and q^i, respectively. The DEA model can be depicted as:

$$\begin{aligned}
&\max_{\theta,\lambda} \theta \\
&st. \\
&-\theta q^i + Q\lambda \geq 0 \\
&x^i + X\lambda \geq 0 \\
&I1'\lambda = 1 \\
&\lambda \geq 0
\end{aligned}$$

Where, $1 \leq \theta < \infty$, and $1/\theta$ denotes the i[th] entity's output increment when the input remains unchanged and $1/\theta$ denotes the TE. Using the DEA method, what we report is the value of $1/\theta$. The efficiency value for points above the production frontier is 1, indicating the production is effective.

The DEA method also needs to use the input and output data. In the following section, the authors will introduce how the input and output data from provincial enterprises are processed. The output is denoted by the value added by manufacturing, and the input includes both capital and labor. All indicators have been processed to facilitate comparison between different years. The manufacturing TE of 29 provinces (regions and municipalities) excluding Tibet and Chongqing are surveyed in this paper. As Chongqing did not become a municipality directly under the central government until later, its data are incorporated into Sichuan province.

To calculate the value added at constant prices, this paper first worked out the sector-specific manufacturing price index by dividing the provincial-and-sector-specific current-price output by the constant-price output. This way, they were able to work out the sector-specific constant-price index of each year. They then arrived at the value added at constant prices for each year by dividing the provincial-and-sector-specific value added in the current price by the constant-price index of the corresponding year. Finally, by adding up the value added of all sectors, the authors arrived at the provincial-specific value added to manufacturing that they employ in this paper. However, since 2004, the *China Industrial Economy Statistical Yearbook* no longer reports the sector-specific constant-price total output, so the authors made constant-price processing of the value added to corresponding sectors using the provincial-and-sector-specific producer's price index in this paper. Such processing takes the year 1990 as the base period.

Before 1999, the *China Industrial Economy Statistical Yearbook* reported total number of employees; after 1999, it reported "average annual number of employees." Due to this change, there is a discrepancy in the number of manufacturing's employees counted before and after 1999. Even if we use the same standard, the average annual number

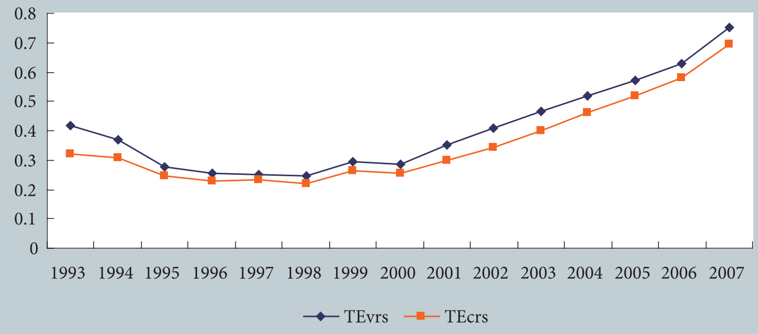


Figure 1: China's manufacturing TE during 1993-2007

of employees in the manufacturing sector declined during 1999-2002. This can be attributed to the following reasons: First, affected by the 1997 Asian Financial Crisis, many SMEs reduced production levels or even went bankrupt, which led to an overall cut in employment; second, as reform of state-owned enterprises came to an end, scores of workers were laid off; third, state statistics caused some errors. The statistics standard of the *China Industrial Economy Statistical Yearbook* was changed from "independent accounting unit" before 1998 to "all state-owned enterprises and non-state-owned industrial enterprises with product sales revenue of over RMB 5 million" after 1998, which affected the statistics scope. However, these factors do not stop us from arriving at a basic diagnosis of the trend of China's manufacturing TE.

As for capital data, existing literatures provide different processing methods. This paper uses the "average annual balance of net fixed assets" as reported in the *China Industrial Economy Statistical*

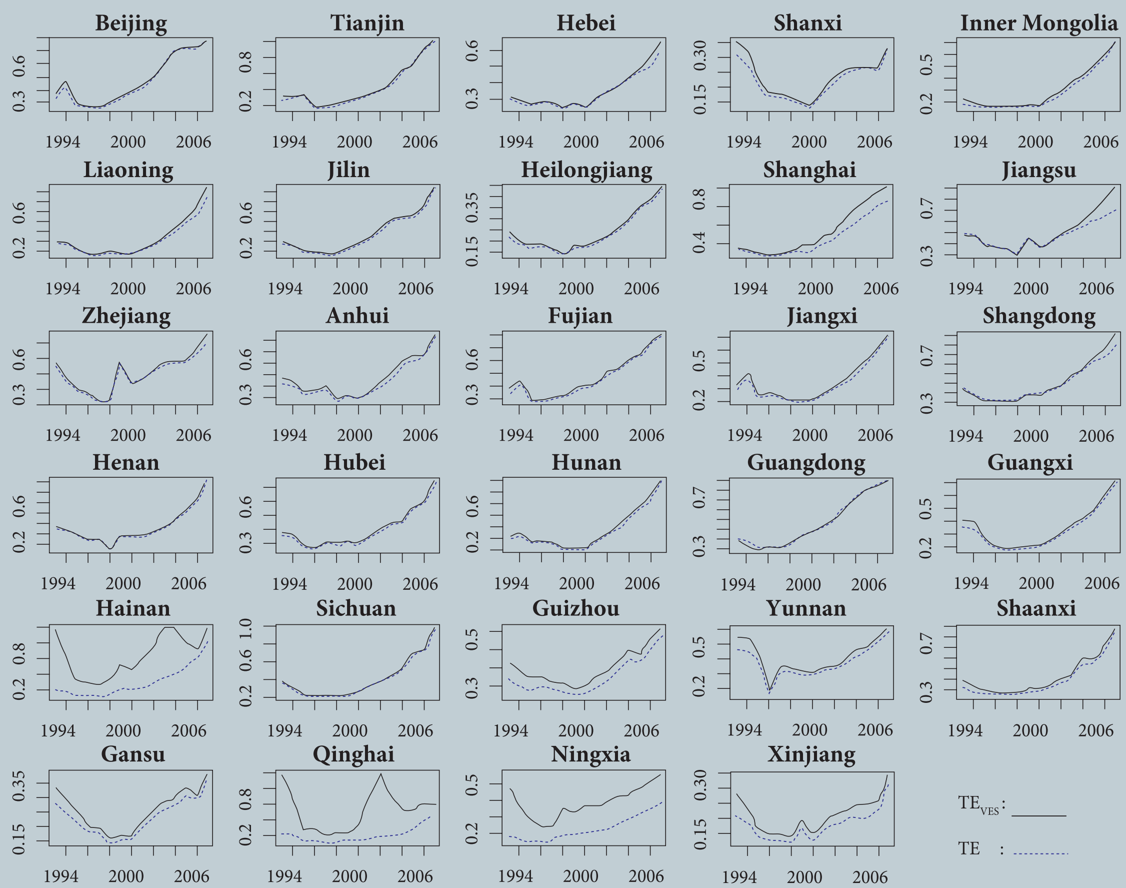


Figure 2: China's manufacturing TE and TE$_{VRS}$ in 29 provinces during 1994-2006

Yearbook or the *China Industrial Statistical Yearbook* to denote capital inputs, and adjust the price using the fixed-asset price index with the year 1990 as the base period.

(II) Calculation result

Using the above processed data, the authors derived 1993-2007 input and output panel data from the manufacturing industries of Chinese provinces after adding up province-and-sector-specific data. They then worked out China's manufacturing TE in all provinces during 1993-2007 by DEA. The average value of TE is shown in Figure 1. As the results show, China's manufacturing TE remained stagnate during 1995-1999, then increased rapidly after 2000.

To reveal regional differences in industrial performance, this paper also reported the manufacturing TE for every province during 1993-2007. As indicated by Figure 2, regional differences in China's manufacturing TE are manifested in several aspects. First, the manufacturing TE is generally smaller or equal to TE_{VRS} in every province. The gap between the two can be explained by the SE. This gap is relatively large in Hainan, Qinghai, Ningxia and Xinjiang, which means that the manufacturing SE is low in these regions. Second, the manufacturing TE takes on a U-shape curve in most provinces. After 2000, the TE_{VRS} shows an obvious upward trend in most provinces. Compared with TE_{VRS}, the manufacturing TE of all provinces fluctuates more. The manufacturing TE and TE_{VRS} in Shanxi, Jilin, Anhui, Guizhou, Shaanxi, Gansu and Qinghai remained stable or slightly declined around 2005, whereas those in other areas saw a steady increase. Third, the manufacturing TE has not evidently increased in some provinces. It is worth mentioning that although the manufacturing TE has seen a slight rise in Shanxi, Heilongjiang, Gansu and Xinjiang in recent years, it is still comparatively lower than in other regions, demonstrating a noticeable regional gap in China's changing manufacturing TE. Some provinces have made use of their TE advantage and enhanced their industrial competitiveness, but others have not. Fourth, the period of 1995-1999 saw a low tide for the manufacturing TE in most provinces. Reasons for this are complicated, including fallout from the Asian Financial Crisis.

III. Model, variables and data

(I) Econometric model

Causes of changes in the manufacturing TE are very complicated. Academia has not yet agreed on underlying factors which account for the overall change in the TE and in regional gaps. On the surface, changes in factor prices are the external cause, but virtually, it is not the case. An internal logical relationship may exist between the two, or, the factor price is the endogenous factor of the manufacturing TE function.

To study whether factor costs affect China's manufacturing TE, this paper makes TE the induced latent variable and the factor price index the independent variable. The econometric model is as follows:

$$TE_{it} = \eta_i + \alpha_k wage_{i,t-k} + \alpha_l input_{i,t-l} + \varepsilon_{it} \quad (1)$$

Where, TE denotes technical efficiency; *wage* refers to employees' average real wage index that denotes the labor cost; *input* refers to the purchasing price index for raw materials, fuels and power. that are used to measure the factor input cost of these elements; η_i and ε_{it} refer to the cross-section individual effect and the error item, respectively.

Based on model (1), this paper will use different estimation methods under specific conditions. First, if a difference in the individual effect is not obvious, we can directly use OLS to make the estimate. This method is also called the Pooled Regression Model (Pooled); second, if there is an obvious difference in the individual effect, then we can use the Fixed Effect Regression Model (FE). This method is more ideal, in that it can yield consistent estimates of parameter values which would otherwise be deviated if we use the first method. Further, if the individual effect is unrelated to the explanation of variables, then the Random Effect Regression Model (RE) will be more helpful. Deciding to choose either FE or RE is generally made with the aid of the Hausman test. Third, if the error item's ε_{it} structure is rather complicated and may involve heteroscedasticity or serial correlation, then we can use the Panel Corrected Standard Error (PCSE). This method can yield robust standard errors and avoid overestimating the significance of variables due to possible existence of heteroscedasticity or lag correlation.

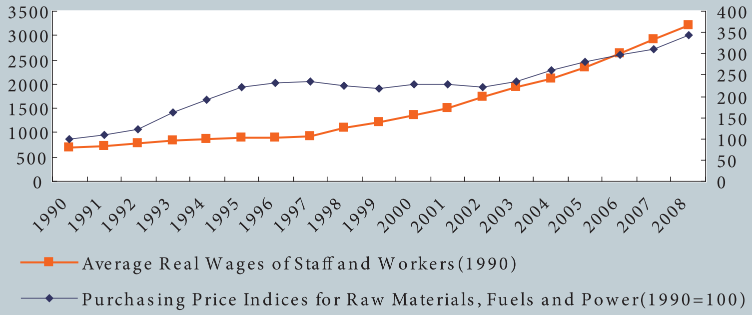
(II) Variable explanation and data source

Due to difficulties in data collection, this paper only explored the impacts that labor cost and the purchasing cost of raw materials, fuel and power have on China's manufacturing TE.[5] According to statistics, the average ruling-price wage of workers employed in China's manufacturing industry has risen rapidly since the reform and opening-up (see Table 1). One point that needs to be clarified is that the State Statistics Bureau and the Ministry of Human Resources and Social Security adjusted the grouping of sectors in 2002. Therefore, data reported after 2002 is based on that adjustment. To more accurately reflect the actual national wage trend of manufacturing employees, the

Table 1: The average wages of workers in China's manufacturing industry at ruling prices during 1985-2008 (RMB/person per year)

Year	1985	1986	1987	1988	1989	1990	1991	1992
Wage of manufacturing workers	1,112	1,275	1,418	1,710	1,900	2,073	2,289	2,635
Year	1993	1994	1995	1996	1997	1998	1999	2000
Wage of manufacturing workers	3,348	4,283	5,169	5,642	5,933	7,064	7,794	8,750
Year	2001	2002	2003	2004	2005	2006	2007	2008
Wage of manufacturing workers	9,774	11,001	12,496	14,033	15,757	17,966	20,884	24,192

Data Source: China Labour Statistical Yearbook



Note:
(1) The left ordinate axis refers to average real wages of manufacturing workers in *yuan*.
(2) The right ordinate axis refers to the purchasing price index for raw materials, fuels and power.
Data source: Compiled based on the *China Labour Statistical Yearbook* and *China Compendium of Statistics* of all years

Figure 3: Average real wages of manufacturing workers and the purchasing price index for raw materials, fuels and power

authors worked out an urban CPI-based constant-price average wage (see Figure 3). From Figure 3, we see the average real wages of workers employed in China's manufacturing industry grew quite slowly for seven to eight consecutive years starting from the early 1990s until it begun to rise more quickly in 1997, showing signs of the Lewis Turning-Point. This may be closely related to China's rapid industrialization. According to Figure 1 and Figure 3, the average real wages of workers employed in China's manufacturing industry began to rise quickly after 1997, but the manufacturing TE did not see any sharp increases until after 2000. This indicates that rises in the former and the later are not synchronous. An increase in the TE lags behind an increase in employees' wages.

To make a more direct comparison of variables, Figure 3 also describes the trend of China's purchasing price index for raw materials, fuels and power since 1990. In the early 1990s, the index doubled within a short period of three to four years, but remained relatively stable during 1996-2003 and rose again after 2003. According to the statistics, in 2007, the purchasing price index for raw materials, fuels and power had risen by around 250 percent versus 1990, a time span of less than two decades.

The authors worked out the manufacturing TE of 29 provinces during 1993-2007 by DEA, and collected the average real wage index for workers and the purchasing price index for raw materials, fuels and power from the China Compendium of Statistics, thereby constructing the 29×15(N×T) panel data model. These two indices take the year 1990 as the base period, i.e., evaluation of the price indices is 1 in 1990.[6] The authors directly used the comparable average real wage indices for workers, because they are adjusted after inflation and can better reflect how workers' real wages relate to shifts in supply and demand in the labor market.[7] Table 2 lists the arithmetic mean of both indices in all regions during 1990-1995. From Table 2 we see the average real wage index for workers after accounting for price factors in all regions in 2007 was 5.49 times that of 1990; the purchasing cost index for raw materials, fuels and power rose 3.31-fold versus 1990. By comparing Table 2 with Figure 3, we can find that the average real wages of manufacturing workers have risen less quickly than those of workers in other sectors in the regions.

IV. Results analysis

Based on the above econometric model, we took the TE calculated by CRS-DEA and VRS-DEA separately as the explained variable and the factor price as the explaining variable. The econometric results are shown in Table 3. As stated above, there is a response lag between China's manufacturing TE and factor price rises. Models A and B mainly determine the lag phase of the explaining variable "wage" and "input," respectively. Based on the "step-by-step" principle for explaining dependent variables, we finally break the lag phase into three

Table 2: Arithmetic mean of the factor cost index in all regions during 1990-2007

Year	1990	1991	1992	1993	1994	1995
Average real wage index of workers (1990=1)	1.00	1.04	1.09	1.21	1.37	1.45
Purchasing price index for raw materials, fuels and power (1990=1)	1.00	1.12	1.21	1.65	1.95	2.23
Year	1996	1997	1998	1999	2000	2001
Average real wage index of workers (1990=1)	1.54	1.61	1.78	2.00	2.24	2.59
Purchasing price index for raw materials, fuels and power (1990=1)	2.35	2.38	2.29	2.22	2.33	2.34
Year	2002	2003	2004	2005	2006	2007
Average real wage index of workers (1990=1)	2.98	3.31	3.68	4.18	4.76	5.49
Purchasing price index for raw materials, fuels and power (1990=1)	2.29	2.43	2.75	2.96	3.14	3.31

Data source: China Compendium of Statistics

steps or a set of 3 and 5 steps as explaining variables of "wage," and 4 steps for "input." It indicates that the manufacturing TE lags behind factor price rises for three to five years.

Model C (14)-(15) includes the best lag phase of "wage" and "input" worked out by Models A and B. Compared with Models (7) and (8), the fitting R_2 of Model (14) is not better, but compared with the model that only introduces the Step 3 lag of "wage" or the Step 4 lag of "input," the adjusted R_2 is obviously better, and the coefficient is basically consistent with those above. Based on Model (14), we introduced the Step 5 lag of "wage" to estimate Model (15), where an adjusted R_2 is further increased. The adjusted R_2 of both models increases from 0.52 and 0.43 to 0.58 and 0.46, respectively, and the introduced lags of both "wage" and "input" are significant.

Although we attempt to find whether factor price rises will affect the TE of manufacturers, the econometric results are simply a statistical verification of the relationship between the two, which does not explain the real causal logic in a comprehensive way. The TE of manufacturers is not entirely determined by factor inputs. Other factors such as the regional industrial structure, foreign trade and industrial agglomeration can also affect the TE of local manufacturers. If key explaining variables are missed, parameters estimated by OLS become biased estimates. Therefore, this paper adopts FE to come up with consistent estimates of parameter values when some explaining variables are missing, i.e., denoting local characteristics that affect the TE of manufacturers by the individual effect. Part D uses the estimate results gained by FE, which is a re-estimate of the model in part C. Compared with Models (14)-(17), the "wage" coefficient estimated by FE is lower, which shows that the estimate by OLS has an upward bias and the "input" coefficient has a downward bias. The Hausman test result does not support further estimates by the Random Effect Regression Model. As the TE estimated by DEA is merely a comparison of different entities, the TE value of a single entity will be of no practical significance when there is no reference. Therefore, this paper does not provide a detailed explanation of specific parameter values.

Part E is the estimate gained by PCSE, which is mainly designed to get robust estimation errors and to determine the significance of the coefficient more rationally. When error items go against the assumption of independent and identical distribution, OLS will often underestimate the standard error of the coefficient and therefore amplify the coefficient significance. It will make otherwise insignificant variables become significant. PCSE can consider heteroscedasticity or serial correlation that may be involved in error items, and therefore can arrive at robust estimates of standard errors. From the results, we can find the coefficient significance test t-value for the estimates calculated from PCSE in part E is much smaller than that in part C, proving the existence of heteroscedasticity or serial correlation among error items. But the coefficient estimated by PCSE passes at least the 10 percent significance level, which explains that factor price has an evident impact on the TE of manufacturing.

To measure the impact factor price rises have on the TE of manufacturing based on the estimation results in Table 3, the authors took the TE and TE_{VRS} calculated by CRS-DEA and VRS-DEA separately as the explained variable and conducted robustness tests on the estimated coefficient and standard errors. The results show that factor price rises have a positive effect on China's manufacturing TE. Such effect tends to peak three to five years

Table 3: Estimation results of factor prices and China's manufacturing TE

Method of estimation (Model No.)	Explained variable / Explaining variable	TE (CRS-DEA)			TE_{VRS} (VRS-DEA)			
		Coefficient	t value	R^2	Coefficient	t value	R^2	Sample size
A: The Pooled Regression Model (Pooled) that only considers the labor cost								
Pooled (1)	L1.wage	0.0543***	8.79	0.30	0.0572***	8.36	0.27	420
Pooled (2)	L2.wage	0.0575***	11.00	0.31	0.0552***	9.37	0.23	405
Pooled (3)	L3.wage	0.0685***	15.34	0.44	0.0668***	13.49	0.34	390
Pooled (4)	L4.wage	0.0595***	12.24	0.33	0.0562***	10.71	0.24	375
Pooled (5)	L5.wage	0.0651***	17.30	0.41	0.0627***	15.00	0.30	360
Pooled (6)	L6.wage	0.0521***	9.88	0.27	0.0464***	8.30	0.17	345
Pooled (7)	L3.wage	0.0470***	11.54	0.56	0.0484***	9.42	0.43	360
	L5.wage	0.0380***	10.66		0.0367***	8.66		
Pooled (8)	L1.wage	0.0094	1.61	0.56	0.0150**	2.04	0.44	360
	L3.wage	0.0444***	9.71		0.0443***	7.52		
	L5.wage	0.0354***	7.91		0.0294***	5.93		
B: The Pooled Regression Model (Pooled) that only considers the cost of raw materials, fuels and power								
Pooled (9)	L1.input	0.1629***	7.77	0.19	0.1807***	8.49	0.19	420
Pooled (10)	L2.input	0.1598***	8.14	0.19	0.1649***	7.88	0.16	405
Pooled (11)	L3.input	0.1767***	8.36	0.22	0.1983***	7.95	0.22	390
Pooled (12)	L4.input	0.2038***	11.38	0.27	0.2186***	10.7	0.25	375
Pooled (13)	L3.input	0.05377	1.57	0.28	0.0777**	2.05	0.26	375
	L4.input	0.1598***	5.18		0.1548***	4.92		
C: The Pooled Regression Model (Pooled) that considers the labor cost and the cost of raw materials, fuels and power								
Pooled (14)	L3.wage	0.0576***	14.37	0.52	0.0550***	12.16	0.43	375
	L4.input	0.1060***	5.89		0.1251***	6.03		
Pooled (15)	L3.wage	0.0414***	11.97	0.58	0.0411***	9.58	0.46	360
	L5.wage	0.0352***	10.18		0.0305***	8.40		
	L4.input	0.0707***	3.65		0.0920***	4.33		
D: Estimates from the Fixed Effect Regression Model (FE) that considers the labor cost and the cost of raw materials, fuels and power								
FE(16)	L3.wage	0.0353***	7.16	0.51	0.0353***	6.21	0.42	375
	L4.input	0.1184	1.61		0.1184***	4.9		
FE(17)	L3.wage	0.0392***	8.01	0.58	0.0382***	7.44	0.45	360
	L5.wage	0.0337***	5.43		0.0290***	5.35		
	L4.input	0.1127***	3.53		0.1782***	5.85		
E: Estimates from the Panel Corrected Standard Error (PCSE) that considers the labor cost and the cost of raw materials, fuels and power								
PCSE(18)	L3.wage	0.0576***	5.07	0.52	0.0551***	4.68	0.43	375
	L4.input	0.1060***	2.85		0.1251***	3.12		
PCSE(19)	L3.wage	0.0414***	3.43	0.58	0.0411***	3.14	0.46	360
	L5.wage	0.0351***	3.00		0.0305**	2.39		
	L4.input	0.0707*	1.92		0.0920**	2.19		

Note: ***,** and * denote a significance level of 1%, 5% and 10%, respectively; (1)-(19) denote the model No.; Estimated standard errors of model (1)-(17) have allowed for heteroscedasticity; models (16) and (17) have controlled the individual effect of regions; models (18) and (19) adopt the PCSE to deal with complicated panel error structures such as serial correlation and heteroscedasticity.

later. The existence of a cost-push TE is statistically verified.

V. Conclusion and insights

Is there a cost-push TE in China's manufacturing sectors? This is the core issue that is addressed in this paper. Using 1993-2007 panel data of Chinese provinces' manufacturing industries, the paper calculated the TE and TE_{VRS} by DEA. The results show that China's manufacturing TE remained stagnate during 1995-2000 and then saw an obvious increase after 2000, especially after 2006. The manufacturing TE has mostly taken on an upward trend in all provinces in recent years.

Since the early 1990s, the prices

of major input factors in China's manufacturing sectors (labor cost, raw materials and fuels, etc.) have generally gone up, although there are differences in the rising rate and time span across different regions. However, factor price rises are out of step with the trend of the manufacturing TE; there is a response lag between the two.

According to the econometric analysis results, factor price rises promote China's manufacturing TE and TE_{VRS}, with the promotional effect reaching its peak three to five years later. In other words, factor price rises have a positive effect on the manufacturing TE, which validates the assumption of a cost-push TE.

Conclusions of this paper have rich policy implications, providing some useful insights on the state's current efforts to adjust the structure and promote upgrading:

1. We should look at rising factor prices in China's manufacturing sectors since the 1990s objectively. China's rapid industrialization and urbanization have certainly generated huge demands on factor resources. Besides, the government has unveiled a series of specific measures to promote factor flow and to promote reform of the factor price system, which has made prices reflect the scarcity of factor resources via the market mechanism. Guided by price signals, enterprises are able to keep up their market competitiveness by technical and management innovation, thus improving the industry's overall TE. Therefore, the government should restrain from pursuing any acts that may distort the factor price system, and should forgo protecting low-efficiency enterprises.

2. We should clearly recognize that factor price rises have become an endogenous factor to promote China's manufacturing TE. Since 2000, factor price rises have been, to a large extent, a result of the supply and demand mechanism. Although the signals of factor prices affect an enterprise's operation decisions, enterprises still need some time to strategize the renovation of equipment, introduction of new technologies, increase investment in R&D, etc. Naturally, this leads to a response lag in between. While formulating industrial policies, the government can focus on short-term polices aimed at the micro incentive mechanism that orientates enterprises towards the optimal allocation of factor resources, thereby improving the factor-allocating efficiency. Mid- and long-term policies and programs should highlight the technical innovations and industrial upgrading of enterprises, which would let innovation push economic growth and catalyze the transformation of the economic development pattern.

3. We should formulate and implement policies that orientate local industries towards transformation and upgrading. There are regional discrepancies in terms of how the manufacturing TE is influenced by factor price rises. Such discrepancies may be caused by local factor endowments, the industrial structure and historical factors, etc. In this sense, we should adopt measures that fit in with the local factor endowment structure. For central and western regions that are rich in factor resource endowments, policies should focus on first improving the factor resource-allocating efficiency, and then on technical upgrading five to ten years later. For eastern regions where the comparative advantage of labor resources is non-existent, the top priority should be to speed up industrial upgrading and eliminate outdated production capacities.

4. We should promote reform of the factor price system to fuel the transformation of the economic development pattern. Previous studies prove that China's factor prices are distorted due to forceful governmental intervention. This makes it hard to transform China's economic growth pattern. This paper adds further evidence. But we should note that even if guided by the market mechanism, it will still take some time for factor prices to become an element in enterprises' technical innovation. The current string of factor price rises is basically an initial response to the reform of the factor price system. It should become the impetus in promoting the transformation of the economic growth pattern.

Although our conclusions provide some insights for local governments' industrial policies, governments still face a dilemma: On one hand, if factor prices become fully liberalized, a multitude of SMEs will go bankrupt because they will not be able to afford sudden factor price rises, a situation all levels of government are reluctant to see; on the other hand, if we do not liberalize it, all polices and planning aimed at transforming the economic growth pattern will be less enforceable. To break this dilemma, we should set a proper pace for the reform of the factor price system and enhance industrial upgrading-related policies.

As to whether rising factor prices promote China's manufacturing TE, we made some initial researches in this paper, but these need to be studied further so that we can establish an index that can fully reflect changes in factor prices, to calculate the TFP of China's manufacturing sectors using other methods and to further study how factor price rises affect China's manufacturing sectors under different ownership structures. CE

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Note:

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1 Scholars have made special studies on defining "productivity" and "production efficiency." Zhang Jun, Shi Shaohua and Chen Shiyi (2003) believe that "productivity" refers to the ratio of output to input; It includes both single-factor productivity and total factor productivity. For traditional economic indicators, "productivity" refers to "single-factor productivity" only, such as the labor productivity and fund ratio of production, etc; And TFP refers to the ratio of total output to total factor input. The total factor input here is a weighted average of all inputted factors. Some researchers use it to measure the productivity and its trend. As for "production efficiency," Wei Chu and Shen Manhong (2007) believe it is a measurement of the production status where the output is maximized with certain inputs, including the TE and scale efficiency, etc.

2 As Zhang Jun, Shi Shaohua and Chen Shiyi's (2003) paper has made a comprehensive and thorough roundup of China's industrial performance, this paper simply provides an overview of literatures after their paper.

3 Though mining and quarrying is also included in the industry, factor price rise affects manufacturing the most; And provinces' data of mining and quarrying are missed in some years, so this paper only deals with manufacturing. Unless otherwise mentioned, the industry stated below refers to manufacturing.

4 The DEA-estimated efficiency is called the TE, or "pure" TE and the scale efficiency (SE) in Timothy J.Coelli's *et al.* (2004) literature. The former is equal to the arithmetic product of the latter two. Referring to this literature, the authors adopt DEA to calculate China's manufacturing TE in this paper.

5 There is a need to differentiate "capital" from "fund" when we consider the capital cost. Fund refers to liquid assets including cash, short-term bonds, etc.; Capital refers to funds that are exclusively used for investment. It can be physical or nonobjective and hence, is a broader concept than "fund". What we label as the corporate loan interest rate is the fund cost which is only a part of the capital cost. This paper does not include the capital cost due to limited data availability. Also, as the interest rate is basically the same in all regions, the loan cost across the country tends to be the same.

6 The average real wage index for workers = (Workers' average wage index during the report period / Urban CPI during the report period) × 100%. Workers' average wage index = Workers' average wage during the report period / Workers' average wage during the base period.

7 The average real wage index for workers in all regions reflects the wages of workers in all regions. In effect, manufacturing enterprises' response to the labor cost depends more on the wage level of all workers, but not merely that of manufacturing workers. When wages rise in other sectors, manufacturers face the pressure of potential wages rise as well. Therefore, this index is a proper way of measuring the labor cost.