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# THE EFFECT OF VAT ON PRODUCTIVITY IN CHINA-BASED ON THE SFA MODEL TEST

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## Abstract

This paper adopts trans-log production function based on the SFA model, empirically test how the change of the proportion of the value added tax impacts on each part of China's productivity. The results show that, in tax structure, if the proportion of the value added tax is higher, the more conducive to the improvement of production efficiency. But it is not good for the technical efficiency and scale efficiency. This means the effects of value added tax on productivity is complex in China. We suggest, in the design of the VAT system, we should pay more attention to its influence on productivity. For example, implement value added tax subsidy for technology research and development (R&D). Focus on the adjustment effect of value added tax on the specialized division of labor.

*Keywords*: the proportion of the value added tax, production efficiency, technical efficiency, scale efficiency.

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## 1. Introduction

The rapid growth of China's economy over the past thirty years is the comprehensive reflection of the improving resource liberation and efficiency. In addition to the disintegration of the planned economy and the reform and opening up policy, technology progress, the improvement of enterprise management, specialization in production, the transformation of government functions etc., these are all contributed to China's productivity improvement.

In the numerous factors influencing productivity, tax, as the most important part of the economic system, its influence can not be ignored. The reform of the tax system in 1994 established the basic framework of the current tax system. In the framework of the existing tax system, the effect of VAT on China's economy has been the major concern constantly. One important reason is that, value added tax is the major tax in China's tax system, in 2012, the domestic value added tax accounted for 26.2% of tax revenues. With the reform pilot and formal implementation of the "business tax change into value added tax", the importance of value added tax is more and more outstanding in China.

Value added tax is based on the added value in production and circulation. The legal nominal tax rate is 17%, and 13% is the low tax rate in China. At the same time, the value added tax is a tax shared by the central government and local government, the sharing ratio is 75% : 25%, respectively. The value added tax has been undergoing rapid development internationally. Fifty years ago, value added tax is rarely mentioned except in France and some professional literature. By the year 2000, nearly 120 countries adopted the value added tax in the world. Today's popular for value added tax is due to the VAT can optimize the efficiency of tax structure, and it also can reduce the marginal cost of government financing (Keen and Lockwood [1]). Even American experts worry the convenience of value added tax financing and consequently become "the printing presses" for the government (President's Advisory Panel [2]).

How this popular tax impacts China's productivity is this paper's main concern. The existing domestic research has not distinguished the composition of productivity, and most of the research is just simply narrative, or just a simple list of data, the lack of empirical econometric analysis is a weak point of these studies. We will from the provincial level specially probe into how the change of the proportion of the value added tax impacts on each part of China's productivity based on the SFA model. We will distinguish productivity based on the study of Kumbhakar and Lovell, then observe how the change of the proportion of the value added tax impacts on each part of China's productivity. On August 1, 2013, the "expanding scope" for VAT is formally introduced in China, the reform of "business tax change into value added tax" has been one of the most important components in China's taxation system in recent years. Therefore, this article's research has certain practical significance.

## 2. Literature Review

Value added tax is only a tax on final consumption. So as long as the design is appropriate, VAT is a particularly efficient tax. From the respect that producers and the users in the production process face the same prices, value added tax is in accordance with the neutral tax, can avoid the low efficiency of some other indirect tax. The enterprise will not castigate the output decision due to the change of VAT tax. This implicates the value-added tax is a powerful method to promote economic growth. Taxing on intermediate transactions, business tax will lead to the loss of the production efficiency. Sales tax also inevitably leads to loss of productivity due to the difficulty in distinguishing the final sales (Ring [3]). So in practice, value added tax is often used to replace the business tax and the single stage sales tax.

But some scholars believe that, value added tax in simplicity and universality has the potential advantages compared with the turnover tax, but the comparative advantage is not dramatically remarkable in economic efficiency to the thought of ordinary person. In some countries, particularly developing countries, value added tax is the core content of the modern tax management system with it simplify the tax management, improve tax compliance. But, value added tax has some potential disadvantages and is not conducive to efficiency. When the transaction chain once broken, value added tax will lead to the loss of the production efficiency. In addition, because tax system is not perfect, and the statutory tax rebate is too high, these means the value-added tax will not help the export and trade, hence reduce exports and domestic output (Desai-Hines [4]). Meanwhile, value added tax will have a negative impact on informal sector of the economy (Piggott and Whalley [5]; Emran and Stiglitz [6]; and Keen [7]).

Therefore, based on the not clear performance of value added tax, whether value added tax is conducive to the improvement of the efficiency is only one empirical study, how to explore the efficiency gain or efficiency loss is a problem in the experience (Keen and Lockwood [1]).

The existing domestic research has not distinguish the composition of productivity, and many research is just simply narrative, or just a simple list of data, the lack of empirical econometric analysis is a weak point of these studies. We will from the provincial level specially probe into how the change of the proportion of the value added tax impacts on each part of China's productivity based on the SFA model.

## 3. The Model Specification

### 3.1. The decomposition of total factor productivity

Solow (1957) formally proposed the aggregate production function with constant returns to scale and growth equation, and thus decompose the concept of total factor productivity: It is an important index to measure the productivity. For a long time, the neoclassical economic growth theory saw the growth rate of total factor productivity as the technology progress. Many studies do not distinguish the total factor productivity, in fact, total factor productivity can be decomposed into production efficiency, technical progress, scale efficiency, and resource production efficiency (Kumbhakar and Lovell [8]). Kumbhakar and Lovell [8] obtained the decomposition formula of the growth rate of total factor productivity

$$TFP_{it} = TE_{it} + TP_{it} + (E-1)\sum_{j} \frac{E_j}{E} x_j, \quad j = 1, 2. \tag{1}$$

Here, $TFP_{it}$ represents the change rate of total factor productivity, $TE_{it}$ denotes the change rate of production efficiency, $TP_{it}$ is the rate of technological advance, $E_j (j = 1, 2)$ presents the output elasticity of capital and labor, respectively, $E$ indicates the scale elasticity, and $x_j$ is the change rate of inputs factor $j$.

### 3.2. The trans-log production function

With the selection of different production function, the estimation of total factor productivity will exist certain differences, this paper adopts trans-log production function form. This function has the following advantages:

(1) Allow substitution elasticity variable among inputs factor.

(2) Allow the existence of the non neutral technological advances, and technological progress can be decomposed into a common item and a particular item changing in different regions and time.

(3) The TFP can be decomposed into technical progress item, production efficiency item, and scale efficiency item conveniently. Taking into account the capital and labor as the main input factors of production and technical progress, we put the concrete form of the trans-log production function is

$$\begin{aligned} \ln Y_{it} &= \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 t + \beta_4 \frac{\ln^2 K_{it}}{2} + \beta_5 \frac{\ln^2 L_{it}}{2} \\ &\quad + \beta_6 \frac{t^2}{2} + \beta_7 \ln K_{it} \ln L_{it} + \beta_8 t \ln K_{it} + \beta_9 t \ln L_{it} + \varepsilon_{it}. \end{aligned} \tag{2}$$

Here, $Y_{it}, K_{it}, L_{it}$ represents real output, real capital, and labor for province $i$ in time $t$, respectively. $t$ is the time trend, denotes technology progress.

Based on the type of trans-log production function, then we can define capital output elasticity, labor output elasticity, and scale elasticity for province $i$ in time $t$. In addition, we can also define technology progress rate as follows:

$$E_{Kit} = \frac{\partial \ln Y_{it}}{\partial \ln K_{it}} = \beta_1 + \beta_4 \ln K_{it} + \beta_7 \ln L_{it} + \beta_8 t, \tag{3}$$

$$E_{Lit} = \frac{\partial \ln Y_{it}}{\partial \ln L_{it}} = \beta_2 + \beta_5 \ln L_{it} + \beta_7 \ln K_{it} + \beta_9 t, \tag{4}$$

$$E_{it} = E_{Kit} + E_{Lit}, \tag{5}$$

$$TP_{it} = \frac{\partial \ln Y_{it}}{\partial \ln t} = \beta_3 + \beta_6 \ln t + \beta_8 \ln K_{it} + \beta_9 \ln L_{it}. \tag{6}$$

In the expressions above, $E_{Kit}, E_{Lit}, E_{it}$, and $TP_{it}$ denotes capital output elasticity, labor output elasticity, scale elasticity, and technology progress rate, respectively, for province $i$ in time $t$.

### 3.3. The stochastic frontier analysis

This paper adopts the stochastic frontier analysis (SFA) developed by Battese and Coelli [9]. The basic idea for SFA is assuming the input factor $X_{it}$ can produce $Y_{it}$ in the most effective cases, then the relationship between input and output $Y_{it} = f(X_{it}, \beta)$ can represents the production possibilities frontier. The distance between sample points and random boundary is efficiency loss. As a part of random errors, the efficiency loss is taken into account in the model. Formally, SFA can be expressed as follows:

$$Y_{it} = X_{it}\beta + \omega_{it} - \nu_{it}, \quad i = 1, 2, \cdots, N; \quad t = 1, 2, \cdots, T. \tag{7}$$

Here, $\beta$ is the parameter to be estimated, $Y_{it}$ is the actual output, correspondingly in this paper, is the logarithm of real output for province

$i$ in time $t$; $X_{it}$ is the input factor, it refers to the actual capital stock, labor force, time trend and the logarithm of its quadratic term and cross term correspondingly. $\omega_{it}$ is the random error term, follows a standardized normal distribution $N(0, \sigma_w^2)$, independent to $\nu_{it}$; $\nu_{it}$, the inefficiency item for province $i$ in time $t$, and the distribution of $\nu_{it}$ could have four kinds in different situations: half normal distribution, truncated normal distribution, exponential distribution, and gamma distribution. In this paper, we assume $\nu_{it}$ obeys the half normal distribution $N(\mu_{it}, \sigma_\nu^2)$, and is a nonnegative random variable. According to Battese and Coelli [9], $\nu_{it}$ can be expressed further as

$$\nu_{it} = Z_{it}\gamma + \varepsilon_{it}. \tag{8}$$

Here, $\gamma$ is the parameter to be estimated, $Z_{it}$ is each factor that affects the inefficiency item, independent of the production process. This paper introduces the following variables as the factors that affect the inefficiency item: The proportion of state owned industrial output value accounted for the total industrial output value, the proportion of fiscal expenditure accounted for GDP, the proportion of exports accounted for GDP, the initial human capital, the initial physical capital, the ratio of value added tax accounted for tax revenue, the regional dummy variables; $\varepsilon_{it}$ obeys the normal distribution $N(0, \sigma_\varepsilon^2)$. The technical efficiency term can be defined as

$$TE_{it} = \exp\{-\nu_{it}\} = \exp\{-Z_{it}\gamma - \varepsilon_{it}\}. \tag{9}$$

In this paper, the technical efficiency is defined as the production efficiency.

### 3.4. Estimation method

For the estimation of production function and the inefficiency production function, early researchers used two step estimation method. Firstly, estimate the production function and then calculate the inefficiency term. Finally, estimate the production inefficiency equation.

Because SFA contains a composite error, the least square method is no longer applicable. Battese and Coelli [9] recommended the use of maximum likelihood estimation. For the production inefficiency equation, the truncated regression is appropriate due to the inefficiency term is non-negative. There are some defects in the measurement as to the two step estimation method, so later one step estimation method was developed to compensate for the method of two step estimation. The one step estimation method adopts maximum likelihood estimation or nonlinear least squares estimation. In order to compare the robustness of models, two methods were both used to estimate in this paper at the same time.

In addition, we follow the panel data model to predict technical progress equation and scale efficiency equation.

## 4. Data Specification

We used the data mainly from the Chinese statistical yearbook, provincial statistical yearbook, “Compilation of statistical data in recent sixty years of China”, the network database etc.. We adopted the panel data of provinces, and the section is not included Tibet and Hainan, Chongqing and Sichuan provinces were combined, including 28 provinces, municipalities and autonomous regions. The initial time is 1994 in which year the reform of localized fiscal tax system was started, and the ending year is 2011, consisting 18 years of data.

The main variables and interpretation:

*The real GDP* $(Y_{it})$. We computed the GDP based on the year 1978 according to the index of GDP and the nominal GDP.

*The actual capital stock* $(K_{it})$. We calculated the actual capital stock according to the perpetual inventory method. Key variables of perpetual inventory method include: The initial phase of capital stock, gross capital formation, price indices of fixed assets investment, and depreciation rate.

According to China's economic growth data, we can obtain the data of actual capital stock in 1994-1999 years. For the data of other years, we calculated them based on the data we obtained. We suppose the depreciation rate is 10%, and the actual capital stock in 1978 see as the base period.

*The labor force* $(L_{it})$. There are several statistical caliber for the labor force, we statistic labor data according to the number of employees, divided by the three industrial division.

*The proportion of the value added tax* $(VAT_{it})$. We measure the index by the ratio of domestic value added tax accounted for tax revenues in each province. The proportion of the value added tax value implicit the degree of importance for value added tax in tax structure.

*The efficiency index.* In this paper, we decompose total factor productivity into production efficiency $(TE_{it})$, technology progress efficiency $(TP_{it})$, and scale efficiency $(SE_{it})$. The production efficiency $(TE_{it})$ is computed by the SFA model, while technology progress efficiency $(TP_{it})$ and scale efficiency $(SE_{it})$ are calculated by the formula applied by (Kumbhakar and Lovell [8]).

*The control variables*. The control variables we selected are including: The level of the market $(market_{it})$, which is denoted by the proportion of the total state owned industrial value accounted for total industrial output value. The degree of government intervention $(government_{it})$ is measured by the proportion of fiscal expenditure accounted for GDP. The degree of openness is viewed by the proportion of exports accounted for GDP. The initial stage of the human capital stock $(hc_{it})$ is measured by the population ratio that the persons educated exceed primary school in 1982. Physical capital stock $(mc_{it})$ is measured by the actual capital stock in 1978. And area dummy variables were constructed.

The statistical characteristics of the variables are shown in Table 1.

**Table 1.** Variables and their statistical characteristics

| Variables | Obs. | Mea. | Sta. | Min | Max |
|---|---|---|---|---|---|
| Real GDP [billion yuan] | 504 | 691.2 | 575.7 | 35.83 | 3385 |
| The actual capital [billion yuan] | 504 | 3862 | 4625 | 120.1 | 35000 |
| Labor force [million] | 504 | 2474 | 1664 | 232.7 | 6486 |
| The proportion of VAT | 504 | 0.216 | 0.0510 | 0.0830 | 0.396 |
| Marketization | 504 | 0.525 | 0.208 | 0.107 | 0.899 |
| Government intervention | 504 | 0.150 | 0.0720 | 0.0490 | 0.579 |
| Open degree | 504 | 0.164 | 0.195 | 0.0150 | 0.937 |
| The initial human capital | 504 | 0.605 | 0.0960 | 0.427 | 0.778 |
| The initial capital [billion yuan] | 504 | 146.7 | 74.98 | 37.44 | 370.6 |

## 5. Empirical Test for the Effect of the Proportion of the Value Added Tax on Productivity

According to the above, to test the effect of the VAT on productivity efficiency, we construct the following four econometric models. Combining the trans-log production function and SFA model, we construct an empirical model for production function and the production inefficiency equation as follows:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 t + \beta_4 \frac{\ln^2 K_{it}}{2} + \beta_5 \frac{\ln^2 L_{it}}{2} + \beta_6 \frac{t^2}{2} + \beta_7 \ln K_{it} \ln L_{it} + \beta_8 t \ln K_{it} + \beta_9 t \ln L_{it} + \omega_{it} - \nu_{it}, \quad (10)$$

$$\nu_{it} = \gamma_0 + \gamma_1 \ln vat_{it} + \gamma_2 market_{it} + \gamma_3 government_{it} + \gamma_4 openness_{it} + \gamma_5 hc_{it} + \gamma_6 mc_{it} + \gamma_7 east_{it} + \gamma_8 west_{it} + \varepsilon_{it}. \quad (11)$$

The technical efficiency equation is

$$TP_{it} = \alpha_0 + \alpha_1 \ln vat_{it} + \alpha_2 market_{it} + \alpha_3 government_{it} + \alpha_4 openness_{it} + \alpha_5 hc_{it} + \alpha_6 mc_{it} + \alpha_7 east_{it} + \alpha_8 west_{it} + u_{it} + \xi_{it}. \tag{12}$$

The scale efficiency equation is

$$SE_{it} = \alpha_0 + \alpha_1 \ln vat_{it} + \alpha_2 market_{it} + \alpha_3 government_{it} + \alpha_4 openness_{it} + \alpha_5 hc_{it} + \alpha_6 mc_{it} + \alpha_7 east_{it} + \alpha_8 west_{it} + w_{it} + \xi_{it}. \tag{13}$$

The trans-log production function was estimated by using the two step method and one step method. Manufacturing efficiency value, technology change value, and scale efficiency change value can be estimated based on the analysis above. And then estimate the efficiency equations. The estimation results are showed in Table 2.

**Table 2.** Estimation of the production function and efficiency equation

| | The trans-log production function estimation | | The production (in) efficiency equation estimation | |
|---|---|---|---|---|
| | Two step method | One step method | Two step method | One step method |
| ln$K$ | $2.973^{***}$ (0.310) | $2.430^{***}$ (– 0.453) | | |
| ln$L$ | $-1.854^{***}$ (0.269) | $-1.294^{***}$ (0.419) | | |
| $t$ | $-0.384^{***}$ (0.467) | $-0.342^{***}$ (– 0.068) | | |
| $(\ln K)^2$ | $-0.285^{***}$ (– 0.069) | $-0.172^{*}$ (– 0.088) | | |
| $(\ln L)^2$ | $0.383^{***}$ (0.047) | $0.351^{***}$ (– 0.066) | | |
| $t^2$ | 0.001 (0.002) | 0.003 (0.003) | | |
| ln$K$ln$L$ | $-0.092^{**}$ (0.038) | $-0.134^{***}$ (0.041) | | |
| $t$ln$K$ | $0.040^{***}$ (0.010) | $0.028^{**}$ (0.013) | | |
| $t$ln$L$ | $0.012^{*}$ (0.006) | $0.017^{***}$ (0.006) | | |
| lnvat | | | $0.001^{***}$ (0.000) | $-3.200^{**}$ (1.451) |
| Market | | | $0.002^{***}$ (0.000) | – 1.891 (1.983) |
| Government | | | $0.005^{***}$ (0.001) | – 7.293 (6.085) |
| Openness | | | $0.001^{**}$ (0.000) | – 3.053 (3.671) |
| hc | | | $0.005^{***}$ (0.001) | $-13.229^{***}$ (3.641) |
| mc | | | $0.000^{***}$ (0.000) | – 0.005 (0.005) |
| East | | | 0.000 (0.000) | – 1.149 (1.366) |
| West | | | $-0.001^{***}$ (0.000) | 0.853 (0.716) |
| Maximum likelihood | – 105.768 | – 81.388 | – 105.768 | – 81.388 |
| Observed value | 504 | 504 | 504 | 504 |
| Section num. | 28 | 28 | 28 | 28 |
| Hausman statistics | | | | |
| Panel model | | | | |

**Table 2.** (Continued)

| | Technical efficiency equation estimation | | Scale efficiency equation estimation | |
|---|---|---|---|---|
| | Two step method | One step method | Two step method | One step method |
| $\ln K$ | | | | |
| $\ln L$ | | | | |
| $t$ | | | | |
| $(\ln K)^2$ | | | | |
| $(\ln L)^2$ | | | | |
| $t^2$ | | | | |
| $\ln K \ln L$ | | | | |
| $t \ln K$ | | | | |
| $t \ln L$ | | | | |
| lnvat | $-0.033^{***}$ (0.005) | $-0.033^{***}$ (0.005) | $-0.015^{***}$ (0.003) | $-0.011^{***}$ (0.003) |
| Market | $-0.149^{***}$ (0.010) | $-0.146^{***}$ (0.010) | $0.025^{***}$ (0.006) | $0.022^{***}$ (0.005) |
| Government | $0.366^{***}$ (0.214) | $0.392^{***}$ (0.022) | $0.062^{***}$ (0.014) | $0.050^{***}$ (0.011) |
| Openness | $0.035^{***}$ (0.012) | $0.041^{***}$ (0.012) | 0.011 (0.008) | 0.005 (0.006) |
| hc | $-0.041$ (0.026) | $-0.051^{*}$ (0.026) | $-0.094^{***}$ (0.016) | $-0.078^{***}$ (0.013) |
| mc | | | $0.000^{**}$ (0.000) | $0.000^{***}$ (0.000) |
| East | | | $-0.031^{***}$ (0.012) | $-0.021^{**}$ (0.009) |
| West | | | $-0.008$ (0.012) | $-0.007$ (0.009) |
| Maximum likelihood | | | | |
| Observed value | 504 | 504 | 504 | 504 |
| Section num. | 28 | 28 | 28 | 28 |
| Hausman statistics | 40.10 | 50.13 | 0.00 | 10.39 |
| Panel model | F | F | R | R |

Notes: $^{*}$, $^{**}$, $^{***}$ represents the confidence level at 10%, 5%, and 1%, respectively.

### 5.1. The analysis of trans-log production function estimation

Compare the two methods, we can find that the estimation results are with little difference, this proves the estimation results of the trans-log production function based on SFA model is relatively robust. At the same time, most variables and their quadratic items in the production function are very significant. Particularly, for the two step method, the average capital output elasticity is 0.364, the average labor output elasticity is 0.482; as for the improved one step method, the average capital output elasticity is 0.468, the average labor output elasticity is 0.438. So, we can refer that the estimation results obtained by the two methods are consistent to the actuality. However, according to the maximum likelihood value, two step method is superior to the one step method. In fact, the Monte Carlo simulation method confirmed one step method is better than two step method. The two step will cause the estimation results partial in certain conditions.

### 5.2. The analysis of the production (in) efficiency equation estimation

Similarly, following the two methods, we obtain the estimation value of production efficiency. The estimation results are obtained by two steps: Firstly, we construct the production efficiency equations according to the production efficiency value, and then estimate it by truncated regression. The one step method uses the maximum likelihood method to analyse production inefficiency equation in the SFA model. Thus, the robust estimation results should show the opposite signs under the two methods. From the production efficiency estimation results, the average production efficiency is 0.971 in the two step method estimation. However, under the one step method, the average production efficiency is 0.903. The distribution map of the production efficiency for the one step method is shown in Figure 1. From Figure 1, we can see, since 1994, the production efficiency in more than half of the provinces is above 90%, and the distribution is close to the half normal distribution.

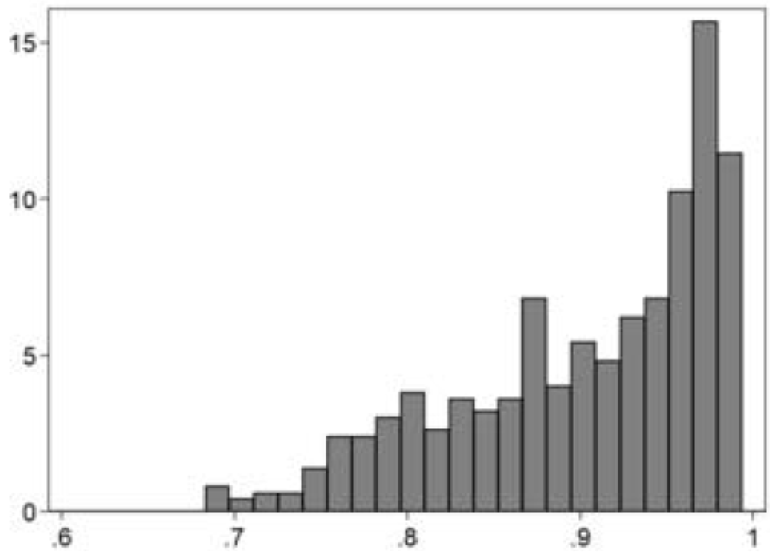


**Figure 1.** The production efficiency distribution.

**Notes:** The vertical axis represents the ratio, the horizontal axis represents the production efficiency.

We mainly focus on the effect of the proportion of the value added tax on production efficiency. From Table 2, we can conclude: The proportion of the value added tax has a positive impact on production efficiency, and the positive effect is remarkable whether under one step method or two step method. The larger the proportion of value added tax in the tax structure, the higher production efficiency. This may be relevant to the transformation and reform of value added tax in recent years, and also because the value added tax system is more flexible than other tax system. The transformation of value added tax will have the Avec-Johnson effect: when more capital will replace labor, capitalization level will lead to the improvement of production efficiency.

Effects for other variables on productivity is not significant, except the significant robust positive effect of the initial human capital on production efficiency. In spite of this, the effect in the two methods is consistent. Our estimation results show, the larger the proportion of state owned industrial output value accounted for industrial output value, the higher the production efficiency; the larger the proportion of fiscal expenditure accounted for GDP, the higher the production efficiency. With the deepening of the opening up and increasingly fierce for international competition, state owned enterprises, basically established the modern enterprise system, have a more significant positive impact on the economy after the two financial crisis after 1994. Meanwhile, the government actively expand infrastructure spending in recent years, creating good conditions for the improvement of production efficiency. In addition, the results also show the deepening of the opening up is conducive to the improvement of production efficiency. The province with higher initial human capital its production efficiency is also higher, at the same time, production efficiency of Eastern provinces is higher than that of Western Provinces.

### 5.3. The analysis of technical efficiency equation estimation

The Hausman test suggested that we should use the fixed effect model to estimate technical efficiency equation, therefore, we omit the regional dummy variables and the initial capital stock. From the estimation results, the larger the proportion of the value added tax, the less conducive to the technological progress, and the conclusion not only significant but robust. With the transformation of value added tax, investment in fixed assets not only can improve the profitability of enterprises, but can enjoy the value added tax deduction. Relatively speaking, technology research and development should face the risk of research activity, but there is not enough subsidy for R&D to compensate for this risk in the value added tax system. Therefore, the value-added tax does not have comparative advantages over other taxes on promoting technological progress.

### 5.4. The analysis of scale efficiency equation estimation

The Hausman test suggested a random effects model in the estimation of scale efficiency equation. Therefore, we use the generalized least square method to estimate the model.

We found that, the larger of the value added tax, the less conducive to the scale efficiency. And the effect is significant and robust. According to Smith theorem, the scale efficiency is relative to specialization, and specialization can promote the scale efficiency. Theoretically value added tax is only tax on added value, so it should be able to promote the specialization of labor division. While China's value added tax is not conducive to improve scale efficiency, this may be related to China's specific design of value added tax system.

For the control variables, the degree of nationalization and government expenditure ratio are both beneficial to the improvement of the scale efficiency. The state owned enterprises are generally with large scale, at the same time, some state owned enterprises are the result of natural monopoly, so it is beneficial to improve the scale efficiency. Government spending provides a favorable investment environment for economic development, and some expenditure plays a leading role in the specialization of labor division, so it is in favor of specialization of regional labor division. Effect of openness on the scale efficiency is positive, but not significant. The higher the initial stock of human capital, the less conducive to the scale efficiency. The higher the initial capital stock, the more benefit to scale efficiency. For the area differences, scale efficiency is significantly negative effect for East area, while the scale efficiency is not significant for West China, the possible cause is that the eastern regions are not endowed with centralized natural resources.

## 6. Summary

Value added tax is an important part of the tax structure in China, and it has an important impact on productivity. Productivity is usually measured by total factor productivity, in fact, productivity can be decomposed into production efficiency, technical efficiency, and scale efficiency. How value added tax will affect productivity, this problem might rely heavily on empirical analysis. Based on trans-log production function and stochastic frontier analysis, this paper carried the relatively comprehensive empirical test to analyse how the proportion of value-added tax in the tax structure impact on each part of productivity.

Our empirical results show that: (1) The proportion of the value added tax has significant and positive effect on production efficiency on average, that is to say, the larger the proportion of the value added tax, the higher the production efficiency. This may be relative to the transformation and reform for value-added tax, and the flexibility of value-added tax system than other tax system. (2) The proportion of the value added tax has a significant negative impact on technical efficiency on average, that is to say, the larger the proportion of the value added tax, the less conducive to the technological progress. This may be because that technology R&D faces the research risks, but the value added tax dose not render enough tax concessions for technology R&D, and can not compensate for the technology R&D risks, therefore, the value added tax does not have an advantage over other taxes on the promotion of technological progress. (3) On average, the proportion of the value added tax has a significant negative impact on scale efficiency, that is to say, the larger the proportion of the value added tax, the less conducive to the scale efficiency. This may because that the design of China's value added tax system is not conducive to specialization, thus China's value added tax is not conducive to improve scale efficiency. To sum up, the effect of proportion of value added tax in the tax structure on China's productivity is complex.

In recent years, the Chinese government has carried out a series of adjustments for the value added tax system, including the transformation and expansion of value added tax, etc.. These reforms really help to reduce the tax burden, but how value added tax affect the productivity should not be ignored. We suggest, with the reform "business tax change into value added tax" and the expansion of the value added tax, we should focus on the design that can optimize the tax system. Productivity is the core of economic growth, the value added tax system should not hinder the productivity progress, and give impetus to economic growth. For example, it is appropriate to supply tax subsidy for enterprises' technology R&D, to avoid the enterprise employ capital to replace technology R&D, and to encourage enterprises to increase R&D investment. In addition, the design of value added tax should be conducive to the specialization. Be sure that value added tax only tax on the final transactions, should avoid double taxation, and encourage the improvement of scale efficiency.

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