

Nonlinear Shock Effect of China's Fiscal Policy on Total Factor Productivity—Based on the Dual Perspective of Aggregate and Structure

Hong Yin, Long Zhang, Xiangsong Ye*

In different economic periods, if the government blindly adopts expansionary fiscal policy, it may not be able to effectively increase total factor productivity (TFP). Based on this, this paper constructs a factor augmented vector autoregressive model with time-varying parameters and stochastic volatility (SV-TVP-FAVAR), and explores the nonlinear shock effect of China's fiscal policy on TFP from the dual perspective of aggregate and structure. The study finds that: (1) At the aggregate level, the increase in fiscal expenditure in each period has a significant inhibitory effect on TFP, while the increase in fiscal revenue has a significant promotion effect on TFP; (2) At the structural level of expenditure, in the period of economic depression and high economic growth, the increase in investment expenditure, education expenditure, technology expenditure, and public service expenditure all have a strong incentive effect on TFP, but the increase in science and technology and education expenditure in the period of economic stability has not effectively improved TFP; (3) At the structural level of tax, the increase in commodity tax, including consumption tax, value-added tax, and tariff, and individual income tax will significantly inhibit the increase in TFP, but the increase in corporate income tax can significantly increase TFP. Therefore, under the new economic normal, policy makers should build a two-wheel driven fiscal policy of “aggregate regulation and structural optimization” to optimize the structure of fiscal expenditure and taxation, and promote high-quality economic development.

Keywords: fiscal policy, total factor productivity (TFP), nonlinear shock effect

1. Introduction

In recent years, China's economy has faced a complex situation in which the

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government must deal with the slowdown in economic growth, make painful structural adjustments, and absorb the effects of previous economic stimulus policies all at once. The 19th CPC National Congress pointed out that “China’s economy has been transitioning from a stage of rapid growth to a stage of high-quality development and is now in a pivotal stage for transforming the growth model, improving the economic structure and fastening the new growth drivers. As one of the important indicator of measuring economic development, Total factor productivity (TFP) improvement has become one of the most important strategic supports of promoting sustainable and healthy development of economy and improving economic competitiveness. As an important driving force of economic growth, fiscal policy can not only directly improve TFP through regulating resource allocation of factor markets, but also indirectly impact TFP through other channels. At the same time, with the increasing fluctuation of global economic cycle, the regulatory effect of fiscal policy on TFP depends on the changes of external economic environment to a large extent. For instance, the same fiscal policy that promotes the TFP at one period may generate inhibitory effect in another period. Therefore, using time-varying parameter model to investigate the nonlinear effect of China’s fiscal policy on TFP in different economic periods and under different external environments is important for the formulation of fiscal policy and the improvement of TFP.

Researches on TFP growth, especially the relationship between fiscal policy and TFP, attract increasing attention in academia. Among them, most of the scholars investigate the topic from dual perspective: the aggregate and structure of fiscal revenue and expenditure. From the perspective of fiscal expenditure, Guo and Jia (2005) found that expansive fiscal policy has a positive effect on both national and provincial TFP, by using the panel data model. Nijkamp *et al.* (2004) proposed that infrastructure investment by government is beneficial for the future development of an economy and the promoting effect increases along with time. Zhang *et al.* (2004) pointed out that fiscal expenditure for social security can boost labor quality, increase investment in human capital and thus improve TFP. Through constructing vector auto-regression model, Guo *et al.* (2006) found that fiscal expenditure on science and education can improve resource use efficiency and increase the stock of social human capital, which is good for capital formation and economic growth and has an important effect on TFP increase. From the perspective of fiscal revenue, Liang and Zhang (2017) pointed out that imposing tax on enterprises could generate inhibitory effect on enterprise innovation and FDI. Meanwhile, imposing tax on personal income could decrease self-motivation and lower people’s expectation on returns to education. Both of these are not conducive to TFP increase. Zheng and Zhang (2018) believed that decreasing corporate income tax can improve TFP through different channels, including alleviating financing constraints, optimizing resource allocation and increasing capital inputs to R&D and human capital, though the effect gradually declines across time.

Overall, more fiscal revenue and less fiscal expenditure can inhibit the growth of TFP. However, with the further researches, some scholars got the opposite conclusions that fiscal expenditure on infrastructure could deteriorate technological efficiency and fiscal expenditure on decrease the relative compensation of social high-efficiency behavior, and individual income tax collection can lower the opportunity cost of receiving education. Therefore, more fiscal revenue and less fiscal expenditure are better for productivity improvement and human capital formation, and thus promoting TFP growth (Lindbeck, 2006; Buyse *et al.*, 2013). The literature review can be concluded through the following two aspects. First, most of the existing papers that study the effect of fiscal policy on TFP are based on vector auto-regression model, panel vector auto-regression model, DID method, RD method, DSGE model and other econometric models that do not consider the time-varying features of parameters. However, the effect mechanism of fiscal policy on TFP depends on different external environments in different periods, so constant parameter econometric model cannot capture the time-varying effect of fiscal policy on TFP. This is also one of the important reasons why scholars in different countries cannot reach an agreement on the effect of fiscal policy on TFP. Second, due to the limitation of freedom degree of parameter estimation, most of the previous researches only took few variables into consideration, such as fiscal policy instrument and TFP. However, TFP improvement is influenced not only by changes of fiscal policy, but also by other economic indicators. Therefore, omitting important variables in the model may lead to the missing of important information. Based on this, this paper applies factor augmented method to extract the unobservable common factor from lots of macro-economic variables to introduce into basic vector auto-regression model. Then we take the method of innovative random walk to conduct the time-varying process on the matrix of coefficients and disturbance. In the end, we obtain the SV-TVP-FAVAR. Then, from the perspective of aggregate and structure of fiscal policy, the paper investigates the effect of China's fiscal expenditure and revenue on TFP from the first quarter of 2007 to the fourth quarter of 2017, by employing the time-varying model. Through three-dimensional impulse response analysis, the nonlinear shock effect of China's fiscal policy on TFP is discovered. Based on the nonlinear feature, policy implications for fiscal policy regulation in different periods to promote TFP are proposed.

2. Model Construction and Parameter Selection

2.1. The Principals of the Model

This section will introduce the construction principals of SV-TVP-FAVAR (Korobilis, 2013). First, we construct a classical VAR model (Sims, 1980):

$$y_t = b_1 y_{t-1} + \dots + b_p y_{t-p} + v_t \quad (1)$$

where $y'_t = [TFP_t, F_t]$, and TFP_t represents the TFP at time t . F_t is the fiscal policy with $1 \times l$ dimension. When analyzing from the aggregate level, $F_t = [FE_t, TR_t]$, where FE_t and TR_t indicate fiscal expenditure and revenue, respectively. When analyzing from the structure level, $F_t = [FI_t, EE_t, TE_t, PSE_t]$, where FI_t , EE_t , TE_t and PSE_t represent fiscal expenditure on investment, education, technology and public services. When analyzing from the perspective of the structure of fiscal revenue, $F_t = [CT_t, IT_t]$, where CT_t and IT_t is commodity tax and income tax, respectively. The coefficient b_j of the lagged term of each y_t is with the dimension of $(l+1) \times (l+1)$, $j=1, \dots, p$; $v_t \sim N(0, \Omega)$, Ω is the covariance matrix with the dimension of $(l+1) \times (l+1)$.

According to the dynamic factor augmented method proposed by Boivin *et al.* (2006), we degrade other important economic information variable with the dimension of n to unobservable common factor f with the dimension of k , and $k \leq n$. Then, the k factors are incorporated to the classical VAR model, which can avoid the missing of important economic information when analyzing the effect of China's fiscal policy on TFP.

Next, time-varying treatment is made on the coefficients and disturbance term, and we get the time-varying parameter model with the following form:

$$y_t = b_{1t} y_{t-1} + \dots + b_{pt} y_{t-p} + v_t \quad (2)$$

where $y'_t = [f'_t, TFP_t, F_t]$ is the unobservable common factor vector with the dimension of $(k+1)$, and $[TFP_t, F_t]'$ is the observed TFP variable and China's fiscal policy vector with the dimension of $(l+1) \times 1$. b_{jt} is the $(m \times m)$ coefficient matrix, $j=1, \dots, p$, $t=1, \dots, T$, $m=k+l+1$; $v_t \sim N(0, \Omega_t)$, $t=1, \dots, T$.

Furthermore, each of the overall economic information vector x_{it} can be viewed as obtained from the factor regression result from f_t , TFP_t and F_t , and has the disturbance term with stochastic volatility:

$$\begin{cases} x_{it} = \tilde{\lambda}_i^f f_t + \tilde{\lambda}_i^T TFP_t + \tilde{\lambda}_i^F F_t + u_{it} \\ u_{it} = \rho_{i1} u_{it-1} + \dots + \rho_{iq} u_{it-q} + \varepsilon_{it} \end{cases} \quad (3)$$

where $\varepsilon_{it} \sim N(0, \exp(h_{it}))$. We suppose ε_{it} is unrelated with the unobservable common factor and not auto-correlation, that is for any $i, j=1, \dots, n$, $i \neq j$ and any $t, s=1, \dots, T$, $t \neq s$, we have $E(\varepsilon_{it} f_t) = 0$ and $E(\varepsilon_{it} \varepsilon_{js}) = 0$. Then, Equation (3) can be rewritten as:

$$x_t = \lambda^f f_t + \lambda^T TFP_t + \lambda^F F_t + \Gamma(L)x_t + \varepsilon_t \quad (4)$$

where $\Gamma(L)=\text{diag}(\rho^1(L), \dots, \rho^n(L))$, $\rho^i(L)=\rho_{il}+\dots+\rho_{iq}L^q$, $\lambda_j=(I_n-\Gamma(L))\lambda_j$, $j=f, T, F$; $\varepsilon_t \sim N(0, H_t)$, $H_t=\text{diag}(\exp(h_{1t}), \dots, \exp(h_{nt}))$, and the error term has the random walk form: $h_{it}=h_{it-1}+\eta_{it}^h$, $\eta_{it}^h \sim N(0, \sigma_h)$.

Then, we decompose the covariance matrix Ω_t with the time-varying treatment (Primiceri, 2005; Cogley and Sargent, 2005):

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t' \quad (5)$$

$$\Omega_t = A_t^{-1} \Sigma_t \Sigma_t' A_t'^{-1} \quad (6)$$

where $\Sigma_t = \text{diag}(\sigma_{1,t}, \dots, \sigma_{m,t})$, and A_t is lower triangular matrix with a principal diagonal of 1. Define $B_t = \left(\text{vec}(b_{1t}), \dots, \text{vec}(b_{pt}) \right)'$, $\log \sigma_t = (\log \sigma_{1t}', \dots, \log \sigma_{mt}')'$ and, $\alpha_t = \left(\alpha_{j1,t}', \dots, \alpha_{j(j-1),t}' \right)'$ are all the parameters of the model, which can be obtained by using the innovative random walk method (Koop *et al.*, 2009):

$$\begin{cases} B_t = B_{t-1} + J_t^B \eta_t^B \\ \alpha_t = \alpha_{t-1} + J_t^\alpha \eta_t^\alpha \\ \log \sigma_t = \log \sigma_{t-1} + J_t^\sigma \eta_t^\sigma \end{cases} \quad (7)$$

where $\eta_t^\theta \sim N(0, Q_\theta)$ is the innovative variable, and Q_θ corresponds to the innovative covariance matrix of B_t , α_t and $\log \sigma_t$. $J_t^\theta = 0$, $\forall t=1, \dots, T$ represents that the parameter is constant, while $J_t^\theta = I$, $\forall t=1, \dots, T$ represents that the parameter is time-varying, $\theta_t \in \{B_t, \alpha_t, \log \sigma_t\}$.

Then, the VAR system has the following formation after the treatment of lagged operator:

$$y_t = B_t(L)y_t + A_t^{-1} \Sigma_t \varepsilon_t^y \quad (8)$$

$$g_t = A y_t + \Gamma(L)g_t + W_t \varepsilon_t^g \quad (9)$$

where $g_t' = [x_t', TFP_t, F_t]'$; $y_t' = [f_t', TFP_t, F_t]'$; $W_t = \text{diag}(\exp(h_{1t})/2, L, \exp(h_{nt})/2, 0_{1 \times (l+1)})$,

$W_t W_t' = \begin{bmatrix} H_t & 0_{1 \times (l+1)} \end{bmatrix}'$; $B_t(L) = b_{1t}L + \dots + b_{pt}L^p$. $(\varepsilon_{1t}^g, \varepsilon_{2t}^g)$ is the structural disturbance term

with independent and identical standard normal Distribution. $A = \begin{bmatrix} \lambda^f & \lambda^{T,F} \\ 0_{(l+1) \times k} & I_{(l+1)} \end{bmatrix}$,

$\lambda^{T,F} = [\lambda^T, \lambda^F]$. Plugging Equation (8) into Equation (9), we get the VMA expression of the model:

$$g_t = \tilde{F}(L)^{-1} A \tilde{B}_t(L)^{-1} A_t^{-1} \Sigma_t \varepsilon_t^y + \tilde{F}(L)^{-1} W_t \varepsilon_t^g = \Delta_t(L) \zeta_t \quad (10)$$

where $\tilde{B}_t(L) = I - B_t(L)$; $\tilde{F}(L) = I - F(L)$; ζ_t is an innovative vector with standard normal distribution.

2.2. Variable Selection and Data Description

TFP. Under the condition of Hicks-neutrality technology and constant return to scale, TFP can be represented as the residual term obtained by deducting the growth rate of capital and labor from the production growth rate. Production level, capital volume and total labor are measured as the total outputs, physical capital stock and total human capital respectively.¹ (1) As for the physical capital calculation, the estimation of the capital stock at the base year and measurement of real net investment are the two difficult points. Zhang and Zhang (2003) pointed out that when calculating the real new formed capital, most of the researches use the total social fixed capital investment data after deducting non-productive investment. However, the estimations are very sensitive to different kinds of reasons for deduction. Shan (2008) believed that gross fixed capital formation can accurately measure capital stock, which is calculated by National Bureau of Statistics and equals deducting non-productive investment (such as land use fees) from fixed capital investment and adding other investment terms that are not included in the statistical data. (2) The estimation of total amount of human capital. The existing researches make linear estimation of human capital by applying different methods, including cost method, income method, future revenue method, education year method. Referring to Peng (2005), this paper applies the education year method for the following two reasons. First, this method considers the different effects of different education stages on production efficiency. Second, for the data availability, although education year method neglects the effects of work experience and on-job training on human capital, the data, especially quarterly data on work experience and on-job training are hard to get. Since the quarterly data for the measurement of physical capital stock and total amount of human capital cannot be obtained directly, this paper takes the dataset constructed by Chang *et al.* (2016) for analysis,

¹ Using the number of employment would overestimate TFP, therefore, this paper uses the total amount of human capital to measure labor level and runs the robustness check in later section. We are grateful for referees who come up with this suggestive comment.

which include the quarterly data of gross fixed capital formation, price index of gross fixed capital formation and employment. The yearly data on average education level are obtained from National Bureau of Statistics, which are transformed to quarterly data by using the linear interpolation.

Variables on fiscal policy. Since this paper investigates the effect of fiscal policy on TFP from both aggregate and structure level, the variables on fiscal policy include aggregate variables and structural variables. The selection rules are referred to Chu and Jian (2014). (1) The aggregate variables of fiscal policy include fiscal expenditure (*FE*) and fiscal revenue (*FR*), which are measured by the share of total amount of fiscal expenditure in GDP and the share of total tax in GDP. (2) The structural variables of fiscal policy include fiscal expenditure on investment (*FI*), on education (*EE*), on technology (*TE*) and on public service (*PSE*). These variables are indicated as the share of each kind of fiscal expenditure in total amount of fiscal expenditure. Among them, fiscal expenditure on public service is measured by general public service expenditure and government investment expenditure is measured by the appropriation from national budget in the fixed capital investment. (3) The tax structural variables of fiscal policy include commodity tax (*CT*) and income tax (*IT*). Among them, commodity tax are classified into consumption tax (*CON*), value-added tax (*VAT*) and tariff (*TAR*). Income tax are classified into individual income tax (*IIT*) and corporate income tax (*EIT*). All of these indicators are measured by the share of each kind of tax in total tax revenue amount. Theoretically, consumption tax, value-added tax, business tax and tariff all belong to commodity tax. However, after the implementation of “replacing business tax with value-added tax” in 2016, there is not data on business tax after 2016. Therefore, this paper defines the commodity tax as the sum of value-added tax, consumption tax and tariff.

Variables that are needed for the extraction of common factor. To accurately investigate the nonlinear shock effect of China’s fiscal policy on TFP, this paper aims to extract common factors from lots of macro-economic variable information. The macro-economic information set is formed by 104 economic variables at three levels. They include (1) variables at the production level, such as GDP, the value added of the tertiary sector and trade amount of import and export; (2) variables at the price level, such as CPI and index of commodity retail price; (3) variables at the financial level, such as weighted average interest rates of interbank lending, broad money and average exchange rate of USD against RMB.

Considering the trend of global economic cycle and that the reform of classification of fiscal revenue and expenditure was implemented in 2007, we choose the analyzing period from the first quarter in 2007 to the fourth quarter in 2017 (abbreviated as 2007 Q1–2017 Q4). Non quarterly data such as weighted average

interest rates of interbank lending and average exchange rate of USD against RMB are transformed to quarterly data, all data are adjusted quarterly, and horizontal difference and logarithm difference are made on non-stationary series. Relative indicators are used to define TFP, fiscal expenditure and tax, where price deflation is not needed. Some of the officially unpublished basic data (such as the quarterly gross fixed capital formation) are obtained from Change *et al.* (2016), while other basic data are from National Bureau of Statistics and China Economic Information Network.

3. Empirical Analysis

The section uses the SV-TVP-FAVAR constructed in previous section and three-dimensional impulse response analysis to investigate the nonlinear shock effect of China's fiscal policy on TFP at different economic development stages from both the aggregate level and structural level.

3.1. The Aggregation Analysis

This section takes the period from the first quarter in 2007 to the fourth quarter in 2017 as the shock period of fiscal expenditure and tax at the aggregate level and uses the three-dimensional impulse response method to analyze the effect of one unit standard deviation shock of fiscal policy on TFP. The left part of Figure 1 is the impulse response of TFP to the continuous shock of fiscal expenditure, while the right part is the impulse response of TFP to the continuous shock of tax.¹

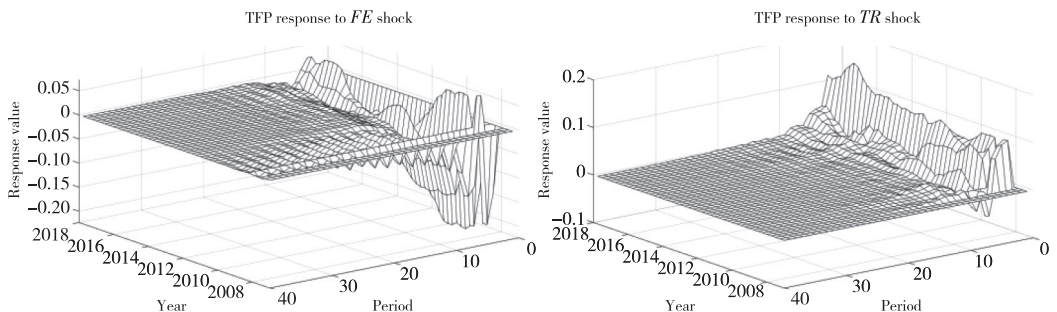


Figure 1. The Continuous Shocks of Fiscal Expenditure and Tax on TFP at the Aggregate Level

¹ The continuous shock in this paper indicates the continuation in horizontal time, that is, a shock is imposed in each period in the research period. This is different from the continuous shock in the vertical time.

According to the left part of Figure 1, there is a significant negative shock effect of fiscal expenditure on TFP and the strength of the shock is decreasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the minimum value of response to positive shock of one unit standard deviation are -20.99% , 11.53% and 14.32% , respectively. Therefore, the increase of fiscal expenditure has an inhibitory effect on TFP in different economic periods, but the effect is weakened in the periods of boom and stability. During financial crisis, Chinese government increased investment on heavy chemical industry and infrastructure by a large extend to curb the economic growth slowdown. As a result, there was an excessive expansion of fiscal expenditure and social capital in infrastructure, real estate and heavy chemical industries, while the inputs on production equipment and R&D was insufficient. This also led to the real problem, such as redumtant construction and excessive production capacity, which resulted in the social investment distortion. After the financial crisis, with the improvement of external economic environment, China's economy rebounded with high growth rate and the inhibitory effect of fiscal expenditure on TFP weakened, but the inhibitory effect was still dominant. This was due to the undesired consequences of expansive fiscal policy which weakened the promotive effect of fiscal expenditure on TFP. Furthermore, the excessive expansive fiscal policy for a long time can lower the use efficiency of fiscal funds and result in unreasonable resource allocation. In the end, huge fiscal expenditure can continuously accumulate public debt risk, decreasing the regulatory effect of fiscal expenditure.

According to the right part of Figure 1, there is a significant positive shock effect of tax on TFP and the strength of the shock is increasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the maximum values of response to positive shock of one unit standard deviation were 9.71% , 10.28% and 15.33% , respectively. Therefore, the increase of taxa has a positive effect on TFP in different economic periods, and the effect is more obvious in the period of economic stability. Theoretically, government can achieve optimal resource allocation through adjusting commodity tax rate and income tax rate, changing household consumption preference and changing the usage of capital and labor by enterprises. Meanwhile, government can exert its function of regulating macro-economy and motivate individual and enterprises to behave in consist with the national policy target through adjusting tax structure and implementing preferential tax policy. In the end, as an important source of fiscal revenue, higher tax is beneficial for government to increase inputs to infrastructure and public facilities, which is good for improving the external environment of enterprise production and operation and facilitating economic agglomeration, thus stimulating technological innovation by enterprises and improving TFP. Especially in the period of economic stability, with the increasing household income and enterprises return, the positive effect of tax on TFP is more obvious through

alleviating the financing constraints, optimizing resource allocation and increasing scale economics.

From the aggregate level, the expansion of fiscal expenditure and tax generates nonlinear shock effect on TFP. Increasing fiscal expenditure generates obvious inhibitory effect on TFP, and the effect is weakened in the periods of economic boom and stability. Increasing tax has a promotive effect on TFP, which is strengthened in the period of economic stability. However, the analysis at the aggregate level cannot reveal the nonlinear shock effect of structure adjustment of fiscal expenditure and tax. Next, we will investigate this nonlinear shock effect at the structural level.

3.2. Structural Analysis

Focusing on the period from the first quarter to the fourth quarter in 2007, this section analyzes the positive shock effect on TFP by one unit standard deviation of fiscal expenditure on investment, education, technology and public services. Then the positive shock effects on TFP by one unit standard deviation of different kind of commodity tax and income tax are analyzed.

3.2.1. The Effect of Fiscal Expenditure on TFP at the Structural Level

We choose fiscal expenditure on investment, education, technology and public services as the shock generators to investigate the effect of structural adjustment of fiscal expenditure on TFP. The results are shown in Figure 2.

According to the upper left part of Figure 2, fiscal expenditure on investment has a positive shock effect on TFP and the influence degree is increasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the maximum values of response to positive shock of one unit standard deviation were 26.79%, 19.33% and 19.77%, respectively. Therefore, the increase of fiscal expenditure on investment has a positive effect on TFP in different economic periods, and the effect is weakened in the periods of economic boom and stability. This result is consistent with that in Guo and Jia (2005). As one kind of productive investment, fiscal investment can lead the direction of social investment, promote the development of industries that are picked by national industrial policies, provide better investment environment for business activities of private sectors and thus boost the outputs of private sectors. Therefore, fiscal expenditure on investment has a significant improvement on TFP through the channels of remedying up the market failure, maintaining resource allocation and regulating economic operation. Besides, in the new normal period, the economic growth momentum is changing from factor driven to innovation driven. The limitation of only depending on increasing factor input shows up, and the driving effect of government investment expenditure on TFP is relatively weak.

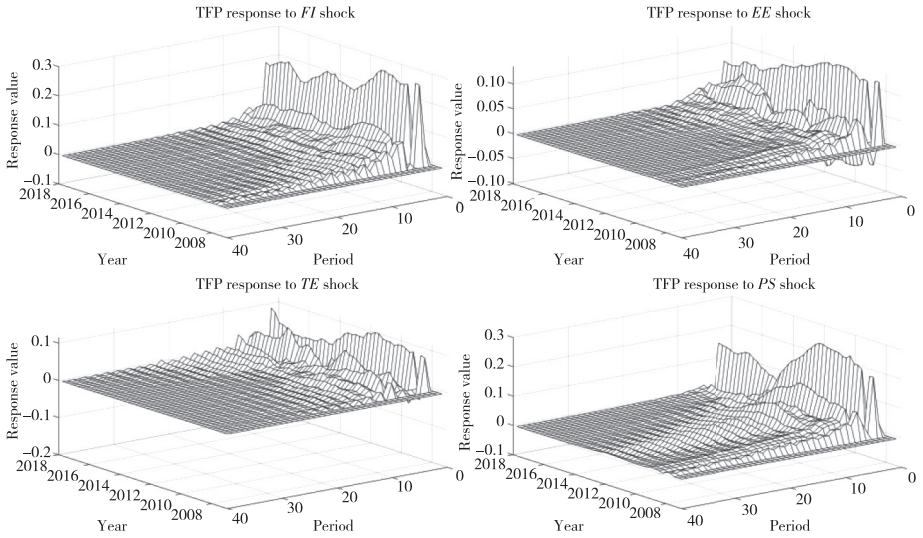


Figure 2. The Continuous Shocks of Fiscal Expenditure on TFP at the Structural Level

According to the upper right part of Figure 2, fiscal expenditure on education has a positive shock effect on TFP, but the influence degree is decreasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the maximum values of response to positive shock of one unit standard deviation were 12.00%, 11.28% and -8.83% , respectively. Therefore, the increase of fiscal expenditure on investment has a positive effect on TFP in the periods of economic depression and boom. This effect becomes inhibitory in the period of economic stability. According to the analysis in previous section, fiscal expenditure on education can motivate individuals to receive higher education and thus promote the technological advances. Therefore, in the periods of economic depression and boom, the positive effect is significant. In contrast, in the period of economic stability, since the scope of fiscal expenditure on education becomes smaller and the expenditure efficiency decreases, fiscal expenditure on education has inhibitory effect on TFP. This result is consistent with Zhan and Liu (2019). It is extremely unfavorable to the economic transformation of the new normal of china's economy.

According to the lower left part of Figure 2, the TFP effect of fiscal expenditure on technology has a similar pattern as fiscal expenditure on education, and the positive shock effect is decreasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the maximum values of response to positive shock of one unit standard deviation were 9.65%, 9.33% and -12.72% , respectively. Therefore, the increase of fiscal expenditure on technology has a positive effect on TFP in the periods of economic depression and boom, while this effect becomes inhibitory in the period of economic stability. Science and technology are the important motive of a country's social development and

economic growth. However, the R&D of technology advances has the features of large investment, long cycle and slow effect, so individuals and enterprises are reluctant to invest. As a result, government becomes the most promotor for the R&D of science and technology. In the economic new normal, the requirement for technological R&D is demanding. However, R&D not only has to bear huge sunk cost, but also faces the monopoly of core technology by developed countries. Therefore, in the stable economic period, the driving effect of the increase of fiscal expenditure on technology on TFP is not significant.

According to the lower right part of Figure 2, fiscal expenditure on public services has a positive shock effect on TFP, but the influence degree is decreasing over years. In 2008 Q3, 2012 Q2 and 2016 Q1, the maximum values of response to positive shock of one unit standard deviation were 21.95%, 20.70% and 15.26%, respectively. Therefore, similar to fiscal expenditure on investment, fiscal expenditure on public services has a significant role in promoting TFP in different periods, and this promotion is greatly weakened and the effect lasts shortly in the stable economic period. Theoretically, the increase of fiscal expenditure on public services can eliminate the regulatory obstacles on human resource allocation, optimize human resource allocation, alleviate preventive saving motive by households, stimulate domestic demand and thus promote economic development and improve social innovative ability. In the period of economics stability, the positive effect is weakened. The possible reason might be that the consumption boost effect of fiscal expenditure on public service is limited in the new normal and the rapidly expanding expenditure can increase government deficit. This can not only increase producers' tax burden, but also lower enterprises' support on R&D, which arrives in a lower positive TFP effect of fiscal expenditure on public services under the new normal.

From the structural level, fiscal expenditure on investment, education, technology and public services has nonlinear effect on TFP. In the period of economic depression and boom, the TFP effects of fiscal expenditure on investment, education, technology and public services are promotive, while in the period of economic stability, the promotive TFP effects of each kind of expenditure weakened, especially for expenditure on education and technology, the effect becomes inhibitory.

3.2.2. The Effect of Tax on TFP at the Structural Level

We choose commodity tax and income tax as the shock generators to investigate the effect of structural adjustment of tax on TFP. Here commodity tax include consumption tax, value-added tax and taiff. Income tax include individual income tax and corporate income tax. The impulse response results are shown in Figure 3 and Figure 4, respectively.

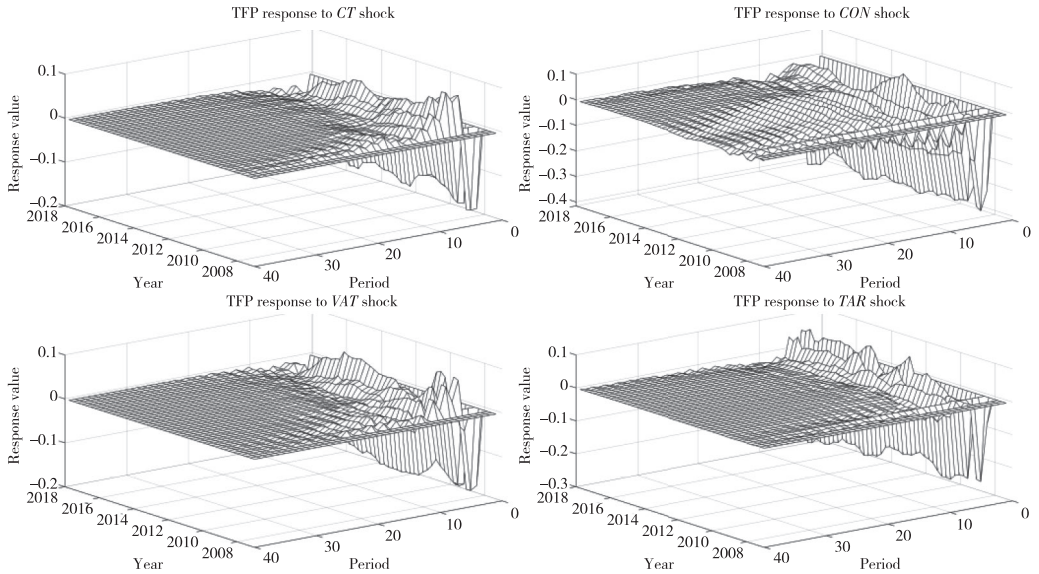


Figure 3. The Continuous Shocks of Commodity Tax on TFP at the Structural Level

According to Figure 3, there is a significant negative effect of commodity tax on TFP. In 2008 Q3, 2012 Q2 and 2016 Q1, the minimum values of response to positive shock of one unit standard deviation were -17.16% , -15.13% and -16.80% , respectively. Therefore, the increase of commodity tax has an obvious inhibitory effect on TFP in different economic periods. The possible reason is that although commodity tax is levied on enterprises, it is borne by consumers in the end. This leads to a higher price index and “crowding out effect” on household consumption. The decrease of domestic final demand would inhibit the incentives to produce and thus not good for TFP improvement (Gao, 2012; Xi, 2014). Especially in recent year, the income inequality is increasing along with the economic growth, and the increase of commodity tax still generates a significant inhibitory effect on middle- and low-income groups. Next, we investigate the effect of different kinds of commodity tax, such as consumption tax, value-added tax and tariff, on TFP.

According to Figure 3, the following findings can be concluded. First, in different economic periods, a unit increase of consumption tax (CON) all leads to the significant decrease of TFP. In 2008 Q3, 2012 Q2 and 2016 Q1, the minimum values of response to positive shock of one unit standard deviation were -35.92% , -36.97% and -34.36% , respectively, indicating that the increase of consumption tax generates significant “crowding out effect” on household consumption. Second, in 2008 Q3, 2012 Q2 and 2016 Q1, the minimum values of response to positive shock of one unit standard deviation of value-added tax (VAT) were -17.26% , -18.37% and -13.21% , respectively, showing that value-added tax increase had a significant inhibitory effect on TFP

improvement. Though value-added tax is an indirect tax that its change would not influence the tax burden and production decision of enterprises, it is borne by consumers in the end. Therefore, the increase of VAT could exacerbate price distortion and “crowd out” household consumption, and thus lower the resource allocation efficiency and inhibit production and incentives to innovation. Third, in 2008 Q3, 2012 Q2 and 2016 Q1, the minimum values of response to positive shock of one unit standard deviation of tariff (*TAR*) were -24.70% , -23.59% and -26.26% , respectively, showing that tariff increase had a significant inhibitory effect on TFP improvement. Decrease of tariff results in lower product prices in foreign markets relative to domestic markets, so consumers are inclined to buy imported goods. As a result, the shares of domestic enterprises and domestic market decrease, that is, the “price effect” has an inhibitory effect on TFP improvement. On the other hand, the decrease of tariff would make enterprises to improve production technology to enhance competitiveness (for instance, enterprises can benefit from learning foreign new technology that is embedded in imported intermediate products), and benefit from the scale economics (Traca, 1997; Wang *et al.*, 2015). The significant inhibitory effect of tariff on TFP shows that the positive effect brought by “price effect” cannot offset the negative effect induced by less competitiveness. That is, the increase of tariff could lower the scale economics of enterprises and inhibit TFP improvement through weakening the competition.

Figure 4 shows that the positive effect of income tax on TFP dominates in different economic periods and the effect increases along with the shock strength increase. In 2008 Q3, under one unit of positive shock of income tax, TFP responded to increase immediately and significantly. The effect reached the maximum in third period with the value of 11.22% . Afterwards, the response amplitude fluctuated slightly and converged to the steady state around the 13th period. In 2012 Q2, the response of TFP to on unit positive shock of income tax reached the maximum in the third period with the value of 15.68% . Similarly, in 2016 Q1, the response of TFP to on unit positive shock of income tax reached the maximum in the third period with the value of 18.88% . Therefore, there is a significant promotive effect of income tax increase on TFP and the effect increases with time. Theoretically, the effect of income tax increase on TFP can be classified into two aspects. First, from the macro perspective, as one of the main channel of fiscal revenue, higher tax is benefit for government to improve infrastructure and public facilities to improve the external environment of enterprises and thus attracts investment. Second, from the micro perspective, higher income tax has a “crowding out effect” on household consumption, R&D inputs of enterprises and human resource investment. Furthermore, resource misallocation resulted from the distortion of factor market would lead to enterprises with higher TFP not obtain enough factor resources and thus not reach the optimal production scale. In contrast, enterprises with lower TFP obtain excessive resources, which results in overcapacity. The increase of income tax would aggravate the behavior of “seeking preferential tax policies” of enterprises with

lower TFP, which would generate negative effect on TFP. The response results found in this paper show that the increasing share of income tax in total tax has a positive effect on TFP, which means that the promotive effect of income tax from the macro-economic level is higher than the negative inhibitory effect from the micro-economic level.

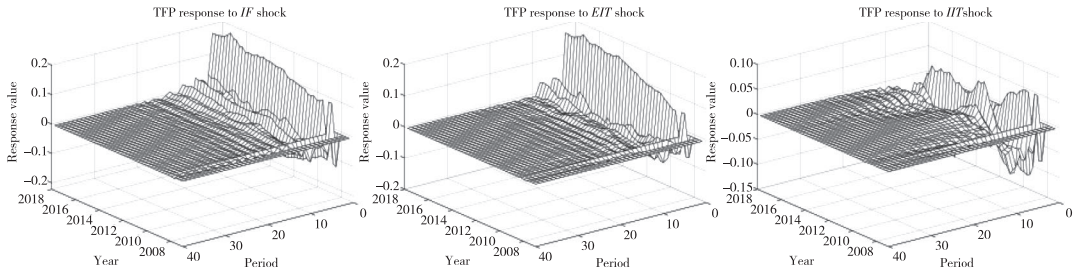


Figure 4. The Continuous Shocks of Income Tax on TFP at the Structural Level

According to Figure 4, we find that first, one unit positive shock of corporate income tax would increase TFP by a large extend, for instance, the maximum response values in 2008 Q3, 2012 Q2 and 2016 Q1 were 7.97%, 15.23% and 18.55%, respectively. Therefore, the promotive effect of corporate income tax on TFP is significant. This indicates that the positive effect of levying corporate income tax by alleviating government financing constraint, increasing infrastructure and R&D investment and other public expenditure is larger than the negative effect. Second, the response of TFP to one unit positive shock of individual income tax is mainly negative, for instance, the minimum response values in 2008 Q3, 2012 Q2 and 2016 Q1 were -9.05%, -4.26% and -10.03%, respectively. Therefore, different from corporate income tax, individual income tax generates significant inhibitory effect on TFP. This reveals that the negative effect of increasing individual income tax on TFP through reducing household dispensable income and lowering production enthusiasm is larger than the positive effect through increasing public expenditure.

From the structural perspective, the expansion of commodity tax and income tax generates nonlinear shock effect on TFP in different economic periods. The increase of commodity tax, such as consumption tax, value-added tax and tariff, has a significant inhibitory effect on TFP. In contrast, the increase of income tax has a promotive effect on TFP and the effect increases over years. Moreover, there is a heterogeneous effect of different income taxes on TFP, where increase of corporate income tax mainly promotes TFP, while increase of individual income tax mainly inhibits TFP.

3.3. Robustness Test

Considering that the TFP calculation based on Solow residual by deducting the

contribution of material capital stock and labor force has some limitation. This paper further replaces the quantity of labor force by the total amount of human capital, and deducting the contribution of quality of labor force and thus estimating TFP more accurately. Figure 5 shows the estimation results of TFP growth rate: TFP1 where only the quantity of labor force is deducted and TFP2 where the total amount of human capital is deducted. As shown in the Figure 5, TFP1 and TFP2 remain the same fluctuation trend, indicating that comparing to TFP1, there is significant change of the general trend of TFP after deducting the contribution of human capital, but there are some differences in level values. The values of TFP2 are lower than those of TFP1 at most times, which is due to the fact that TFP1 is overestimated since the contribution of quality of labor force is not excluded. We also analyze the nonlinear shock effect of China's fiscal policy on TFP1 from both aggregate and structural perspective. Comparing to the above results (which are the effect of fiscal policy on TFP2), the positive effect of fiscal policy on TFP1 is relatively strengthened. This is mainly due to the overestimation of TFP1. However, the main results still remain, that is the increase of fiscal expenditure on investment, education, technology, public services and corporate income tax would have significant promotive effect on TFP1, while the increase of value-added tax, consumption tax, tariff, and individual income tax would generate significant inhibitory effect on TFP1. Therefore, the main results are robust whenever which TFP estimation method is adopted.

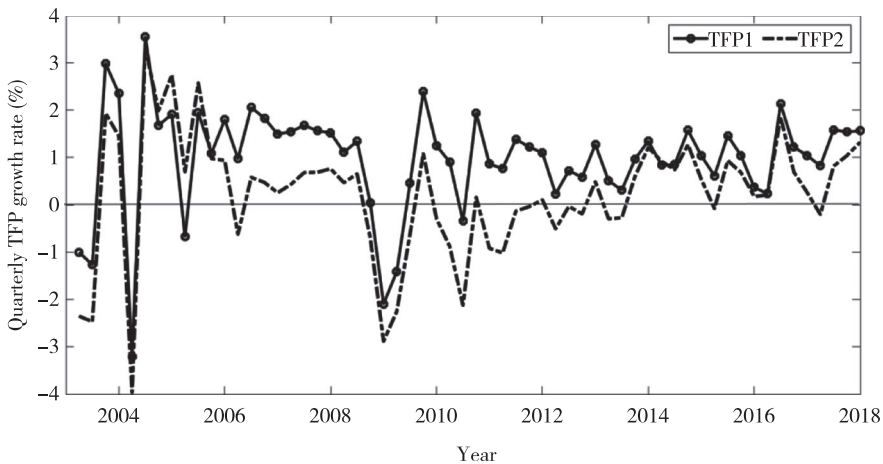


Figure 5. Comparison of TFP Growth Rate Estimations

4. Conclusions

TFP is the important strategic support for promoting economic steady development and enhancing economic competitiveness in China's economic transition period. As

the main regulatory method of government macro-economic adjustment, fiscal policy would generate different effects on TFP when different instruments are used. Based on SV-TVP-FAVAR model, this paper investigates the nonlinear shock effect of China's fiscal expenditure and tax on TFP in different economic periods from the aggregate perspective and structural perspective.

Results are as follows. In different economic periods, both fiscal expenditure and tax have significant nonlinear shock effect on TFP. First, at the aggregate level, the increase of fiscal expenditure has a significant inhibitory effect on TFP and the effect is weakened in the periods of economic boom and stability. The increase of tax has a significant promotive effect on TFP, and the effect is strengthened in the period of economic stability. Second, at the structural level, the increase of fiscal expenditure on investment, education, technology and public services would generate promotive effect on TFP. However, in the period of economic stability, there are large differences of the effects of different kinds of fiscal expenditure. For instance, the TFP effects of fiscal expenditure on investment and public services are weakened, while the TFP effects of fiscal expenditure on education and technology become negative. Third, at the structural level, there is a significant heterogeneity of the TFP effect of different taxes. The increase of commodity tax, consumption tax, value-added tax and tariff would generate significant inhibitory effect on TFP. The TFP effect of income tax increases over years, where the increase of corporate income tax and individual income tax has promotive and inhibitory effect on TFP, respectively.

Based on the above conclusions, we propose the following policy suggestions. On the one hand, the fiscal expenditure scale can be expanded moderately and the expenditure structure should be optimized. This paper finds that the increase of fiscal expenditure scale cannot effectively increase TFP, therefore, the fiscal policy should transform from scale expansion to structural optimization and thus improve the quality and efficiency of fiscal expenditure. First, the government should keep the fiscal expenditure level on investment and public services. Fiscal expenditure on investment is the major driving force to promote economic development and guide the direction of social investment, while fiscal expenditure on public services can effectively alleviate households' preventive saving motive and promote domestic demand. Therefore, the promotive effect of these two kinds of expenditure on TFP should be fully made use of. Second, the government should optimize the structure of fiscal expenditure on technology and stick to differentiated policy supply mode. Fiscal expenditure on technology should strengthen the support on strategic emerging industries. The precision-oriented fiscal expenditure system should be emphasized and form the effective evaluation mechanism of technological supports to ensure the maximization of fiscal resource utility. Third, the government should optimize the structure of fiscal expenditure on education and enhance the efficiency of fiscal expenditure on education. The government should make good resource allocation among different innovation

types and education levels, make full use of education resources to motivate innovation, optimize the rural-urban structure of education expenditure and enhance the equality of rural-urban education. At the same time, the government should actively implement education support policy, reduce the “brain drain” and waste of education resources in western China, and thus improve the use efficiency of education expenditure.

On the other hand, the commodity tax share should be reduced and the tax structure should be optimized. First, reducing the share of consumption tax, value-added tax, tariff and individual income tax in total tax revenue can effectively alleviate the tax burden of households, increase domestic demand and motivate enterprise to innovate. At the same time, by cutting the trade barrier of tariff and non-tariff, the government can promote the free trade of intermediate products, enhance the mastery of new products, new technology and new production method by enterprises and thus promote the enterprise output and production efficiency. Second, as the main source of fiscal revenue, corporate income tax can generate heterogeneous effect on TFP through macro and micro channels. Nowadays, the promotive effect of corporate income effect on TFP is more significant, so the government should maintain the tax burden on enterprise and optimize the tax structure. At the same time, more tax incentives should be appropriately given to R&D enterprises, especially small and medium-sized enterprises with strong R&D capabilities and motivations, to alleviate their financing constraints and thus encourage enterprise to innovate.

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