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Analyses of topical policy issues

Impact of the VAT reduction policy on local fiscal pressure in China in light of the COVID-19 pandemic: A measurement based on a computable general equilibrium model

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ABSTRACT

Value added tax (VAT) reduction is an important tool for cultivating new driving forces for economic development, and it has had a notable impact on local fiscal pressure. Taking the 2018–2019 VAT rate reduction in China as an example, this paper uses a CGE model to estimate the impact of the VAT reduction policy on local fiscal pressure in China in light of the COVID-19 pandemic. The results show that local fiscal pressure increased from 0.342 to 0.435, an increase of 27.08%. The study provides policy implications on optimizing tax structure and alleviating local fiscal pressure.

1. Introduction

The COVID-19 pandemic in early 2020 dealt an unprecedented blow to China's economic development. In the first quarter of this year, China's GDP fell by 6.8% year on year, while total fixed asset investment and total imports and exports dropped by 16.1% and 6.4% year on year, respectively.[1] At the same time, due to "structural deleveraging", the growth rate of total fixed asset investment in China decreased year on year, from 7.2% in 2017 to 5.4% in 2019. Slow fixed asset investment lowered the GDP growth rate from 6.95% in 2017 to 6.11% in 2019.[2] China's economy is facing tremendous downward pressure. Faced with the double pressure of the COVID-19 pandemic and domestic economic downturn, VAT reduction policy could help to reduce the operating burden on enterprises and boost the vitality of market entities, thereby easing the downward pressure on the Chinese economy and promoting high-quality development. However, amid increasing downward pressure on the Chinese economy, local governments are currently facing decreasing growth of fiscal revenue, increasing the rigidity of people's livelihood expenditures and growing fiscal pressure. The vigorous implementation of a VAT reduction policy in 2018–2019 inevitably led to a substantial reduction in local government tax revenue, thereby leading to a larger gap in fiscal revenue and expenditure and a further increase in local fiscal pressure. Therefore, it is essential to focus on the impact of the VAT reduction policy on local fiscal pressure to prevent and defuse the potential financial risks of local governments.

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1 Data from the National Bureau of Statistics in China.

2 Data from the National Bureau of Statistics of China.

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The literature has shown that as an important measure to optimize the tax structure and deepen supply-side structural reform, a VAT reduction policy can help to reduce the operating burden on market subjects, stimulate firm investment and improve their production efficiency (Cai and Harrison, 2011; Liu and Lu, 2015; Zwick and Mahon, 2017; Zhang et al., 2018). However, the increase in fiscal expenditure and decrease in tax revenue caused by the 2018–2019 VAT reduction policy may further affect the balance of local fiscal revenue and aggravate the financial pressure of local governments, resulting in an increase in debt (Guo, 2019; Zhang, 2019). Some scholars have suggested that the excessive size of government debt is not conducive to economic development and that when government debt reaches a certain critical point, an economic crisis will result (Hogan, 2004; Adam and Bevan, 2005). Previous studies have mainly focused on the empirical analysis of the economic effect of the VAT reduction policy, while research on its impact on local fiscal pressure remains scarce and limited to normative analysis, with few empirical analysis. Therefore, taking the reduction in China's VAT rate from 17% to 13% in 2018–2019 as an example, this paper uses a computable general equilibrium (CGE) model to simulate and examine the impact of the VAT reduction policy on local fiscal pressure in the context of COVID-19.

CGE is an analytical study method based on general equilibrium theory. The concept of general equilibrium was proposed by Walras in 1874. The general equilibrium solution was proved by Arrow and Debreu and CGE has since become a widely used analytical method. General equilibrium theory is often used to examine the behaviours and mutual influences of multiple markets and economic entities, and CGE models can be used to analyse fiscal and tax policies. Empirical analysis of the 2018–2019 VAT rate reduction based on the CGE model showed that, first, the VAT reduction policy stimulated the vitality of market subjects and boosted economic growth. However, due to the decrease in VAT revenue, local fiscal pressure increased from 0.342 to 0.38, an increase of 10.96%. Second, with the COVID-19 outbreak, the path of the effect of the VAT reduction policy changed, and real GDP growth rate fell from 0.21% to −6.73%. In addition, the financial resources of local governments declined sharply. Local fiscal pressure grew from 0.38 to 0.435, an increase of 14.53%. Finally, fiscal revenue and the expenditure gap accounted for almost half of local fiscal revenue, posing a significant challenge to the sustainability of local finance.

The contributions of this paper are as follows. First, a CGE model is constructed to analyse the impact of the VAT reduction policy on local fiscal pressure. Most of the literature on CGE models has used standard CGE models, without examining the impact of fiscal and tax policies on the central and local governments. Therefore, this paper divides the government module of the standard CGE model into a local government module and a central government module, and constructs the revenue and expenditure models of the central and local governments, respectively. Second, a quantitative research method is used to analyse the impact of the VAT reduction policy on local fiscal pressure. Few studies have analysed the impact of the VAT reduction policy on local fiscal pressure using an empirical method. Therefore, this paper develops a CGE model to analyse the relationship between the VAT reduction policy and local fiscal pressure and to simulate the impact of the 2018–2019 VAT rate reduction on economic growth, industrial development and local fiscal pressure, to optimize tax systems and prevent and resolve fiscal risks in China and other countries. Third, we study the impact of the COVID-19 outbreak on local fiscal pressure in China. Combined with the simulation of the COVID-19 pandemic, the fiscal pressure faced by local governments in China is measured accurately and policy recommendations are proposed to alleviate local fiscal pressure and defuse local financial risks.

Referring to the research method proposed by Chen et al. (2010), this paper also conducts a robustness test by changing the elasticity of substitution of the capital and labour elements and the elasticity of substitution of the Armington function and the CET function to verify the reliability of the research findings. The test results showed that after changing the elasticity coefficient, the growth rate of the main macroeconomic variables, the output value of various industries, and local fiscal pressure were not significantly different from the simulation results of the previous model, indicating that the model had good stability.

2. Literature review

The VAT reduction policy is not only a necessary path to fully achieve the "tax neutrality" principle of VAT and optimize resource allocation efficiency; it is also a significant way to continuously improve economic efficiency and cultivate new momentum for economic development. However, as VAT is the largest source of tax revenue in China, the VAT reduction policy should have a substantial effect on local financial pressure. CGE models are often used to analyse and study fiscal tax policy. They can also be used to quantitatively evaluate the VAT tax reduction policy effect. This paper summarizes the achievements of previous research on the VAT reduction policy in the Chinese context and CGE models. It reviews and comments on the relevant literature in the following three dimensions.

2.1. The economic effect of the VAT reduction policy

VAT reduction helps to optimize the VAT system and promote the principle of tax neutrality. It is also a key way to reduce the proportion of indirect taxes, optimize the structure of the tax system and strengthen tax macro-control capabilities (Hu and Wang, 2017; Wang et al., 2019). There have been two main streams of research on the economic effect of the VAT reduction policy in the Chinese context.

The first has addressed the influence of the VAT policy on resource allocation efficiency. Many scholars have studied how to quantitatively measure the influence of VAT transformation on enterprises' investment. These studies have shown

that reducing VAT can stimulate enterprises' fixed asset investment and improve labour and capital productivity, thus increasing resource allocation efficiency (Cai and Harrison, 2011; Wang, 2013; Zhang et al., 2018; Du et al., 2020). Lan et al. (2020) studied the influence of the 2012–2016 "Replacing Business Tax with Value-added Tax" reform in China. They showed that enterprises in the pilot areas were motivated to increase their research and development (R&D) investment, and the total factor productivity of these enterprises increased substantially.

The second stream of research has explored the influence of the VAT reduction policy on China's industrial structure. Some scholars have studied the influence of the 2012–2016 "Replacing Business Tax with Value-added Tax" reform on the industrial structure and found that it had the potential to reduce the tax burden of the service industry, increase the contribution of the tertiary industry and improve the industrial structure (Sun, 2018; Lan et al., 2020). Other scholars have studied the influence of the VAT on the transformation and upgrading of the manufacturing industry. They have predicted that too high a VAT burden will exert harmful effects on firms' innovation activities and the transformation and upgrading of the manufacturing industry (Howell, 2016; Liu et al., 2020; Qi et al., 2020).

2.2. The impact of the VAT reduction policy on local fiscal pressure

Local fiscal pressure is the pressure caused by the imbalance between fiscal revenue and expenditure by local governments. Numerous domestic and foreign scholars have mainly studied the influence of VAT reduction on local fiscal pressure in terms of the following two aspects.

First, these scholars have studied the impact of VAT reduction on local fiscal revenue. Most domestic scholars have held that the VAT reduction policy affected the tax revenue of local governments. They believed that the fiscal revenue structure of local governments changed, and that the scale of local governments' non-tax revenue would increase to fill the gap between fiscal revenue and expenditure. It is necessary to perfect the local tax system and establish the main tax category of the local government (Hwan, 2016; Yang, 2017a; Guo, 2019). Lu et al. (2016) evaluated the impact of the 2012–2016 "Replacing Business Tax with Value-added Tax" reform on local finance according to 2007–2014 provincial panel data and typical city and county panel data. Studies have shown that the 2012–2016 "Replacing Business Tax with Value-added Tax" reform had the greatest influence on the fiscal revenue of provincial and district/county governments. The scale of non-tax revenue of the grassroots government increased significantly, and the fiscal revenue and expenditure gap was very large.

Second, many scholars have studied the impact of the VAT reduction policy on local fiscal pressure. Under China's current financial system, financial rights are not compatible with the expenditure responsibilities of local finance. The difference between revenue and expenditure is prominent. After the issuance of the Budget Law of the People's Republic of China in 2015, illegal local borrowing and implicit guarantee behaviours persisted despite repeated prohibitions (Gong et al., 2011; Yang, 2017b; Zhang et al., 2020). The VAT reduction policy has reduced local fiscal revenue, increased fiscal deficits, worsened local fiscal pressure and increased the debt risk of local governments. Financial sustainability is being increasingly challenged, and financial risk has become more prominent (Guo, 2019). Mohanty (2020) argued that the fiscal deficit influences economic growth both directly and indirectly through channels of investment, interest rates, the current account deficit and the composition of government expenditure. It is therefore necessary to control the growth rate of the deficit and debt to reduce financial risks.

2.3. The application of CGE models to VAT reduction policies

Numerous domestic and foreign scholars have simulated the influence of VAT reduction policies on the macro economy using CGE models. Bye et al. (2012) simulated the Norwegian Value-added Tax Reform using a CGE model and found that non-standard VAT rates could damage residents' welfare. Chen et al. (2010) considered China's national conditions using a Keynes macro-closure CGE model. Through simulations, they found that VAT transformation had a limited effect on real GDP and led to increased unemployment. Tian and Hu (2014) simulated the impact of the 2012–2016 "Replacing Business Tax with Value-added Tax" reform on the macro economy using a dynamic CGE model and found that the "1+7" expansion had a level effect rather than a growth effect on economic growth. Wang (2016) simulated the income distribution effect of the 2012–2016 "Replacing Business Tax with Value-added Tax" policy and found that a decrease in the average VAT rate offset the adverse influence of the regressive effect of the VAT, which was a vital factor in improving income distribution. Many scholars have simulated the reduction in China's VAT rate in 2019 (Liu and Zhang, 2019; Wan and Chen, 2020). They found that the VAT reduction policy promoted economic growth, increased residents' income and improved social welfare. Takeda and Arimura (2020) used a dynamic CGE model to examine the effects of environmental tax reform in Japan and found that this reform tended to generate more desirable impacts than the pure carbon tax by improving welfare or by increasing GDP while reducing emissions.

In summary, studies in many fields have highlighted the effectiveness of VAT reduction in optimizing China's business environment and cultivating new economic development in recent years. Fruitful study results have been produced regarding the economic effect of the VAT reduction policy and its influence on local financial pressure using CGE models. The study methods used have included fixed effects models, the difference-in-differences method, the instrumental variable method and CGE models. However, there are some limitations in the literature. First, the literature on the impact of the VAT reduction policy on local fiscal pressure has focused on normative analysis, with little empirical analysis.

Second, there are some limitations in the empirical analysis of VAT reduction policies, and econometric models have been mostly used to evaluate the policy effects of VAT transformation and the 2012–2016 "Replacing Business Tax with Value-added Tax" reform. Due to the lack of data, econometric models have not been able to empirically analyse China's tax reduction policies over the past two years, such as the reduction of the VAT rate and the 2018 individual income tax reform. The advantage of CGE models over econometric models is that the data required by the models are relatively easy to obtain and can be used to evaluate China's tax policies over the past two years. In addition, CGE models can take the economic system as a whole and investigate the interaction between various sectors of the economy, to obtain more comprehensive and detailed simulation results. Therefore, relying on the 2017 Social Accounting Matrix Table, this paper builds a national CGE model that includes 42 industries to measure the effects of the 2018–2019 VAT rate reduction in China on local financial pressure influenced by the outbreak of COVID-19.

3. Methodology

To study the impact of the VAT reduction policy on local fiscal pressure against the background of the COVID-19 pandemic, this paper constructs a CGE model with 42 industries, capital factors, labour factors, residents, the central government, local governments and international trade. Each industry produces only one product. An industry is denoted by i and commodities are denoted by j. The government module of the CGE model is an innovation. By constructing the revenue and expenditure models of the central and local governments, this paper investigates the impact of the VAT reduction policy on local and central fiscal pressures. The resident module and trade module are the same as in the standard CGE model and are not repeated in this paper. The standard CGE model can be found in Chang (2010).

3.1. Production module

The standard CGE model regards VAT as a factor tax, which does not reflect the actual VAT rate in China. Therefore, referring to the research results of Wan and Chen (2020), this paper uses a two-level nested production function that includes the statutory tax rate of VAT to describe the production activities of various industries. The first level of nested functions and the value-added part of the second level of nested functions are expressed by CES functions with lower elastic values. The middle input of the second layer of nested functions is in the form of a Leontief function:

$$X_i = AP_i \cdot (\beta_i \cdot U_i^{\rho_i} + \gamma_i \cdot V_i^{\rho_i})^{\frac{1}{\rho_i}} \tag{1}$$

$$\frac{PV_i}{PU_i} = \frac{\gamma_i}{\beta_i} \cdot (\frac{U_i}{V_i})^{1-\rho_i} \tag{2}$$

$$PX_i \cdot (1 - \frac{tva_i}{1+tva_i} \cdot leiv_i - it_i - dct_i) \cdot X_i = PU_i \cdot U_i + PV_i \cdot V_i \tag{3}$$

$$V_i = AV_i \cdot \left(\gamma_{li} \cdot L_i^{\rho_i^v} + \gamma_{ki} \cdot K_i^{\rho_i^v}\right)^{\frac{1}{\rho_i^v}} \tag{4}$$

$$\frac{W}{R} = \frac{\gamma_{li}}{\gamma_{ki}} \cdot (\frac{K_i}{L_i})^{1-\rho_i^v} \tag{5}$$

$$PV_i \cdot V_i = W \cdot L_i + R \cdot K_i \tag{6}$$

$$QX_{j,i} = ut_{j,i} \cdot U_i \tag{7}$$

$$PU_i = \sum ut_{j,i} \cdot PC_j. \tag{8}$$

X_i represents the quantity of products produced by domestic production activities. AP_i indicates the scaling parameter of the CES production function for the producer. β_i and γ_i represent the coefficients of the intermediate and factor inputs. U_i and V_i represent the intermediate and factor inputs, respectively. ρ_i is related to the elasticity of substitution of the intermediate and factor inputs of the CES production function. PV_i and PU_i represent the prices of the intermediate and factor inputs, respectively. PX_i indicates the price of domestic production. tva_i represents the statutory tax rate of VAT. $leiv_i$ represents the VAT adjustment ratio. it_i is the production tax rate. dct_i represents the consumption tax rate. AV_i represents the scaling parameter of the CES function of factor inputs. γ_{li} and γ_{ki} represent the coefficients of the labour and capital inputs, respectively. ρ_i^v is the elasticity of substitution of the capital and labour elements. W and R represent the prices of the labour and capital elements, respectively. $QX_{j,i}$ represents the intermediate demand for the commodity by the producer. $ut_{j,i}$ represents the use table of intermediate demand divided by total intermediate inputs. PC_j represents the price of the commodity sold in the domestic market.

3.2. Government module

To study the impact of VAT reduction on local fiscal pressure, the government module contains central and local government revenue, expenditure and savings. The revenue of the central government comes from VAT on domestic goods, consumption tax on domestic goods, import tariff, consumption tax on imported goods, VAT on imported goods,

individual income tax and revenue provided by the local governments to the central government, as shown in Eq. (9). The revenue of local governments includes VAT on domestic goods, individual income tax, production tax and transfer payments and tax returns by the central government to the local governments, as shown in Eq. (10):

$$FGY = svtf \cdot \sum DVAT_i + \sum IMTX_j + \sum IMVT_j + \sum IMCT_j + \sum DCT_j + shtf \cdot HHTX + LGTG0 \tag{9}$$

$$LGY = \sum IDTX_j + (1 - svtf) \cdot \sum DVAT_i + (1 - shtf) \cdot HHTX + FGTG0 \tag{10}$$

$$FGC_j \cdot PC_j = \alpha_{fg} \cdot (FGE - FGTH0 - FGTG0) \tag{11}$$

$$LGC_j \cdot PC_j = \alpha_{lg} \cdot (LGE - LGTH0 - LGTG0) \tag{12}$$

$$FGS = FGY - FGE \tag{13}$$

$$LGS = LGY - LGE. \tag{14}$$

FGY and FGY represent the revenue of the central and local governments, respectively. $DVAT_i$ represents VAT on domestic goods. $IMTX_j$ is the import tariff. $IMVT_j$ indicates VAT on imported goods. $IMCT_j$ represents consumption tax on imported goods. DCT_j indicates consumption tax on domestic goods. $HHTX$ is the individual income tax. $LGTG0$ represents the revenue provided by local governments to the central government. $svtf$ and $shtf$ represent the central government's share ratios of VAT on domestic goods and individual income tax, respectively. $IDTX_j$ is the production tax. $FGTG0$ represents the transfer payments and tax returns by the central government to local governments. FGC_j and LGC_j represent the purchase expenditures of the central and local governments, respectively, on commodity j. α_{fg} and α_{lg} indicate the proportions of the purchase expenditures of the central and local governments, respectively, on commodity j. FGE and LGE represent the expenditures of the central and local governments, respectively. FGS and LGS represent the savings of the central and local governments, respectively.

3.3. Investment module

Total domestic investment consists of investments in all sectors, as shown in Eq. (15). $TINV$ represents total investment. INV_j represents investment by commodity.

$$TINV = \sum_j INV_j \cdot PC_j \tag{15}$$

3.4. Equilibrium and macro closure

Model equilibrium requires a balance of supply and demand in the domestic commodity market, factor market and international foreign exchange market, as shown in Eqs. (16), (17), (18) and (19). In addition, we add the dummy variable $WALRAS$ to the investment and savings identity to test whether the model settings are correct, as shown in Eq. (20). Some variables must be fixed as exogenous to ensure that the model is solvable. Considering the exogenous effects of the COVID-19 pandemic on the investment of all sectors and the labour supply, this paper fixes investment by commodity and labour endowment as exogenous variables. In terms of equilibrium in the domestic commodity market, central and local fiscal expenditures are taken as exogenous variables. For the international foreign exchange market, the exchange rate (EXR) and foreign savings ($FSAV$) are fixed as exogenous variables because China is a developing country. It cannot have too great a deficit or fluctuation in the balance of payments (Chang, 2010).

$$QC_j = \sum QX_{j,i} + HC_j + FGC_j + LGC_j + INV_j \tag{16}$$

$$\sum L_i = LS \tag{17}$$

$$\sum K_i = KS \tag{18}$$

$$\sum PIMP_j \cdot IMP_j = \sum PEXP_j \cdot EXP_j + FSAV \tag{19}$$

$$TINV = (1 - mpc) \cdot (1 - hht) \cdot HY + FGS + LGS + FSAV + WALRAS \tag{20}$$

$$LS = \overline{LS} \tag{21}$$

$$INV_j = \overline{INV_j} \tag{22}$$

$$FGE = \overline{FGE} \tag{23}$$

$$LGE = \overline{LGE} \tag{24}$$

$$EXR = \overline{EXR} \tag{25}$$

$$FSAV = \overline{FSAV} \tag{26}$$

HC_j represents the residents' consumption of product j. *KS* is the labour endowment and *KS* is the capital endowment. *mps* represents residents' consumption tendency. *hht* is the individual income tax rate. *EXR* represents the exchange rate. *FSAV* represents foreign savings.

4. Data

A social accounting table, also called a social accounting matrix (SAM), is used to demonstrate the national economic accounting system. Various components of the social economic system and their relations are displayed in a matrix table, which provides the necessary data foundation for macroeconomic analysis. The data in this paper come from the 2017 SAM produced by the Centre for Economic Systems Simulation Research in China. The table is based on the 2017 Input–Output Table issued by the National Bureau of Statistics, and uses statistics data from the *2017 China Statistical Yearbook*, *China Fiscal Yearbook 2018* and *China Tax Yearbook 2018*. The 2017 SAM table includes 42 industries, 42 types of goods and services, labour factors, capital factors, residents, local governments, the central government, production tax, domestic goods VAT, import tariff, imported goods consumption tax, imported goods VAT, domestic goods consumption tax, individual income tax and foreign and investment accounts. Government is divided into central and local governments, and government consumption is divided into local government consumption and central government consumption. Government consumption in the SAM table is assumed to be provided by the local governments, and the data come from "Government Consumption Expenditure" in the 2017 Input–Output Table. The transfer payments from the central and local governments to residents, those from local governments to the central government and those from the central government to local governments all come from the *China Fiscal Yearbook 2018*.[3]

This paper uses the SAM table to calibrate and estimate related parameters such as the scaling parameter of the CES production function for producers, the scaling parameter of the CES function of factor inputs and the scaling parameter of the transformation function. This paper refers to the research results of Zheng and fan (1998) and Pang et al. (2018) regarding the elasticity of substitution of the intermediate and factor inputs of the CES production function, the elasticity of substitution of the capital and labour elements and the elasticity of substitution of the Armington function and the CET function. For the robustness test, the elasticity coefficient is based on GTAP7 data.

5. Important indicators

5.1. Local fiscal pressure

After the tax-sharing system reform, the transfer payment system was established, and to a certain extent, the transfer payments from the central government to local governments made up for the vertical gap in local government revenue and expenditure. Fan (2015) proposed that a large number of transfer payments contributed to the gradual annual increase in the share of local governments in the fiscal revenue redistribution process. For example, in 2018, the redistributed fiscal revenue nearly doubled, rising from CNY9.7904 trillion to CNY17.9898 trillion. Therefore, the primary fiscal revenue and expenditure gap is insufficient to accurately measure local fiscal pressure. To measure local fiscal pressure more accurately, referring to the findings of Wang and Gu (2019), this paper adds the revenue provided by local governments to the central government to the formula for calculating local fiscal pressure, and subtracts the transfer payments and tax returns from the central government to local governments:

local fiscal pressure = (the expenditures of local public finance + the revenue provided by local governments to the central government – the transfer payments and tax returns by the central government to local governments – the revenue of local public finance)/(the revenue of local public finance + the transfer payments and tax returns by the central government to local governments)

5.2. VAT adjustment ratio

As there are tax relief measures in China's "Provisional Regulations on Value-Added Tax", such as preferential tax, tax rebates after levies and tax refunds, and as the deduction mechanism is implemented for VAT, the theoretical VAT amount calculated differs greatly from the actual VAT payable of the industry in the Input–Output Table. To ensure the correct calculation of the CGE model, this paper refers to the approach of Tian and Hu (2014) and introduces a VAT adjustment ratio for adjustment.

VAT adjustment ratio $= fdvat_i/(PX_i \cdot X_i \cdot tva_i/(1 + tva_i))$. $fdvat_i$ represents the actual VAT payable of the industry.

[3] The above explanation comes from the *Compilation Instructions and Guidelines of Social Accounting Matrix in China* produced by the Centre for Economic Systems Simulation Research in China in February 2020.

Table 1
The impact of the reduction in the VAT rate from 17% to 13% on China's economy (Unit: 100 million yuan).

Variable	Original value	Tax reduction	Rate of rise	Pandemic + tax reduction	Rate of rise
Actual GDP	842 345.90	844 126.08	0.21%	785 622.38	−6.73%
Residents' income	773 801.32	787 629.70	1.79%	735 355.01	−4.97%
Residents' consumption	320 503.40	323 810.40	1.03%	287 900.94	−10.17%
Public fiscal revenue of the local government	61 283.09	57 849.01	−5.60%	53 128.37	−13.31%
Public fiscal revenue of the central government	64 688.12	60 993.11	−5.71%	56 574.33	−12.54%
Local fiscal pressure	0.342	0.380	10.96%	0.435	27.06%
Central fiscal pressure	0.002	0.061	2697.56%	0.142	6372.32%
Value-added tax	56 131.61	47 587.72	−15.22%	44 270.75	−21.13%
Consumption tax	10 393.97	10 513.66	1.15%	9841.38	−5.32%
Production tax	28 428.23	29 181.50	2.65%	26 442.82	−6.98%
Individual income tax	11 960.50	12 174.24	1.79%	11 366.24	−4.97%
Total export	164 037.12	166 356.38	1.41%	151 998.26	−7.34%
Total import	134 178.67	136 497.92	1.73%	125 125.64	−6.75%
Total investment	368 182.72	368 942.40	0.21%	348 191.69	−5.43%

6. Empirical results and interpretation

6.1. The impact of VAT reduction in 2018–2019 on China's macro economy and local fiscal pressure

VAT reduction is an important tool for China to vigorously promote tax and expenditure reductions and to deepen supply-side structural reform. From the 2012–2016 "Replacing Business Tax with Value-added Tax" reform to the significant drop in the VAT rate in the manufacturing industry in 2019, VAT reform has deepened and has played a major role in optimizing the business environment and stimulating the vitality of market entities. This paper mainly studies the effect of the reduction in China's VAT rate from 17% to 13% in 2018–2019 on China's macro economy and local fiscal pressure. Using GAMS to simulate the impact of the VAT reduction, *WALRAS* is equal to 0.000287 and the value of the dummy variable is close to 0, indicating no error in the model setting.

"Tax reduction" in Tables 1 and 2 reflects the impact of the VAT reduction policy in 2018–2019 on China's macro economy and local fiscal pressure. The VAT rate was reduced from 17% to 13%, and China's actual GDP increased by 0.21%, which indicates that the VAT reduction policy promoted national economic growth. In addition, residents' income and total consumption increased by 1.79% and 1.03%, respectively. People's standard of living improved, and the increase in residents' consumption expanded total social demand, thereby stimulating economic growth. Export and investment increased by 1.41% and 0.21%, respectively, indicating that the VAT reduction had reduced business costs and product prices and enhanced the competitiveness of China's exported products. The policy also stabilized expectations and stimulated the investment demand of market entities.

Both central and local public fiscal revenue decreased significantly, by 5.71% and 5.6%, respectively. The decrease in central public fiscal revenue was slightly greater than that in local revenue. The reduction in local public fiscal revenue caused local fiscal pressure to rise from 0.342 to 0.38, an increase of 10.96%, and central fiscal pressure rose from 0.002 to 0.061, increasing 29-fold. The gap between central and local fiscal revenue and expenditure was significantly enlarged due to the reduction of the VAT rate. The gap between the revenue and expenditure of local governments was particularly prominent, and the resulting local debt problems greatly threatened fiscal sustainability. VAT revenue decreased by 15.19%, and revenue from other production taxes, consumption tax and individual income tax increased by 2.65%, 1.15% and 1.79%, respectively, due to increases in the outputs of various industries and residents' income. Although the VAT reduction policy expanded the government's tax foundation and developed tax sources, on the whole, the VAT revenue decreased significantly, and the increase in revenue from other taxes could do little to hedge against the fiscal risks brought about by the decrease in VAT revenue.

Of the 42 industries, 38 experienced increases in output value. The textile industry grew the fastest, with a growth rate of 2.18%. The manufacturing industry benefited from the VAT reduction policy, and most industries grew by about 1.5%, reflecting China's strong support for the manufacturing industry. The growth rate of the service industry was relatively slow, and some industries had negative growth. Because the 6% tax rate of the service industry was not changed, the reduction in the tax rates of other industries made the input tax deductible relatively low, and thus the industry's tax burden relatively increased.

6.2. The impact of the pandemic on the effect of the VAT reduction policy in 2018–2019

The COVID-19 pandemic of early 2020 brought unprecedented difficulties, risks and challenges to China's economic development. On the demand side, the pandemic greatly reduced the flow of people and materials, and people's consumption of food, clothing, housing and transportation were significantly affected. In particular, consumption in concentrated service industries such as tourism, catering and accommodation, culture and entertainment and transportation was greatly affected. As the pandemic brought uncertainty to the lives of Chinese residents, residents developed preventive

Table 2
The impact of the reduction in the VAT rate from 17% to 13% on the output of 42 industries (Unit: 100 million yuan).

Industry	Original value	Tax reduction	Rate of rise	Pandemic + tax reduction	Rate of rise
Agriculture, forestry, animal husbandry and fishery products and services	110 116.15	111 830.46	1.56%	100 072.49	−9.12%
Coal mining and processing	21 945.82	22 409.48	2.11%	20 942.51	−4.57%
Oil and gas exploration	11 669.49	11 775.32	0.91%	11 318.89	−3.00%
Metal mining and dressing	11 627.31	11 818.76	1.65%	11 253.63	−3.21%
Mining and dressing of nonmetallic and other minerals	9004.75	9134.08	1.44%	8626.62	−4.20%
Food and tobacco	126 223.68	128 315.44	1.66%	115 002.44	−8.89%
Textile	37 925.66	38 754.20	2.18%	35 667.34	−5.95%
Clothing, Shoes, Hats, Leather, Eiderdown and its products	37 802.34	38 411.79	1.61%	35 039.42	−7.31%
Wood products and furniture	25 646.51	25 946.84	1.17%	24 350.58	−5.05%
Paper making, printing and sports goods	39 375.68	40 060.77	1.74%	37 234.19	−5.44%
Petroleum, Coking products and Nuclear fuel	37 646.66	38 361.89	1.90%	35 893.43	−4.66%
Chemical products	149 061.21	151 824.21	1.85%	142 104.30	−4.67%
Nonmetallic mineral products	64 934.98	65 479.97	0.84%	62 136.89	−4.31%
Metal smelting and rolling	104 575.11	106 155.81	1.51%	100 244.26	−4.14%
Metal products	42 920.78	43 444.04	1.22%	40 917.44	−4.67%
General equipment	45 153.01	45 654.33	1.11%	42 989.65	−4.79%
Specialized equipment	34 915.46	35 184.32	0.77%	33 327.38	−4.55%
Transportation equipment	86 691.70	87 716.29	1.18%	82 135.49	−5.26%
Electrical machinery and equipment	60 247.20	60 967.59	1.20%	56 916.41	−5.53%
Communication equipment, computers and other electronic equipment	95 877.34	97 446.63	1.64%	91 059.97	−5.02%
Instrumentation	8507.48	8643.21	1.60%	8194.41	−3.68%
Other manufacture	3744.84	3798.04	1.42%	3545.98	−5.31%
Waste and Scrap	6611.88	6686.83	1.13%	6412.69	−3.01%
Metal products, machinery and equipment repair services	1490.28	1513.12	1.53%	1419.03	−4.78%
Production and supply of electricity and heat	55 561.60	56 657.11	1.97%	52 851.62	−4.88%
Gas production and supply	5422.09	5521.53	1.83%	5066.73	−6.55%
Hydraulic production and supply	2490.92	2524.49	1.35%	2318.07	−6.94%
Construction	228 787.25	228 849.69	0.03%	217 424.98	−4.97%
Wholesale and retail	115 856.67	117 947.20	1.80%	109 214.25	−5.73%
Transport, storage and post	102 566.46	104 100.98	1.50%	97 126.67	−5.30%
Accommodation and catering	38 083.60	38 399.62	0.83%	35 362.86	−7.14%
Information transmission, software and information technology services	56 537.01	56 932.77	0.70%	53 436.45	−5.48%
Financial industry	94 346.15	95 552.16	1.28%	88 609.20	−6.08%
Real estate	78 310.44	78 957.24	0.83%	73 367.15	−6.31%
Leasing and business services	71 792.93	72 979.72	1.65%	67 995.04	−5.29%
Scientific research and technical services	51 055.16	51 204.24	0.29%	49 041.02	−3.95%
Water conservancy, environment and public facilities management	9258.28	9227.93	−0.33%	9027.45	−2.49%
Residential services, repairs and other service departments	26 958.86	27 210.39	0.93%	24 810.82	−7.97%
Education	36 783.17	36 539.50	−0.66%	34 288.73	−6.78%
Health and social work	41 520.62	41 428.85	−0.22%	39 476.30	−4.92%
Culture, sports and entertainment	13 720.09	13 704.25	−0.12%	12 848.62	−6.35%
Public administration, social security and social organizations	55 579.97	54 838.45	−1.33%	53 840.47	−3.13%

approaches, and their willingness and propensity to consume declined greatly. According to the related data of the National Bureau of Statistics of China, in the first quarter of 2020, the total retail sales of consumption goods nationwide decreased by 19% relative to the same period in the previous year, catering revenues decreased by 44.3% and goods retail sales decreased by 15.8%. China's national fixed asset investment also decreased significantly. According to the related data of the National Bureau of Statistics of China, fixed asset investment decreased by 6.3% between January and May 2020, and infrastructure investment decreased by 6.3 relative to the same period in the previous year.

On the supply side, industrial companies encountered difficulties after the 2020 Spring Festival. To effectively prevent and control the pandemic, 23 provincial administrative regions, including Beijing and Hebei province, stipulated that companies could not resume work earlier than February 9, and Hubei province postponed the resumption of work to after March 10. Large-scale work suspension and insufficient resumption of work across the country caused huge difficulties for business operations, causing companies to shut down due to cost pressure, leading to rising unemployment and decreased social stability. According to data from the National Bureau of Statistics of China, the national urban unemployment rate in February was 6.2%, which was the highest since the unemployment survey began in 2018.

The outbreak of COVID-19 also had a notable impact on the global economy and trade. The World Trade Organization released its 2020–2021 trade growth forecast on April 8, 2020. The optimistic estimation was that the total global trade volume would decrease by 13%, and the pessimistic estimation was that it would decrease by 32%. According to the data disclosed by China Customs, China's total import and export volume in the first quarter of 2020 decreased by 6.4%, and its trade surplus decreased by 80.6% compared with the same period in the previous year. Based on the above effects of the COVID-19 pandemic on the demand side, supply side and international trade, the following impacts are inferred: residents' propensity to consume decreased by 5%, investment of various departments decreased by 5%, labour supply

decreased by 10% and net exports decreased by 10%. Under the impact of the COVID-19 pandemic, *WALRAS* is equal to 0.0000223 and the value of the dummy variable is close to 0, indicating no error in the condition settings to simulate the pandemic situation.

"Pandemic + tax reduction" in Tables 1 and 2 reflects the impact of the pandemic on the effect of the 2018–2019 VAT reduction policy. Compared with the effect of the VAT reduction policy in 2018–2019, the actual GDP growth rate decreased from 0.21% to −6.73%. The reason for this significant drop was that the growth rates of the "troika" – residents' consumption, investment and exportation – decreased from 1.03%, 0.21% and 1.41% to −10.17%, −5.43% and −7.34%, respectively. Residents' income also dropped substantially, with the growth rate decreasing from 1.79% to −4.97%. In addition, the original economic growth path deviated due to the impact of the pandemic. The positive effect of the 2018–2019 VAT reduction policy on economic development was offset by the impact of the pandemic, resulting in a full depression of economic aggregate and total demand. Thus, against the background of the pandemic, China faces great pressure to prevent the economy from moving downward. Active fiscal policy is needed to vigorously improve quality and enhance efficiency, and moderately loose monetary policy is needed to mitigate economic fluctuations and ensure stable and sustainable economic development.

Due to the impact of the COVID-19 pandemic, the growth rate of the public fiscal revenue of the central and local governments dropped from −5.71% and −5.6% to −12.54% and −13.31%, respectively, and the government's fiscal power was severely weakened. Local fiscal pressure rose from 0.38 to 0.435, and central fiscal pressure more than doubled, increasing from 0.061 to 0.142. Although the increase in local fiscal pressure was smaller than that of central fiscal pressure, against the background of the COVID-19 pandemic, the VAT reduction policy increased local fiscal pressure to 0.435, and the gap between local governments' revenue and expenditure was about half of that of local fiscal revenue. Fiscal risks cannot be ignored, and fiscal sustainability faces great challenges. Fiscal sustainability is necessary to guarantee the country's macro-control capabilities and long-term stability. Although China is currently concerned primarily with health-related risks, economic risks and financial risks, it must also pay attention to and prevent potential fiscal risks. The growth rates of the VAT, consumption tax, production tax and individual income tax decreased from −15.22%, 1.15%, 2.65% and 1.79% to −21.13%, −5.32%, −6.98% and −4.97%, respectively. Production taxes, an important source of income for local governments, decreased the most, reinforcing the fact that local governments' fiscal pressure is increasing.

The total output of 42 industries declined due to the impact of the COVID-19 pandemic. Agriculture, forestry, animal husbandry and fishery products and services and food and tobacco were affected the most by the pandemic, with their growth rates decreasing from 1.56% and 1.66% to −9.12% and −8.89%, respectively. Resident service, repair and other service departments, gas production and supply, water production and supply, accommodation and catering, and education, culture and entertainment were also affected to a great extent, with decreases of about 8%. As industries related to the national economy and people's livelihood were affected the most by the pandemic, the government should strengthen assistance to enterprises in such industries, introduce tax relief policies and implement measures based on local conditions to maximize the effectiveness of tax policies in alleviating the effects of emergencies.

6.3. Robustness test

The impact of the VAT reduction policy on the macro economy and local fiscal pressure is closely related to the elasticity of substitution of the capital and labour elements and the elasticity of substitution of the Armington function and the CET function. The simulation in Tables 1 and 2 uses the elasticity of substitution of the capital and labour elements and the elasticity of substitution of the Armington function and the CET function, which were estimated by Zheng and fan (1998). The elasticity of substitution of the intermediate and factor inputs of the CES production function is based on the research results of Pang et al. (2018). Estimation errors can affect the simulation results and conclusions of the model. Therefore, this paper refers to the research method proposed by Chen et al. (2010) and tests the robustness of the research results by changing the size of the relevant elastic values. The elasticity coefficient used in the robustness test is based on GTAP7 data.

Tables 3 and 4 show the changes in the main macroeconomic variables, the output value of various industries and fiscal pressure after changing the elasticity coefficient. Affected by the impact of the VAT reduction policy, China's real GDP grew by 0.18% (the real GDP growth rate in the original model was 0.21%) and local fiscal pressure increased from 0.342 to 0.379 (local fiscal pressure estimated with the original model increased from 0.342 to 0.38). With the COVID-19 outbreak, the path of the effect of the VAT reduction policy changed, the real GDP growth rate fell from 0.18% to −6.73% (the real GDP growth rate in the original model fell from 0.21% to −6.73%) and local fiscal pressure increased from 0.38 to 0.431 (local fiscal pressure estimated with the original model increased from 0.38 to 0.435). These results are somewhat consistent with the simulation results of the original model, and the growth rate of other macroeconomic variables and the output value of various industries are also slightly different, indicating the stability of the model and the reliability of the simulation results.

7. Conclusion and recommendations

7.1. Conclusion

VAT reduction is necessary to reduce enterprises' business costs and assist market entities in overcoming difficulties and realizing development. Based on the simulation results, the 2018–2019 VAT rate reduction stimulated the vitality

Table 3
The impact of the reduction in the VAT rate from 17% to 13% on China's economy (Change elasticity, unit: 100 million yuan).

Variable	Original value	Tax reduction	Rate of rise	Pandemic + tax reduction	Rate of rise
Actual GDP	842 419.03	843 902.44	0.18%	785 685.68	−6.73%
Residents' income	773 708.59	788 304.37	1.89%	737 974.95	−4.62%
Residents' consumption	320 530.89	323 706.70	0.99%	287 717.32	−10.24%
Public fiscal revenue of the local government	61 276.94	57 918.13	−5.48%	53 440.23	−12.79%
Public fiscal revenue of the central government	64 693.87	60 993.86	−5.72%	56 874.48	−12.09%
Local fiscal pressure	0.342	0.379	10.71%	0.431	25.93%
Central fiscal pressure	0.002	0.061	2812.35%	0.136	6361.11%
Value-added tax	56 129.89	47 602.94	−15.19%	44 414.82	−20.87%
Consumption tax	10 392.79	10 522.40	1.25%	9877.79	−4.96%
Production tax	28 423.52	29 238.81	2.87%	26 666.43	−6.18%
Individual income tax	11 959.06	12 184.73	1.89%	11 406.73	−4.62%
Total export	164 100.16	166 192.39	1.27%	153 238.23	−6.62%
Total import	134 241.70	136 333.93	1.56%	126 365.62	−5.87%
Total investment	368 129.42	369 399.52	0.35%	350 352.54	−4.83%

Table 4
The impact of the reduction in the VAT rate from 17% to 13% on the output of 42 industries (Change elasticity, unit: 100 million yuan).

Industry	Original value	Tax reduction	Rate of rise	Pandemic + tax reduction	Rate of rise
Agriculture, forestry, animal husbandry and fishery products and services	110 119.82	111 881.70	1.60%	101 003.36	−8.28%
Coal mining and processing	21 946.98	22 392.56	2.03%	20 893.38	−4.80%
Oil and gas exploration	11 668.95	11 747.87	0.68%	11 063.95	−5.18%
Metal mining and dressing	11 627.57	11 825.97	1.71%	11 098.32	−4.55%
Mining and dressing of nonmetallic and other minerals	9004.62	9133.13	1.43%	8601.03	−4.48%
Food and tobacco	126 235.04	128 346.92	1.67%	115 489.10	−8.51%
Textile	37 840.04	38 716.87	2.32%	36 121.44	−4.54%
Clothing, Shoes, Hats, Leather, Eiderdown and its products	37 733.23	38 359.04	1.66%	35 336.00	−6.35%
Wood products and furniture	25 620.70	25 977.37	1.39%	24 444.70	−4.59%
Paper making, printing and sports goods	39 356.98	40 102.86	1.90%	37 227.76	−5.41%
Petroleum, Coking products and Nuclear fuel	37 647.91	38 352.48	1.87%	35 753.17	−5.03%
Chemical products	149 035.93	151 647.53	1.75%	141 434.28	−5.10%
Nonmetallic mineral products	64 931.72	65 471.84	0.83%	61 975.53	−4.55%
Metal smelting and rolling	104 592.24	105 990.33	1.34%	99 563.54	−4.81%
Metal products	42 914.21	43 415.48	1.17%	40 756.71	−5.03%
General equipment	45 155.86	45 543.29	0.86%	42 715.83	−5.40%
Specialized equipment	34 923.44	35 124.46	0.58%	33 160.78	−5.05%
Transportation equipment	86 686.14	87 617.07	1.07%	81 752.68	−5.69%
Electrical machinery and equipment	60 271.17	60 728.38	0.76%	56 383.99	−6.45%
Communication equipment, computers and other electronic equipment	96 258.04	96 530.53	0.28%	89 639.50	−6.88%
Instrumentation	8516.05	8616.50	1.18%	8100.09	−4.88%
Other manufacture	3743.44	3790.66	1.26%	3534.17	−5.59%
Waste and scrap	6612.79	6659.49	0.71%	6315.52	−4.50%
Metal products, machinery and equipment repair services	1490.22	1511.57	1.43%	1417.65	−4.87%
Production and supply of electricity and heat	55 563.35	56 619.01	1.90%	52 728.31	−5.10%
Gas production and supply	5421.64	5522.12	1.85%	5054.61	−6.77%
Hydraulic production and supply	2491.01	2523.48	1.30%	2312.47	−7.17%
Construction	228 786.24	228 852.12	0.03%	217 404.08	−4.98%
Wholesale and retail	115 842.43	118 075.42	1.93%	109 355.15	−5.60%
Transport, storage and post	102 548.32	104 202.03	1.61%	96 965.35	−5.44%
Accommodation and catering	38 084.09	38 434.15	0.92%	35 347.84	−7.18%
Information transmission, software and information technology services	56 539.23	56 972.69	0.77%	53 329.73	−5.68%
Financial industry	94 346.62	95 558.52	1.28%	88 393.51	−6.31%
Real estate	78 295.67	78 940.17	0.82%	72 734.53	−7.10%
Leasing and business services	71 793.41	73 023.95	1.71%	67 955.02	−5.35%
Scientific research and technical services	51 056.83	51 228.15	0.34%	48 953.25	−4.12%
Water conservancy, environment and public facilities management	9258.49	9227.67	−0.33%	8985.17	−2.95%
Residential services, repairs and other service departments	26 962.48	27 207.69	0.91%	24 838.05	−7.88%
Education	36 794.95	36 523.32	−0.74%	34 435.40	−6.41%
Health and social work	41 531.85	41 403.13	−0.31%	39 535.45	−4.81%
Culture, sports and entertainment	13 720.90	13 726.65	0.04%	12 865.51	−6.23%
Public administration, social security and social organizations	55 604.93	54 794.28	−1.46%	54 116.89	−2.68%

of market entities and expanded total demand, thereby stimulating economic growth. The actual GDP rose by 0.21%, and residents' income, residents' consumption, total investment, total export amount and the output value of various industries increased substantially, but due to the reduction of VAT revenue, local fiscal pressure increased from 0.342 to 0.38, an increase of 10.96%.

The outbreak of COVID-19 brought unprecedented difficulties and challenges to China's economic development and changed the path of the effect of the VAT reduction policy. The actual GDP growth rate decreased from 0.21% to −6.73%, and residents' income, residents' consumption, total investment, total export amount and the output value of various industries all decreased substantially. In addition, the fiscal power of local governments was severely weakened. Local fiscal pressure rose from 0.38 to 0.435, an increase of 14.53%. The gap between local governments' revenue and expenditure was nearly half of local fiscal revenue, posing a great challenge to the sustainability of local finance. Although China is deepening its VAT reform, it must place great emphasis on preventing potential risks to local finance.

7.2. Recommendations

The VAT reduction policy is a necessity in the context of supply-side structural reform, and it is important for overcoming the difficulties resulting from the pandemic. It is therefore vital to deepen VAT reform while taking into consideration China's structural and cyclical contradictions as well as COVID-19. In the meantime, it is necessary to prevent fiscal risks and maintain fiscal stability to deal with the economic and health-related risks, guarantee China's long-term stability and enable tax reductions and fee cuts. Not only should the VAT reduction policy be vigorously implemented, but efforts should also be made to prevent and reduce financial risks and to guarantee the sustainability of finance. This paper puts forward the following policy suggestions.

First, it is important to strengthen budget performance management and improve fund utilization efficiency. The comprehensive implementation of budget performance management is an internal requirement for promoting the modernization of the national governance system and governance capacity. Above all, we need to build a scientific performance evaluation system with unified standards to objectively reflect the actual use efficiency of financial funds and to guarantee that budget performance is scientific and impartial. It is also necessary to accelerate informatization construction and establish a budget performance management chain covering all aspects of performance evaluation, performance objectives and performance monitoring. Lastly, we should perfect the performance evaluation system and performance accountability mechanism, implement performance accountability for the ineffective use of budget funds, mismatching and failure to reach expected goals, as well as to reward projects and organizations with high fund utilization efficiency.

Second, it is necessary to reduce general expenditure to guarantee people's livelihoods. Downward pressure on the economy is increasing, and the contradiction between local financial revenue and expenditure is becoming increasingly prominent. A key way to relieve local fiscal pressure is to optimize the fiscal expenditure structure and improve the efficiency of the use of budget funds. Expenditures without budgets and over-budgeted arrangements should be prohibited. The accuracy and effectiveness of the usage of budget funds should be improved. The boundary between the government and the market should be clarified, the scope of local government budget expenditures should be clearly defined, and lists of negatives should be formulated. Furthermore, problems with the government's arbitrary intervention in the market should be addressed using the list system.

Third, it is vital to reform the finance and taxation management system to increase financial resource coordination between the central and local governments. Establishing a central–local fiscal relationship with clear rights and responsibilities, coordinated financial resources and balanced regions will improve work enthusiasm of the central and local governments. It will also provide significant support for local governments to support people's livelihoods and social security. The VAT reduction policy has led to increased pressure on the sustainable finance of local governments. Because the central government has the power to change the relationship between the financial and property rights of the central and local governments, it is essential to advance the fundamental reforms of the fiscal and tax systems at the national level and establish a fair relationship between the financial and property rights of the central and local governments. This will reduce the financial pressure on local governments.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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