An Empirical Analysis of the Effects of Chinese Government Fiscal Policy on GDP Growth based on data frequency

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Abstract. This paper offers an empirical analysis of the effects of fiscal policy on economic growth. We use vector auto regression technique（VAR-SVAR）to distinguish stabilizing，discretionary and promoting effects of government fiscal variables in China on its GDP growth based on data frequency. The variables used here are government expenditure, tax revenue, and GDP, and the index for all these variables are monthly, quarterly and annually time series data, among them annually data covering the period of 1952 to 2022 and monthly, quarterly data covering from 1998-1 to 2022-4. The empirical results indicate that the effects of Chinese government fiscal policy do exist and the GDP growth systematically react to the changes of these fiscal variables. But the effects based on monthly, quarterly data and annually data are different especially on promoting effect, this is something should be studied further more.

Keywords: Data frequency, Government fiscal policy, Effects of fiscal variables, GDP growth.

1. Introduction

Fiscal policy has two major instruments, government expenditure and tax revenue. These two major instruments have been frequently used to adjust the running of the economy on the whole and the effects of the adjustment are subjects of many researchers, especially in recent years. VAR-SVAR is a popular method often used.   Barro (1990) and Bagliano, F.C. and C.A. Favero (1998) tried to identify the effects of fiscal variables on GDP within the framework of this technique. Wang Xiaoli (2007, 2008), did an Empirical Study about the Substitution and Complementary Effects of Chinese Government's Public Expenditure on its GDP's Growth, and paid great attention on the long run and short run effects. Charl, J, Guangling (Dave) L., and Ruthiv, N (2013) identified discretionary policy as unexpected policy shocks and thereby separate the discretionary policy component from any systematic and predictable policy move. Blanchard and Protti 2002, Chen S W. (2014) attempted to construct a structural VAR model and isolated the response of the macroeconomic system to a particular exogenous policy shock and recovered the ones that are related to unexpected government expenditures and tax revenues within the specified system. Some other analyses focus on fiscal sustainability (Chen S W.2014), (Afronso A, Jalles J T., 2015) and so on. But these studies mentioned above do not pay great attention to data frequency problem, some of them use annually data (such as Wang Xiaoli, etc) and some of them use quarterly data (such as Blanchard and Protti, etc), Some of them use monthly data. This is something should be considered because government policy adjustment is very complex and cumbersome to perform, different duration may have different effects, and these effects include stabilizing, discretionary and promoting effects, some of them are existing in its system designing and some of them are existing in the performance of the policy. So, ignoring the relation between data frequency and the effects of the fiscal policy is questionable.

This paper pays more attention on this problem. That is to distinguish stabilizing, discretionary and promoting effects of government spending on economic growth based on data frequency. We believe that data frequency has played a important role in distinguishing these effects because different policy effects can be involved within different time duration. Different data frequency should have different policy effect because government do need some time to adjust its fiscal policy based on the economic situation. Using different frequency data will help us to steer clear of fiscal policy effects on the whole.

2. Methodological Issues

For a stochastic process Yt based on $\{y_{t-1}, y_{t=2,....}\}$, we can prove that the conditional expectation E(Yt) is the best linear estimation which can be represented by Yt*. That is: Yt*= E (Yt/Yt-1, Yt-2……). If the information ut = Yt- Yt*= Yt- E (Yt/Yt-1, Yt-2……) is not based on this stochastic process Yt , we call it innovation. innovation (ut) is also a stochastic process and should abbey a normal distribution with the features of E{ut} = 0, E{ut ut '} = σ^2 , E (ut/Xt-1)=0. If we define (Xt-1) is the information (or data) previous a time period T, and {ut} is the innovation corresponding to (Xt-1). We can express this process like this:

Yt= C+Θ Yt-1+ et

(I-Θ L) Yt= C+ et

Yt= (I-Θ L)-1C+(I-Θ L)-1 et ,

$Yt = \mu + \sum_{i=0}^{\infty} \Theta^i L^i e_t = \mu + \sum_{i=0}^{\infty} \Theta^i e_{t-i}$

If we assume it is only a 2-dimesion-process, and then the idea above can be simply expressed like this:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \theta_{11}(i) & \theta_{12}(i) \\ \theta_{21}(i) & \theta_{22}(i) \end{bmatrix} \begin{bmatrix} e_{1t-1} \\ e_{2t-1} \end{bmatrix}$$

Here $\Theta = \begin{bmatrix} \theta_{11}(i) & \theta_{12}(i) \\ \theta_{21}(i) & \theta_{22}(i) \end{bmatrix}$, and matrix component $\theta_{jk}(i)$ is a multiplier. $\theta_{11}(0)$ represents how many units yt will change at t moment after one unit time if et can change one unit at t moment. $\theta_{11}(1)$ denotes how many units y will change after t+1 moment while et can change one unit at t moment (the same for other items).

$$\begin{bmatrix} y_{1t+s} \\ y_{2t+s} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \theta_{11}(i) & \theta_{12}(i) \\ \theta_{21}(i) & \theta_{22}(i) \end{bmatrix} \begin{bmatrix} e_{1t+s-i} \\ e_{2t+s-i} \end{bmatrix}$$

If there is a change in y, then equation above can be expressed as

$$\begin{bmatrix} y_{1t+s} + \Delta y_{1t+s} \\ y_{2t+s} + \Delta y_{2t+s} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \sum_{i=0,i\neq s}^{\infty} \begin{bmatrix} \theta_{11}(i) & \theta_{12}(i) \\ \theta_{21}(i) & \theta_{22}(i) \end{bmatrix} \begin{bmatrix} e_{1t+s-i} \\ e_{2t+s-i} \end{bmatrix} + \begin{bmatrix} \theta_{11}(s) & \theta_{12}(s) \\ \theta_{21}(s) & \theta_{22}(s) \end{bmatrix} \begin{bmatrix} e_{1t}+1 \\ e_{2t} \end{bmatrix}$$

Use equation this less equation above, we get

$$\begin{bmatrix} \Delta y_{1t+s} \\ \Delta y_{2t+s} \end{bmatrix} = \begin{bmatrix} \theta_{11}(s) & \theta_{12}(s) \\ \theta_{21}(s) & \theta_{22}(s) \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} \theta_{11}(s) \\ \theta_{21}(s) \end{bmatrix}$$

Then the long run multiplier: $\sum_{i=0}^{\infty} \theta_{jk}(i)$ shows the total effect to the kth component which influenced by the jth interference. The accumulate impulse response function are $\theta_{11}(i)$, $\theta_{12}(i)$, $\theta_{21}(i)$, $\theta_{22}(i)$, i=0,1,….

3. Data Description

Assumption 1: The effects of stability and discretionary are the result of system designing，and endogenously existed in the system. The data process should be level stability. The effect of promoting is the result of policy design and is exogenously existed to the system.

Assumption 2: there should be some difference between system designing and policy adjustment. Data frequency may reflect the choice of policy designing and system designing and they should be results of different choice.

Based on above assumptions we use monthly data, quarterly data and annually data to distinguish the stabilizing, discretionary and promoting effects of government fiscal policy on economic growth. The annually data covers from 1952-2022, and monthly and quarterly data covers from 1998 to 2022. But here is a problem that is the shortest time period data for GDP in statistics is quarterly ones, we have to use average method to change these quarterly data into monthly data in order to match the monthly government expenditure and tax revenue data. We hope it has no significant influence on our final results.

Because some time series economic variables are non-stationary, we have to take a more detailed examination of the properties of our data. The stationary property of the time series data has been analyzed using the Augmented Dickey-Fuller(ADF) and Phillips-Perron(PP) unit root tests. After performing these tests, the results indicated that both monthly data, quarterly data and annual data appeared to be stationary, and the long relationships between these variables are existed. That means we can use vector auto regression directly.

Table 1. The ADF Test Results of Annual Data

Variables	Criti. value	Test stat.	P value	R2	DW
dlgdp	-3.548	-4.349	0.0000	0.512	1.97
dlcz	-3.548	-6.037	0.0000	0.702	2.00
dlcs	-3.548	-5.091	0.0000	0.625	2.05

Note* calculated by EVIEWS7.2

Table 2. The ADF Test Results of Month Data

Variables	Criti. value	Test stat.	P value	R2	DW
lgdp	-3.472	-5.827	0.0000	0.18	1.99
lcz	-3.992	-4.463	0.0000	0.76	1.98
Lcs	-3.992	-6.086	0.0000	0.47	2.02

Note* calculated by EVIEWS7.2

3.1 The Model Set Up

As mentioned above, we believe that stabilizing and discretionary ability are the result of system designing and promoting ability is policy designing. According to this idea we will distinguish these effects based on the short run and long run shocks. Here we use VAR and SVAR technique. The main reason for using these approaches is that we believe that these variables are endogenously connected to each other, if we want to estimate the effects of some of them accurately, others must also be included in our investigation. We have to focused on setting a three-variables closed model that consists of the following variables: government expenditure, tax revenue, and the GDP.

The basic VAR model includes the three variables: government tax revenue, government expenditure, and the GDP values. The model can be expressed in the following form:

$$Y_t = C + \sum B_p\, Y_{t-1} + U_t$$

$$Y_t = \begin{bmatrix} gdp \\ cs \\ cz \end{bmatrix} \quad C = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} \quad B = \begin{bmatrix} B_{11} B_{12} B_{13} \\ B_{21} B_{22} B_{23} \\ B_{31} B_{32} B_{33} \end{bmatrix} \quad U_t = \begin{bmatrix} Ugdpe_t \\ Ucse_t \\ Ucze_t \end{bmatrix}$$

In this model:

C is a constant term

$Y_t = (gdp_t, cs_t, cz_t)$, represents gross domestic product, GDP.

CS is tax revenue, and CZ is government expenditure.

$Ugdpe_t, Ucse_t$, and $Ucze_t$ are the so-called induced residuals and are used as the random disturbance terms of GDP, tax revenue and government. these induced residuals are from VAR

analysis and used to form a structure VAR. One of the important identification assumptions is that there is no discretionary response of fiscal policy to unexpected movements in GDP within the same year. So, we can get the following expressions:

$$u_{CZ} = \alpha_1 \cdot u_{GDP} + e_{CZ}$$

$$u_{CS} = \beta_1 \cdot u_{GDP} + e_{CS}$$

$$u_{GDP} = \gamma_1 \cdot u_{CZ} + \gamma_2 \cdot u_{CS} + e_{GDP}$$

These three equations means that we should focus on the structure of the contemporaneous interaction between the endogenous variables. The terms ecz, ecs, and eGDP in these equations are the structural shocks that we should get. And in order to fully identify the model we have to add some restrictions: first, there is no automatic feedback from movements in output on the government expenditure, second, we have used the average tax elasticity and assumed that it is positive. Based on these assumptions, the foregoing model can be written in the following form:

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & -\beta_1 \\ -\gamma_1 & -\gamma_2 & 1 \end{pmatrix} \begin{pmatrix} u_{CZ} \\ u_{CS} \\ u_{GDP} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e_{CZ} \\ e_{CS} \\ e_{GDP} \end{pmatrix}$$

4. Empirical results

The estimated results below are based on data frequency, we use simple regression model, non-structural vector auto regressive model respectively for monthly, quarterly and annually data to find stabilizing, discretionary and promoting effects. For SVAR analysis here only takes reduced model into consideration because we only want to distinguish the long run effect of different data frequency.   Empirical results show that most coefficients in these models are statistically significant, and the relationships among these variables are logical. But the promoting effect involved in accumulated effect is quite different (see figures below).

Here are the estimated results for these models:

For monthly frequency data:

Under simple regression:

lgdp = 0.4130lcs+0.3262lcz+3.682

[11.50]   [9.78]   [40.3]

Under non-structural VAR

lgdp = 0.75lgdp(-1)+0.08lgdp(-2)+0.09lcs(-1)-0.1lcs(-2)+0.08lcz-0.03lcz(-2)+0.6

[11.58]   [1.5]   [4.97]   [-0.65]   [5.8]   [-2.03]   [5.6]

Adj. R-squared 0.993   AIC -2.7   SC -2.6

Under SVAR for reduced model

Ulgdp=0.06ulcs+0.006ulcz

[3.3]   [0.5]

For quarterly frequency data:

Under simple regression:

lgdp = 0.4130lcs+0.345lcz+3.82

[5.52]   [4. 95]   [26.1]

Adj. R-squared 0.949   AIC -0.55   SC -0.51

Under non-structural VAR

lgdp =0.41lgdp(-1)+ 0.54lgdp(-2)+0.164lcs(-1)+0.01lcs(-2)+0.62lcz(-1)-0.17lcz(-2)

[4.85]   [5.6]   [2.5]   [2.5]   [1.2]   [-3.31]

Adj. R-squared 0.988   AIC -3.05   SC -3.04

Under SVAR for reduced model

Ulgdp=1.33ulcs-0.18ulcz

[6.7]   [0.92]

For annually data:

Under simple regression:

lgdp = 3.02lcs-1.83lcz

       [4.28]   [-2.62]

Adj. R-squared 0.98   AIC 0.83   SC 0.9

Under non-structural VAR

lgdp=1.6lgdp(-1)-0.5lgdp(-2)+0,12lcs(-1)+0,12lcs(-2)-0.3lcz(-1)-0.02lcz(-2)

    [11.80]   [-3.51]   [0.58]   [0.57]   [-1.96]   [0.664]

Adj. R-squared 0.999   AIC -8.69   SC -7.45

Under SVAR for reduced model

Ulgdp=0.31ulcs+0.047ulcz

      [2.1]   [0.4]

For promoting effects reflected in accumulated response, the empirical results are quite different. Monthly data and quarterly data show a negative promoting effects of gdp to fiscal expenditure and tax revenue, but annually data shows a different situation, fiscal expenditure has long run positive effect on gdp' growth and tax revenue has a long run negative effect on gdp's growth.
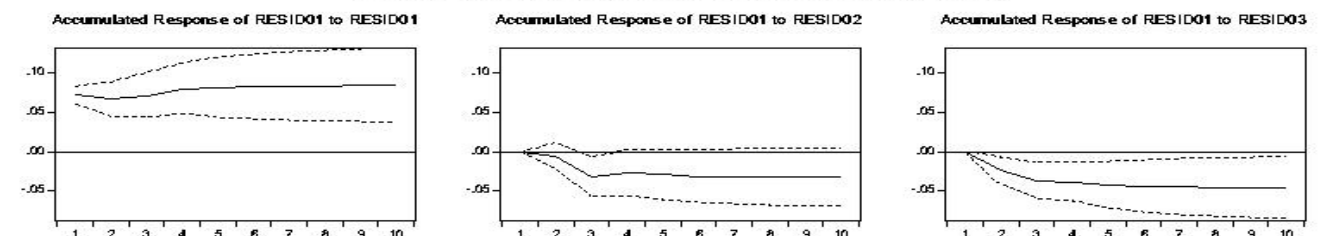
Following figures are the accumulated effects of monthly data
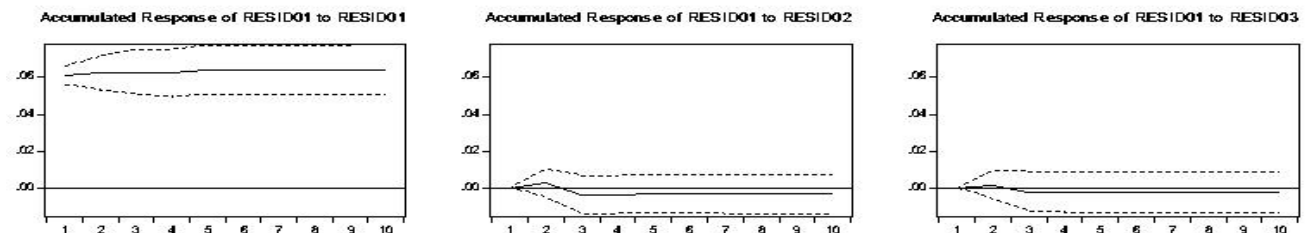
Following figures are the accumulated effects of quarterly data

Following figures are the accumulated effects of annually data
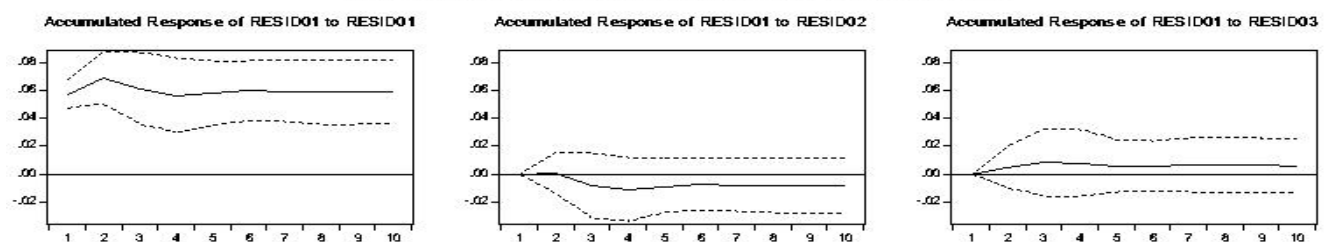
5. Conclusion

Based on the empirical analysis we can get the following enlightens: Firstly, the effects of government fiscal policy can be distinguished by data frequency, different frequency data have different policy effects. Secondly, high frequency data and low frequency have different effects on gdp' growth, most of the short effects are positive. Thirdly, the analysis of Chinese case indicates that the accumulated effect of government expenditure on the growth of the economy has a positive effect on long run gdp' growth but tax has a negative long run effect.

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