An Empirical Analysis of the Effects of Government Expenditure and Tax Revenue on GDP Growth Based on Data Frequency

Xiao-Li WANG\textsuperscript{1,\textasteriskcentered} and Yi-Xing XU\textsuperscript{2,\textasteriskcentered,\textasteriskcentered}*

\textsuperscript{1}Guangxi University of Foreign Languages, Nanning, Guangxi, China
\textsuperscript{2}China Merchants Bank CO., LTD
\textsuperscript{a}Wangxiaoli586@126.com
*Corresponding author

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Abstract. This paper offers a thorough empirical analysis of the effects of fiscal variables on economic growth based on data frequency. We distinguish the Stabilizing and discretionary effects of government expenditure and tax revenue in China on its GDP growth using the vector auto regression technique. The variables used in this study include government expenditure, tax revenue, and GDP values and the statistical values used for all these variables are month and annual time series data among them annual data covering the period of 1952 to 2018 and month data covering from 1998-1 to 2019-9. We believe that stabilizing effect can be found in month data analysis and discretionary effect can be found in annual data analysis. Overall, the empirical results indicate that stabilizing and discretionary effects of Chinese government expenditure and tax revenue do react systematically to output changes strongly. But the accumulated effects on GDP are positive for month data negative for annual data.

Introduction

Government expenditure and tax revenue are major instruments of fiscal policy that has been utilized historically to foster macroeconomic progress. The effects of public expenditure and tax revenue on economic growth have been subject of many researches and have always received extensive attention especially in recent years. Many economic researchers have studied and empirically tested correlation between government variables and growth rate from different perspectives using different econometric methods. These studies can be generally divided into three categories based on the statistical techniques they have used: The first are the early studies that have usually focused on estimating fiscal policy multipliers using macro econometrics models, or on reduced form researches that have concentrated on summary indicators like the structural deficit or other constructed indicators. Barro (1990) and Bagliano, F.C. and C.A. Favero (1998) have tried to identify the effects of fiscal variables on GDP within the framework of this technique. The second group of researchers are those that are based on structural VAR and narrative approaches. Charl, J, Guangling (Dave) L., and Ruthiv, N (2013) identify discretionary policy changes as unexpected policy shocks and thereby separate the discretionary policy component from any systematic and predictable policy move. And, third type are the researches using structure vector auto regression model (SVAR) to do the research. Blanchard and Protti 2002, Chen S W. (2014) attempt to construct a structural VAR model and isolate the response of the macroeconomic system to a particular exogenous policy shocks and recover 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. Most studies mentioned above only pay attention to policy effect and use quarterly data (except Blanchard and Protti). It is questionable because government policy adjustment is very complex and cumbersome to perform, a quarterly data have no enough room to involve such adjustment. Government budget is estimated on an annual basis and every tax and expenditure items are related to a specific fiscal year. On the
other hand, the functions of fiscal policy include stabilizing and discretionary. When we say the
effects of fiscal policy we should involve both stabilizing and discretionary effects.
So this paper studies the subject in a different way. That is distinguishing stabilizing,
discretionary and accumulated effects of government spending on economic growth based on data
frequency. We believe that month data is more suitable to distinguish stabilizing effect because no
policy effect can be involved within such a short time and annual data is more suitable to
distinguish discretionary effect because government has enough time to adjust its fiscal policy
according to the economic situation. By using month data and annual data helps us to steer clear of
fiscal policy effects on the whole. We selected China as a case study for some reasons: First, China
is one of the recently industrialized countries in the world and has achieved remarkable economic
development over the past three decades. Second, China has implemented an “open door” policy
since 1980s with respect to imports and exports and the foreign investment. Since then its economic
system has transformed from a centrally planned economy to a market-based economy. However,
the central government still plays a fundamental role when it comes to China’s economic growth
and development. As a result, the effects of government expenditure and tax revenue on economic
growth are believed to be worth investigating.

Methodological Issues
For an anticipated $Y_t$ according to $\{y_{t-1}, y_{t-2}, \ldots\}$, we can prove that the conditional expectation is the
best linear anticipation which can be devoted by $Y_t^*$. That is:

$$Y_t^* = E \{Y_t/Y_{t-1}, Y_{t-2}, \ldots\}.$$  

If the information included in $u_t = Y_t - Y_t^* = Y_t - E \{Y_t/Y_{t-1}, Y_{t-2}, \ldots\}$
did not refer to $Y_t$ in $\{y_{t-1}, y_{t-2}, \ldots\}$, we call it innovation. To all its random process, $\{u_t\}$ meets:

$$E\{u_t\} = 0, E\{u_t u_t^\prime\} = \sigma^2$$  

and $E\{u_t X_{t-1}\} = 0$. Here $\{X_{t-1}\}$ is the information (or data) before the $t$ moment; and $\{u_t\}$ is the innovation corresponding to $\{X_{t-1}\}$. We can express this process like this:

$$Y_t = \mu + \sum_{i=0}^{\infty} \Theta^i e_i = \mu + \sum_{i=0}^{\infty} \Theta^i e_{t-i}$$  

(1)

If we use a 2-dimesion-process-hypothesis to express what we mentioned above, the thought can
be shown as:

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

(2)

Here $\Theta = \begin{bmatrix}
\theta_{11}(i) & \theta_{12}(i) \\
\theta_{21}(i) & \theta_{22}(i)
\end{bmatrix}$, and component $\theta_{jk}(i)$ is the multiplier. $\theta_{11}(0)$ explains how many units
$y_t$ will change at $t$ moment after one unit time if $e_1$ can change one unit at $t$ moment. $\theta_{11}(1)$ denotes
how many units $y$ will change after $t+1$ moment while $e_1$ can can change one unit at $t$ moment.

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

(3)

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

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

(4)

Use equation (4) less equation (3), we get

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

(5)
Then long term 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

$$\theta_{11}(i), \theta_{12}(i), \theta_{21}(i), \theta_{22}(i), \quad i=0,1,\ldots$$

### Data Description

#### Description of Data

We use month data and annual data to distinguish the stabilizing and discretionary effects of government expenditure and tax revenue on economic growth respectively. The annual data covers from 1952-2018, and monthly data covers from 1998-1 to 2019-9. 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 government expenditure and tax revenue month data. We hope it has no significant affect 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. Performing results indicated that both month data covered from 1998-1 to 2019-9 and annual data covered from 1952-2018 are not stationary; Month data are Ln form stationary and the annual are difference of Ln form stationary. The long cointegrations between these variables are existed.

#### Table 1. The ADF Test Results of Annual Data.

| Variables | Criti. value | Test stat. | P value | $R^2$ | DW |
|-----------|--------------|------------|---------|-------|----|
| dlgdp     | -3.548       | -4.349     | 0.0000  | 0.512 | 1.97 |
| dlcz      | -3.548       | -6.037     | 0.0000  | 0.702 | 2.00 |
| dlcis     | -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 | $R^2$ | DW |
|-----------|--------------|------------|---------|-------|----|
| lgdp      | -3.472       | -5.827     | 0.0000  | 0.18  | 1.99 |
| lcis      | -3.992       | -4.463     | 0.0000  | 0.76  | 1.98 |
| lcis      | -3.992       | -6.086     | 0.0000  | 0.47  | 2.02 |

Note* calculated by EVIEWS7.2

#### The Model Set Up

As mentioned above, we try to distinguish stabilizing effect and discretionary effect based on data frequency. Here we have tried to use vector autoregressive approach to identify stabilizing effect and use structure vector autoregressive approach to identify the discretionary effect. After distinguishing these two effects we will further study the accumulated effects of both functions on GDP growth. The basic rational for the approaches is that we believe that these variables are endogenously connected to each other. For this reason, if we want to estimate the effects of some of them accurately, others must also be included in our investigation. Hence, based on this justification, we have focused on setting a three-variable closed model that consists of the following variables: government expenditure, tax revenue, and the GDP figures. The VAR and SVAR approaches have been utilized to investigate the interrelation among these variables.

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:

$$Y_t = C + \sum B_p Y_{t-1} + U_t$$
\[ Y_t = \begin{bmatrix} \text{lgdp} \\ \text{lcs} \\ \text{lcz} \end{bmatrix} \quad C = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} \quad B = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \quad U_t = \begin{bmatrix} \text{Ulgdpe}_t \\ \text{Ucse}_t \\ \text{Ucze}_t \end{bmatrix} \] (7)

In this model:
- \( C \) is a constant term
- \( Y_t = (\text{lgdp}_t, \text{lcs}_t, \text{lcz}_t) \), represents month and annual Gross Domestic Product, GDP in Ln form.
- \( \text{ICS} \) is the month tax revenue, and \( \text{ICZ} \) is month and annual government expenditure, both are in Ln form.
- \( \text{Ugdpe}_t, \text{Ucse}_t, \text{Ucze}_t \) are the so-called induced residuals and are used as the random disturbance terms of GDP, tax revenue and government expenditure respectively.

In order to gauge the discretionary effect of fiscal variables on economic growth, we have followed the method used by Blanchard and Perotti (2002). This method uses induced residuals \( \text{Ugdpe}_t, \text{Ucse}_t, \text{Ucze}_t \) 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. In other words:

\[
\begin{align*}
\text{u}_{cz} &= \alpha_1 \cdot \text{u}_{gdp} + \epsilon_{cz} \\
\text{u}_{cs} &= \beta_1 \cdot \text{u}_{gdp} + \epsilon_{cs} \\
\text{u}_{gdp} &= \gamma_1 \cdot \text{u}_{cz} + \gamma_2 \cdot \text{u}_{cs} + \epsilon_{gdp}
\end{align*} \] (8)

All these three equations define the structure of the contemporaneous interaction between the endogenous variables. The terms \( \epsilon_{cz}, \epsilon_{cs}, \text{and} \epsilon_{gdp} \) in these equations are the structural shocks that we intend to recover. In order to fully identify the model we have added some additional assumptions: 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:

\[
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & -\beta_1 \\
-\gamma_1 & -\gamma_2 & 1
\end{bmatrix}
\begin{bmatrix}
\text{u}_{cz} \\
\text{u}_{cs} \\
\text{u}_{gdp}
\end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\epsilon_{cz} \\
\epsilon_{cs} \\
\epsilon_{gdp}
\end{bmatrix}
\] (9)

**Empirical Results**

The estimated results below are based on data frequency: for high frequency data (monthly data) we use non-structural vector auto regressive to find stabilizing effect and for low frequency data (annual data) we use reduced residuals to form a structure vector auto regressive model to find discretionary effect. On the whole, empirical results show that most coefficients in these two models are statistical significant and the relationships among variables are logical. Month data analysis shows that the stabilizing effects of current period \( \text{cs} \) and \( \text{cz} \) to \( \text{gdp} \) are statistical significant, but lagged \( \text{cz} \) has statistical insignificant. Accumulated effect is limited.

Here are the estimated results for the two models:

For high frequency month data, the results are as follows:

Current period effects

\[ \text{lgdp} = 0.4130\text{lgdp} + 0.3262\text{lcs} + 3.682 \]

\[ (0.036) \quad (0.033) \quad (0.09) \]

\[ [11.50] \quad [9.78] \quad [40.3] \]

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

Under VAR (after removing insignificant coefficients)

\[ \text{lgdp} = 0.752\text{lgdp}(-1) + 0.0956\text{lcz}(-1) + 0.0766\text{lcs}(-1) + 0.0128 \]

\[ (0.062) \quad (0.019) \quad (0.0134) \quad (0.103) \]

\[ [11.66] \quad [-4.29] \quad [5.729] \quad [5.564] \]

Adj. R-squared 0.993    AIC -2.18   SC -2.62

For low frequency data (under SVAR)

The induced residual’ model:
udgdp = 0.064udcz+0.294udcs
(0.101) (0.151)
[0.633] [1.95]
Adj. R-squared 0.45 AIC -3.38 SC -3.28 F 25
lgdp = 1.65lgdp(-1)-0.5666gdp(-2)-0.317lcz(-1)+0.142lcs(-1)
(0.149) (0.161) (0.161) (0.204)
[11.80] [-3.51] [-1.96] [0.664]
Adj. R-squared 0.999 AIC -2.69 SC -2.45

For accumulated effects, stabilizing ability is much stronger than discretionary ability, this result is logical because month data are Ln form stationary, it is a quantity level analysis and annual data are the difference of Ln form stationary, it is a rate analysis.

The accumulated effects of both data are as follows:

The accumulated stabilizing effects of government expenditure and tax revenue on economy:

The accumulated discretionary effects of government expenditure and tax revenue on economic growth:

Conclusion

Based on the empirical analysis we can get the following enlightens: Firstly, the effects of government spending and tax revenue can be distinguished by data frequency, different frequency data have different policy meaning. Secondly, high frequency data can be used to distinguish fiscal variable’s stabilizing effect and low frequency data can be used to distinguish discretionary effect. Thirdly, the analysis of Chinese case indicates that, for month data, the accumulated effect of government expenditure and tax revenue on the economy are on the quantity level and for annual data the accumulated effect are on the growth rate level. Fourthly, the SVAR model seems to be an appropriate model to determine the discretionary effect.

References

[1] Barro. Government spending in a simple model of endogenous growth [J]. Journal of Political Economy, 1990: 98, s103-s125.

[2] Blanchard, Perotti. An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output [J]. Quarterly Journal of Economics. 2002, 117(4):1329-1368.

[3] Bagliano, F.C. and C.A. Favero. Measuring Monetary Policy with VAR Models: An Evaluation [J]. European Economic Review, 1998: 42, 1069-1112.
[4] Charl, J, Guangling (Dave) L., and Ruthiv, N. Analyzing the effects of fiscal policy shocks in the South African economy. Economic Modeling, 2013, 32: 215-224.

[5] Fazzari S M, Morley J, Panovska I. State-dependent effects of fiscal policy [J]. Studies in Nonlinear Dynamics & Econometrics, 2015, 19(3): 285-315.

[6] Canova, F. and E. Pappa. Price Differentials in Monetary Unions: The Role of Fiscal Shocks [J]. The Economic Journal, 2007: 117, 713-737.

[7] Afronso A, Jalles J T. Fiscal Sustainability: a Panel Assessment for Advanced Economics [J]. Applied Economics Letters, 2015 b, 22(11): 925-929.

[8] Chen S W. Testing for fiscal sustainability: New Evidence from the G-7 and some European Counties [J]. Economic Modelling, 2014, 37(574): 1-15.