

# Multiplier Effects of Government Spending: A Tale of China\*

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Preliminary (February 1, 2013)

## Abstract

Government spending plays an important role in determining economic performance in China. As an example, China's rapid recovery during the recent world financial crisis was due to its aggressive 4-trillion RMB government stimulus program. However, China's government spending programs are also known for their notorious inefficiency and inflationary consequences (such as building highways that lead to nowhere and ghost towns that nobody wants to live). This paper quantifies the macroeconomic effects of government spending in China. We show that (i) government spending in China Granger-causes output and investment booms as well as inflation, and (ii) it has a multiplier close to (or larger than) 3. The large multiplier effects are found not only in aggregate time series data but also in panel data at the provincial level. We provide a theoretical model with market failures and Monte Carlo analysis to rationalize our empirical findings. Specifically, we build a model that can generate boom-bust cycles and multiplier effect similar to those observed in China, and use the model as a laboratory (data generating process) to gauge whether structural VARs can yield consistent estimates of the theoretical multiplier in short samples. Our Monte Carlo analysis supports the large multiplier found in China.

*Keywords:* Government Spending, Fiscal Multiplier, Economic Development, Chinese Economy.

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*JEL codes:* E30, E62, H00, O11.

# 1 Introduction

The macroeconomic effects of government spending in China have been remarkably striking, both in terms of fostering long-run economic growth and in driving short-run business cycles. Consider the following observations:

1. China’s public capital formation in infrastructure (such as urban water supply, electricity, transportation, and telecommunication) has been growing at the fastest speed in the world.<sup>1</sup> Vast improvements are made during the past 30 years in irrigation system, underground sewerage, streets and highway networks, air and rail transportations, electricity transmission grids, gas and oil pipelines, schools, hospitals, etc. As a result, China now enjoys an exceptionally high ranking in the World Bank Logistics Performance Index (LPI). In fact, China is the only developing country that has achieved a LPI index comparable to that of industrial high-income nations in international shipments, infrastructure, custom services, logistic competence, tracking and tracing, and timelines (see Table 1). Such a remarkable catch up in infrastructure has no doubt made a significant contribution to China’s rapid economic growth.

Table 1. World Bank Logistics Performance Index (LPI)

| Country             | LPI  | Customs | Infrastructure | International shipments | Logistics Competence | Tracking & Tracing | Timeliness |
|---------------------|------|---------|----------------|-------------------------|----------------------|--------------------|------------|
| China               | 3.52 | 3.25    | 3.61           | 3.46                    | 3.47                 | 3.52               | 3.80       |
| High income         | 3.54 | 3.36    | 3.58           | 3.36                    | 3.51                 | 3.59               | 3.85       |
| Upper middle income | 2.81 | 2.55    | 2.70           | 2.80                    | 2.74                 | 2.84               | 3.22       |
| Lower middle income | 2.56 | 2.33    | 2.36           | 2.56                    | 2.52                 | 2.54               | 3.02       |
| Low income          | 2.37 | 2.22    | 2.20           | 2.40                    | 2.32                 | 2.33               | 2.74       |

\*Data source: World Bank, 2012, "Connecting to Compete: Trade Logistics in the Global Economy".

2. However, government spending in China has also been reckless and highly inefficient (such as building roads that lead to nowhere and ghost towns that nobody wants to live). As a recent example, a significant fraction of the 4-trillion RMB government stimulus package, designed to counter the adverse impact of the world-wide financial shocks on China’s export sector, went to the housing market and fueled a new round of housing bubble (Deng, Morck, Wu, and Yeung, 2011).<sup>2</sup> It is thus not surprising

<sup>1</sup>China’s infrastructure capital stock, in constant price, grew by 12.3% per year on average from 1978 to 2008. During the same period, China’s average real GDP growth rate was 9.5%.

<sup>2</sup>Wen and Wu (2012) argue that inefficient government expenditures in China can nonetheless serve as a coordination device to prevent recessions.

to note that China’s big government spending programs have often been themselves a major aggravating source of China’s notorious boom-bust cycles.<sup>3</sup>

Therefore, government spending can have a dramatic trade-off: on the one hand it may significantly boost aggregate output, especially in developing countries with massive market failures and at times of recessions; but on the other hand it may have severe adverse consequences, such as unintended inflation and boom-bust cycles. Such trade-off is most clearly revealed in China’s recurrent inflation cycles driven by large government spending (or de-spending) programs (see Section 2).

This paper tempts to estimate the macroeconomic effects of government spending in China. As a large developing country with high saving and high degrees of resource under-utilization, vast missing markets, and a wide range of market failures, China offers a unique opportunity to test the Keynesian notion that government expenditures (even as a pure waste of aggregate resources) can have a multiplier larger than 1 on aggregate income.

We use both nationwide and regional data from post-reform China to estimate the multiplier effects of government spending, defined broadly as total government expenditures excluding government investment.<sup>4</sup> We found that the multiplier is significantly larger than 1—between 2.7 and 5.6 at the national level and between 2.8 and 6.5 at regional level. These estimates are in general far larger than those found in the United States or other developed countries.<sup>5</sup>

The large multipliers may explain why government spending in China (such as the 4 trillion RMB stimulus package implemented in 2008 and 2009) is effective in preventing

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<sup>3</sup>Since the start of economic reform in 1978, the central government has relied heavily on inflationary deficit finance to stimulate the economy. Big stimulate packages often generate short-run booms followed by high inflation. The high inflation in turn causes widespread social-economic problems and then forces the central government to adopt severe measures to cut back spending programs that are largely supported and sustained by self-interested local government agencies. The contraction of government spending in turn leads to recessions. See Section 2 below for more evidences.

<sup>4</sup>In China’s National Income and Product Account, government investment on infrastructures and other public facilities are not included in government expenditures but treated as part of aggregate investment. This definition makes our study and estimation of multipliers consistent with the existing literature (e.g., Ramey, 2011a). We will deal with the macroeconomic effects of government investment on infrastructures in a separate project.

<sup>5</sup>Empirical studies show that the estimated government spending multiplier for developed countries, such as the United States, is in general smaller than 1 or in the range of  $0.6 \sim 1.2$  (Ramey, 2011a). Barro (2011) argues that the multiplier in the United States is more likely to be close to zero. The reason for expecting a small multiplier is that capacity utilization in developed countries is sufficiently high and markets are sufficiently efficient and complete. However, during severe recessions, especially in a situation with a zero nominal interest rate, the multiplier in developed countries can be potentially greater than 1 (e.g., see Christiano, Eichenbaum and Rebelo, 2011). Ramey (2011a), however, finds no empirical evidence for the New Keynesian prediction that the multiplier is larger than 1 when the interest rate is near zero. However, Shaog (2010) finds a multiplier of 2 using regional data by panel regressions. For an comprehensive literature review on empirical and theoretical studies of the fiscal multiplier, see Ramey (2011b).

economic slowdowns and recessions even though it may have been used to built roads that lead to nowhere and houses that nobody wants to live in.

However, the large multiplier effect in China is not without serious costs or detrimental effects. Our empirical study shows that government spending in China has also been itself a major aggravating source of inflation and business cycles.

We use Granger causality test to show that government spending in China Granger causes output and investment growth as well as the periodic boom-bust cycles in them. Also, inflation in China is so strongly and positively correlated with GDP growth, unlike what we see in the U.S. (where inflation is negatively correlated with GDP growth); and a main factor behind this positive correlation is government spending.

More specifically, China exhibits a clear pattern of 7-10 year periodic or semi-periodic boom-bust cycles in government spending, GDP, and the inflation rate, with government spending strongly leads and Granger causes the boom-bust cycle, and with inflation significantly lags the cycle. This pattern suggests that many rounds of economic booms in China were initiated or facilitated by big government spending programs, followed by strong growth and accelerated inflation. High inflation in turn forces the government to cut back its spending, generating a negative multiplier effect and a sharp recession (the so called "soft landing" in China). When a recession persists long enough, it calls for another round of stimulus package to jump start the economy. Such a vicious cycle is a typical feature of the Chinese economy that has long been noted by the existing literature (see, e.g., Lin, Cai, and Li 1996; Lin 2009; and Brandt and Zhu 2000, 2001).

Why is government spending in China so inflationary? Calvo and Guidotti (1993, p. 683) show that "public finance considerations are major determinants of monetary policy as well as the proximate cause of inflation in many [developing] countries." In particular, using cross country data from developing countries, these authors show that high-inflation countries carry higher government deficits. China is no exception to this finding (Brandt and Zhu, 2000). In particular, China's fiscal policies are characterized mainly by (i) the expansion or contraction of credit lending through its large and powerful state-owned banking system and (ii) the simultaneous expansion or contraction of money supply and government deficits. As a recent example, the 4 trillion RMB stimulus package to counter the adverse impact of the world financial crisis on China was implemented through rapid and massive credit expansion by the state-owned banking system and the simultaneous increases in government deficits and money supply (Deng, Morck, Wu, and Yeung, 2011). The inflationary consequence of the 4-trillion stimulus program has called for another round of credit tightening in China

starting in 2011 even though the world economy still remained in deep recession and China's export sector was still in a big slump.

The large multiplier effect and boom-bust cycles in China demand theoretical explanations. A methodological contribution of this paper is to provide a theoretical model to help rationalize (both econometrically and theoretically) the large multiplier effect in China and the recurrent boom-bust cycles in both government spending and aggregate output. Our theoretical analysis aims to address two related issues: (i) to identify a plausible mechanism through which government spending can have a large multiplier effect and at the same time be itself the source of boom-bust cycles; and (ii) to provide a data-generating process for Monte Carlo analyses on the robustness of our empirical estimates of the multiplier based on structural VARs.

However, we do not intend to claim that our model is necessarily the right model to explain the complicated reality of China. It is more of a parsimonious model to facilitate our Monte Carlo analysis. Multipliers are typically estimated by structural VARs based on finite samples and certain critical de-trending procedures and identification assumptions. To assess the reliability and robustness of the empirical estimates, we need a theoretical model that can generate data with similar properties, and show if structural VARs performed on such artificial data can uncover the truth. Hence, even if our model is not the right model for China, our Monte Carlo analysis is helpful in assessing the reliability of the estimated multipliers, especially when the data feature strong periodic boom-bust cycles.

Following the existing literature (e.g., Blanchard and Perotti, 2002; Ramey, 2011a), our empirical estimation of the multiplier is based on structural VARs that identify exogenous shocks to government spending by assuming that the latter variable is predetermined relative to the other variables included in the VAR. However, little existing works have provided Monte Carlo analyses to gauge whether multipliers so estimated are reliable, especially in short samples. There are several major problems involved in estimating the multiplier based on structural VARs. First, how to detrend the data? Using growth rates (i.e., applying the first-difference filter) tend to generate too much noise in the data, and using the de-trended levels (i.e., applying the HP filter or assuming a deterministic linear-quadratic time trend) may tend to generate spurious cycles.

Second, how to identify truly exogenous government spending shocks? Government spending (even military spending) is unlikely to be completely exogenous and irresponsible to changes in aggregate income. When government spending is endogenous or partially endogenous, the typical approach to identify government shocks is to rely on a lower tri-

angular Choleski decomposition by ordering government spending the last in the VAR, so that "shocks" to government spending do not influence other variables on impact. But this practice rules out any multiplier effect in the impact period by assumption. As an alternative, the existing literature (e.g., Ramey, 2011a) uses proxy of government spending that is more or less exogenous judged by Granger causality test, and orders government spending after the proxy variable but before aggregate output and other variables in the VAR, so that "shocks" to government spending can simultaneously affect output. This is the only way to generate a non-zero output elasticity of government spending on the impact period.

How reliable is such an identification method? One way to tell is to construct a theoretical model in which government spending is partially exogenous and partially endogenous, but its underlying shock process is consistent with the empirical identifiability assumptions, and use the model as a data generating process to perform structural VARs exactly the same way as we do in the data.

The third difficulty is how to compute multipliers based on the estimated impulse response functions in the structural VARs. The conventional approach is to have three different measures of the multiplier, (i) the impact multiplier—a measure that focuses on the output elasticity of government spending on the impact period, (ii) the dynamic peak multiplier—a measure that focus on the maximum response of output to government shock when the impulse response function is hump-shaped, and (iii) the cumulative multiplier—a long-run measure that is based on the cumulative sum of the impulse response functions. The rationale behind the long-run measure is that government spending may be itself persistent and may trigger multiple-periods of output responses after the initial shock, as in the standard Keynesian IS-LM model where the multiplier is the infinite sum of the incremental changes in output in each following period after the shock. However, when the impulse responses of output to a government shock are oscillatory around a long-run trend due to endogenous boom-bust cycles (as in the case of China), it is not clear whether the sum of both positive and negative responses is the right measure of the long-run multiplier. For example, the sum of the areas underneath a sine wave may be zero, but this does not mean the lack of a multiplier effect. In particular, given that data are detrended around a balanced growth path, the negative impulse response does not really mean negative values of GDP or government spending, but just values below the long-run mean. Also, the measured multiplier may be infinity if the denominator (the cumulative sum of government responses to its own shock) is zero. To address these issues, a theoretical model that is able to generate oscillatory fluctuations is needed. In the model we can exactly compute the short- and long-run output

elasticities of government spending and use the model as a true data generating process, so as to see if structural VARs can uncover the truth based on finite samples.

Using Monte Carlo analysis based on model-generated data, we found the following results:

1. When the data exhibit strong periodic or semi-periodic cycles, both the impact multiplier and the dynamic (peak) multiplier can be consistently estimated by structural VARs, even in short samples with only about 30 data points.
2. When the data exhibit only a hump-shaped impulse response or weak boom-bust cycles, the impact multiplier can still be consistently estimated but not for the dynamic (peak) multiplier—it tends to be significantly *underestimated* in short samples.
3. When the data exhibit boom-bust cycles, the cumulative multiplier cannot be consistently estimated even in fairly long samples; however, if we use the sum of *absolute values* of the areas underneath the impulse response function, then the absolute cumulative multiplier can be consistently estimated even in short samples.
4. For both the short-run and long-run multipliers, the estimation is far more accurate for samples with a strong cyclical (oscillatory) pattern than for samples with a weak cyclical pattern.
5. Therefore, given the strongly cyclical nature of the Chinese data, our theory-based Monte Carlo analyses suggest that the large fiscal multipliers found in China (in the range of 3 – 5) are consistently estimated without significant bias. Even after taking into account the non-trivial estimation errors in short samples, the impact multiplier is significantly larger than 1 and the dynamic multiplier significantly larger than 4.

The rest of the paper is organized as follows. Section 2 estimates the multiplier effects of government spending using both aggregate and panel data from China. Section 3 provides a business-cycle model to rationalize the empirical findings. Section 4 use the model to conduct Monte Carlo analysis to gage the accuracy of structural VAR methods in estimating the multipliers. Section 5 concludes the paper. Further robustness analyses are provided in the Appendix.

## 2 Empirical Analyses

### 2.1 The Causal Effects of Government Spending

The data used are annual data covering the post-reform period of 1978-2011. Aggregate output  $Y$  is measured by GDP, aggregate consumption  $C$  by total household consumption, aggregate investment  $I$  by gross fixed capital formation, and government expenditure  $G$  by total government consumption expenditures. All data are taken from China Statistical Year Book (2012). Because it is difficult to find price index for each of the individual variables in China, we normalize all variables by the consumer price index (CPI). We will discuss the robustness of our results to price adjustment in the Appendix.

Denote  $\Delta y$  as the annual growth rate of real GDP,  $\Delta c$  real consumption,  $\Delta i$  real investment, and  $\Delta g$  real government expenditures. To document the causal relations among these variables, we first estimate the following equations by ordinary least squares (OLS):<sup>6</sup>

$$\Delta z_t = f(\Delta z_{t-1}, \Delta z_{t-2}), \quad (1)$$

$$\Delta z_t = f(\Delta z_{t-1}, \Delta z_{t-2}, \Delta x_{t-1}), \quad (2)$$

where  $\Delta z$  denotes  $\{\Delta y, \Delta c, \Delta i\}$  respectively and  $\Delta x$  denotes  $\Delta g$ . A variable  $\Delta x$  is said to “Granger cause” a variable  $\Delta z$  when a prediction of  $\Delta z$  on the basis of its past history can be improved by further taking into account the previous period’s  $\Delta x$ . Estimating (1) and (2) gives the following results (standard errors are in parentheses and the significance level (star “\*”) is less than or equal to 5% with a  $t$ -value of  $\pm 1.96$ ):

$$\Delta y_t = \begin{matrix} 0.057 \\ (0.018)^* \end{matrix} + \begin{matrix} +0.615\Delta y_{t-1} \\ (0.18)^* \end{matrix} - \begin{matrix} 0.20\Delta y_{t-2} \\ (0.18) \end{matrix}, \quad R^2 = 0.313 \quad (3)$$

$$\Delta c_t = \begin{matrix} 0.070 \\ (0.02)^* \end{matrix} + \begin{matrix} +0.34\Delta c_{t-1} \\ (0.19) \end{matrix} - \begin{matrix} 0.19\Delta c_{t-2} \\ (0.19) \end{matrix}, \quad R^2 = 0.117 \quad (4)$$

$$\Delta i_t = \begin{matrix} 0.086 \\ (0.027)^* \end{matrix} + \begin{matrix} +0.54\Delta i_{t-1} \\ (0.19)^* \end{matrix} - \begin{matrix} 0.31\Delta i_{t-2} \\ (0.19) \end{matrix}, \quad R^2 = 0.247 \quad (5)$$

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<sup>6</sup>The growth rate is defined as the first difference in logarithm. Only two lags are included in the regressions because adding more lags does not change the results significantly. For example, similar results are obtained when four lags are used.

$$\Delta y_t = \begin{matrix} 0.049 \\ (0.018)^* \end{matrix} + \begin{matrix} +0.32\Delta y_{t-1} \\ (0.22) \end{matrix} - \begin{matrix} 0.11\Delta y_{t-2} \\ (0.18) \end{matrix} + \begin{matrix} +0.30\Delta g_{t-1} \\ (0.15)^* \end{matrix}, \quad R^2 = 0.410 \quad (6)$$

$$\Delta c_t = \begin{matrix} 0.056 \\ (0.019)^* \end{matrix} + \begin{matrix} +0.15\Delta c_{t-1} \\ (0.18) \end{matrix} - \begin{matrix} 0.14\Delta c_{t-2} \\ (0.17) \end{matrix} + \begin{matrix} +0.29\Delta g_{t-1} \\ (0.11)^* \end{matrix}, \quad R^2 = 0.307 \quad (7)$$

$$\Delta i_t = \begin{matrix} 0.030 \\ (0.030) \end{matrix} + \begin{matrix} +0.19\Delta i_{t-1} \\ (0.20) \end{matrix} - \begin{matrix} 0.27\Delta i_{t-2}, \\ (-0.16) \end{matrix} + \begin{matrix} +0.99\Delta g_{t-1} \\ (0.32)^* \end{matrix}, \quad R^2 = 0.454. \quad (8)$$

Equations (3)-(5) suggest that the steady-state growth rate is about 9.7% per year for real GDP, 8.2% for consumption, and 11% for investment.<sup>7</sup> Comparing to equations (3)-(5), equations (6)-(8) suggest that past growth in government spending has a significant effect on current output (consumption, investment) growth, even after the past history of output (consumption, investment) growth is taken into account. For example, a one percentage point higher growth in government spending can raise the GDP growth rate by 0.3 percentage points. Given that the average growth rate of government spending is 9.3% per year, the contribution of government spending to GDP growth is 2.8 percentage points, about 30% of the average GDP growth in China.

In fact, changes in government spending are such an important factor for determining future output (consumption, investment) growth that the predictive power of the past history of these variables is no longer significant in predicting their future growth after past government spending growth is taken into account. The  $R^2$ s in equations (6)-(8) are increased significantly in each case when past government spending growth is added in the regression. This result indicates that government spending contains superior information for predicting future economic activities in China than the lagged growth of GDP (consumption, investment). The most striking case is business investment. Equation (8) shows that a 1 percentage point higher growth rate in government spending can generate an equal percentage point increase in investment growth (the coefficient is 0.99), explaining why government spending can greatly stimulate output growth in China because investment has been one of the three major driving forces behind China's economic growth in the past 30 years (besides direct government spending and total exports).

Equation (6) can also give us a rough idea about the magnitude of the income multiplier. Given that the average government spending-to-GDP ratio is  $\frac{1}{7}$ , the implied short-term

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<sup>7</sup>The unconditional mean of the raw sample for these variables is 9.4%, 8.3%, and 10.8%, respectively.

multiplier is  $7 \times 0.3 = 2.1$  and long-run multiplier is  $\frac{2.1}{1-0.32+0.11} = 2.66$ , assuming that  $\Delta g_t$  is i.i.d. and completely exogenous. Section 2.2 below will provide better estimations of the multiplier by structural VARs that take into account the persistence and possible endogeneity of government spending.

For the reversed question of whether past output (consumption, investment) growth has an effect on current government spending, given the history of government spending, we obtain the following results:

$$\Delta g_t = \begin{array}{ccc} 0.070 & +0.42\Delta g_{t-1} & -0.18\Delta g_{t-2} \\ (0.021)^* & (0.17)^* & (0.15) \end{array}, \quad R^2 = 0.191 \quad (9)$$

$$\Delta g_t = \begin{array}{cccccc} 0.076 & +0.44\Delta g_{t-1} & -0.18\Delta g_{t-2} & -0.20\Delta y_{t-1} & +0.08\Delta c_{t-1} & +0.05\Delta i_t \\ (0.037)^* & (0.24) & (0.19) & (0.62) & (0.49) & (0.25) \end{array} \quad (10)$$

$$R^2 = 0.194$$

Regression (9) indicates that the steady state growth rate of government spending is 9.2% per year.<sup>8</sup> Compared with equation (9), equation (10) suggests that past output, consumption, and investment growth have no significant effect on current government spending growth. Namely, taking into account past growth in these other variables does not improve the prediction for future government spending statistically and economically. The  $R^2$  barely changes when these additional independent variables are included in equation (10).

The results based on equations (3)-(10) suggest that government spending is approximately exogenous in China and more importantly, there is a unidirectional strong "causal" relationship from government spending to consumption, output, and investment. Specifically, changes in government spending Granger causes GDP growth, consumption, growth, and investment growth, but not vice versa. This unidirectional causal relation is in sharp contrast with the dynamic pattern of the U.S. time series data. In the U.S., it is private consumption that Granger causes aggregate output, investment, and government spending, but not vice versa (Wen, 2007).

In addition to the above causal relations, government spending in China has been highly inflationary. This can be seen from the following Granger causality test. Denoting inflation by  $\Delta p$ , we have:

$$\Delta p_t = \begin{array}{ccc} 0.022 & +0.93\Delta p_{t-1} & -0.37\Delta p_{t-2} \\ (0.012) & (0.19)^* & (0.18)^* \end{array}, \quad R^2 = 0.516 \quad (11)$$

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<sup>8</sup>The unconditional mean of the raw sample is 9.3%.

$$\Delta p_t = \begin{matrix} -0.032 \\ (0.015) \end{matrix} \quad \begin{matrix} +0.88\Delta p_{t-1} \\ (0.14)^* \end{matrix} \quad \begin{matrix} -0.03\Delta p_{t-2} \\ (0.16) \end{matrix} \quad \begin{matrix} +0.36\Delta i_{t-1} \\ (0.08)^* \end{matrix} , \quad R^2 = 0.734 \quad (12)$$

$$\Delta p_t = \begin{matrix} -0.013 \\ (0.023) \end{matrix} \quad \begin{matrix} +1.01\Delta p_{t-1} \\ (0.19)^* \end{matrix} \quad \begin{matrix} -0.31\Delta p_{t-2} \\ (0.18) \end{matrix} \quad \begin{matrix} +0.31\Delta g_{t-1} \\ (0.17) \end{matrix} , \quad R^2 = 0.571 \quad (13)$$

Regressions (11) and (12) suggest that investment spending has significant explanatory power for future inflation. A one percentage point higher investment growth can raise the inflation rate by 36 bases points. Since investment growth in China responds to government-expenditure growth one for one, it is not surprising in equation (13) that government spending appears equally highly inflationary. The coefficient on government spending is 0.31, nearly identical to that of investment growth in equation (12), although not as statistically significant as investment in equation (12).

On the other hand, regression (14) shows that past inflation *negatively* Granger causes current government spending growth. Compared with equation (10), past inflation is a far superior predictor for the future path (decline) of government spending than past GDP growth, consumption growth, and investment growth together. The  $R^2$  of regression (10) is increased by 63%. This suggests that the Chinese government may be choosing to counter-react to inflation to smooth the business cycle, given that government spending is highly inflationary. The coefficients show that a one percentage increase in the inflation rate reduces the growth rate of government spending by one third of one percent. So if the inflation rate is 3 percentage points higher than last year, government spending growth would be reduced by 1 percentage point, which in turn would lower the growth rate of GDP by 0.3 percentage point and investment growth by 1 percentage point in the short run.

$$\Delta g_t = \begin{matrix} 0.104 \\ (0.026)^* \end{matrix} \quad \begin{matrix} +0.23\Delta g_{t-1} \\ (0.19) \end{matrix} \quad \begin{matrix} -0.15\Delta g_{t-2} \\ (0.15) \end{matrix} \quad \begin{matrix} -0.35\Delta p_{t-1} \\ (0.16)^* \end{matrix} , \quad R^2 = 0.311 \quad (14)$$

## 2.2 The Multiplier

The multiplier is estimated by structural VARs. Following the existing literature, we place government spending first in the following structural VAR model:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + A_0 \varepsilon_t, \quad (15)$$

where  $X_t$  is a vector including government spending ( $G_t$ ), GDP ( $Y_t$ ), consumption ( $C_t$ ), investment ( $I_t$ ), and inflation ( $\pi_t$ ),  $A_0$  is a lower-triangular matrix, and  $\varepsilon_t$  is a vector of

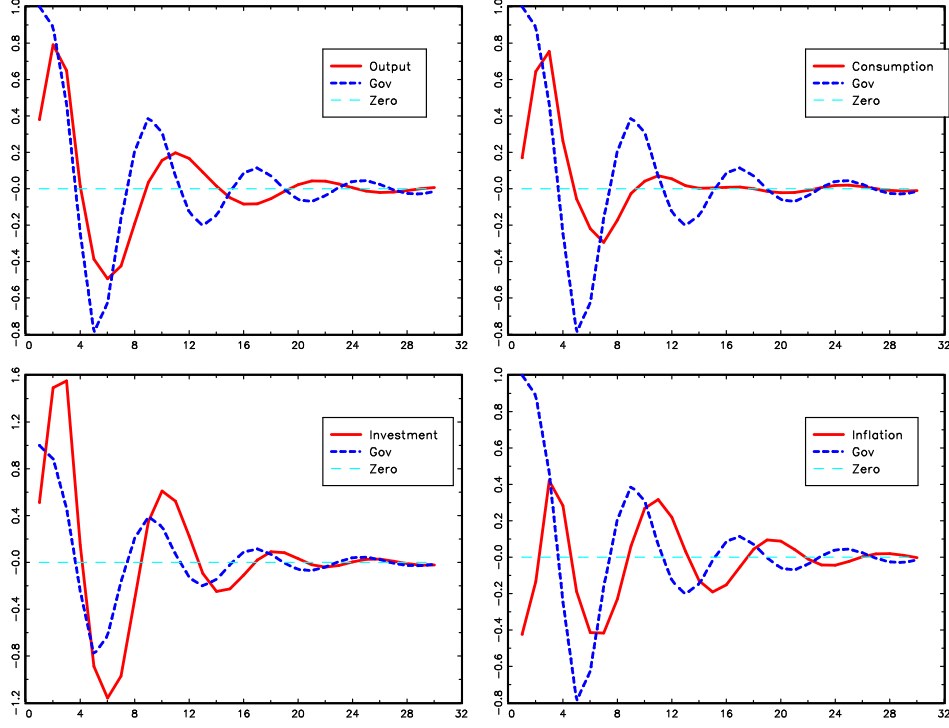


Figure 1: Impulse Responses to a Government Spending Shock.

structural shocks with an identity variance-covariance matrix. Since  $G_t$  is ordered first in the vector  $X_t$ , the first shock in  $\varepsilon_t$  is interpreted as the government spending shock. All variables are in real terms as in the previous subsection and the inflation rate is percentage changes in CPI. Following Ramey (2011a), the VARs are specified in log levels instead of growth rates, with a linear-quadratic time trend and 2 lags included in the regression.

Figure 1 shows the impulse responses of the economy to government spending shock. Several features of Figure 1 are worth noting. First, Chinese economy exhibits periodic boom-bust cycles, with an average cycle length of 7-9 years. Second, government spending (dashed line in each panel) is also itself cyclical and more importantly, it leads the boom-bust cycle in GDP (top-left panel), consumption (top-right panel), and investment (lower left panel) by at least 1 year in each cyclical phase. Third, inflation (lower right panel) strongly commove with the business cycle but tends to lag the boom-bust cycles in GDP and other variables. For example, it lags government spending by 2 years on average in each cyclical phase.

Notice that the periodic boom-bust cycles are not necessarily or entirely an artifact of the linear-quadratic de-trending method. For example, if we simply plot the raw data series, we would still observe a clear cyclical pattern. Figure 2 shows the nominal growth rate of

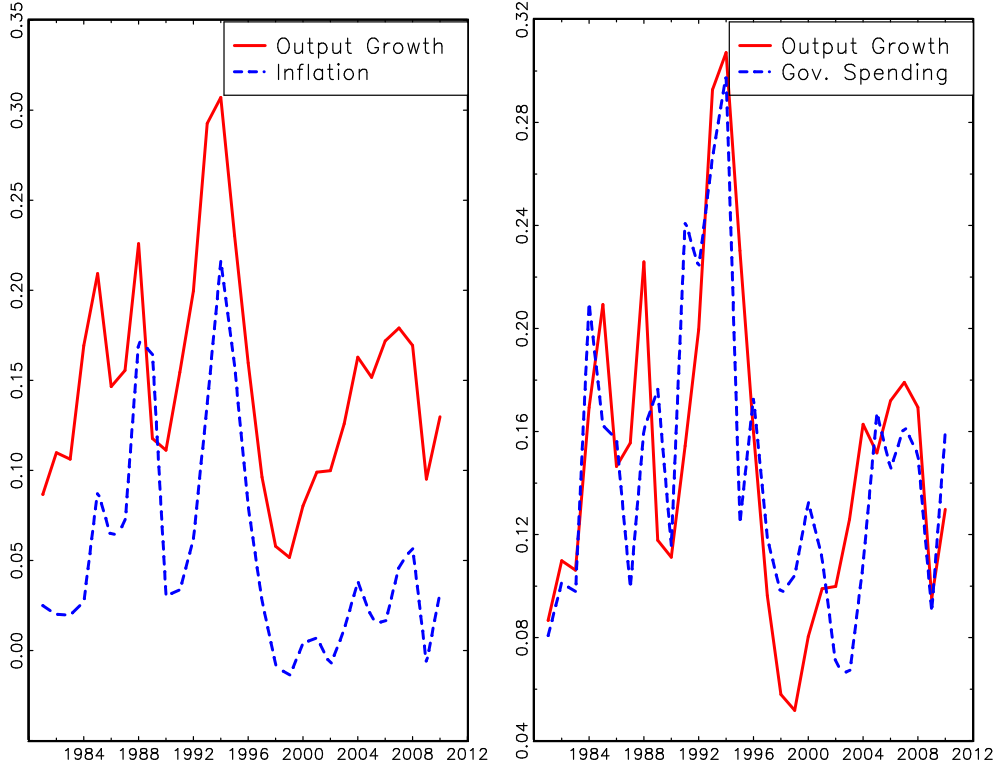


Figure 2: Data: Nominal GDP growth and CPI Inflation.

GDP (solid line in each panel), the CPI inflation rate (dashed line in left panel), and the growth rate of nominal government spending (dashed line in right panel). The figure reveals three important facts about China: (i) the well-known three boom-bust cycles experienced in the 1980s, 1990s and the more recent one around 2008 during the financial crisis; (ii) inflation is strongly procyclical but slightly lags output growth in each boom-bust cycle (this is even more true if we use real GDP); and (iii) changes in government spending is strongly procyclical, as volatile as GDP, and tends to lead GDP over the business cycle.

The existing literature adopts three different ways to compute the multiplier: the impact multiplier, the peak multiplier, and the long-run multiplier. The impact multiplier pertains to the elasticity of output at the impact period. The peak multiplier pertains to the peak response of output in the initial booming phase of the boom-bust cycle. The long-run multiplier pertains to the cumulative changes in output over time divided by the cumulative changes in government spending. These measured elasticities are all multiplied by the average GDP-to-government spending ratio (7.026) in the raw data to obtain the estimated multipliers.<sup>9</sup> The multipliers for consumption and investment are computed similarly (the

<sup>9</sup>Similar to Ramey (2011a), we define the multiplier  $m$  as the absolute increase in GDP level ( $Y_t$ ) above

consumption-to-government spending ratio is 3.193 and investment-to-government spending ratio is 2.337).

Table 2. Estimated Multipliers in China

|                     | Output      | Consumption | Investment  |
|---------------------|-------------|-------------|-------------|
| Impact multiplier   | 2.68 (3.51) | 0.54 (0.63) | 1.20 (1.76) |
| Peak multiplier     | 5.55 (4.84) | 2.41 (1.52) | 3.63 (3.48) |
| Long-run multiplier | 4.86 (12.0) | 3.41 (3.52) | 3.15 (5.37) |

\*Numbers in parentheses are estimations based on one-lagged VAR.

Table 2 reports the estimated multipliers with respect to GDP, consumption, and investment. The output multiplier is between 2.7 and 5.6, consumption multiplier is between 0.5 and 3.4, and investment multiplier is between 1.2 and 3.6. A one dollar increase (decrease) in real government spending can raise (lower) real GDP immediately by about 3 dollars, real consumption by 0.5 dollars, and real investment by 1.2 dollars on impact. In the intermediate run and long run, the multipliers are even larger, as shown in the middle and lower panels in Table 2. As a robustness check, we also report the estimated multipliers when the number of lags is 1 in the structural VAR in equation (15), see the numbers in parentheses in Table 2. The magnitudes are not significantly different, all pointing to large multipliers. The impulse responses to government spending shock with one lag in the structural VAR are graphed in Figure 3.

Further robustness analyses are provided in the Appendix, where we show that (i) the Granger causal relationship between government spending and the economy is robust to price adjustment, so our results are not driven by how the nominal variables are normalized; (ii) the dynamic multiplier is equally large even if we order government spending the last in the structural VARs.

its long-run trend  $\bar{Y}_t$  as a result of a 1 dollar temporary increase in government spending ( $G_t$ ) above its long-run trend  $\bar{G}_t$ :  $m \equiv \frac{d(Y_t - \bar{Y}_t)}{d(G_t - \bar{G}_t)}$ . Suppose we take natural logarithm on GDP and government spending, take out a linear-quadratic time trend, and define the de-trended data series as  $\{\hat{y}_t, \hat{g}_t\} \equiv \left\{ \ln \frac{Y_t}{\bar{Y}_t}, \ln \frac{G_t}{\bar{G}_t} \right\}$ . Suppose by regression analysis we find the coefficient  $\beta$ ,

$$\hat{y}_t = \alpha + \beta \hat{g}_t + e_t. \quad (16)$$

Thus  $\beta$  is the output elasticity of government spending. To convert this elasticity to the multiplier, we can follow the following steps: (i) Let  $\hat{y}_t = \beta \hat{g}_t$ . (ii) Do the following transformation:  $\hat{y}_t \equiv \ln \frac{Y_t}{\bar{Y}_t} \approx \frac{Y_t - \bar{Y}_t}{\bar{Y}_t}$ , and similarly  $\hat{g}_t \equiv \ln \frac{G_t}{\bar{G}_t} \approx \frac{G_t - \bar{G}_t}{\bar{G}_t}$ . (iii) Thus,  $\frac{Y_t - \bar{Y}_t}{\bar{Y}_t} = \beta \frac{G_t - \bar{G}_t}{\bar{G}_t}$ , or  $m = \frac{Y_t - \bar{Y}_t}{G_t - \bar{G}_t} = \frac{\bar{Y}_t}{\bar{G}_t} \beta$  is the measured multiplier.

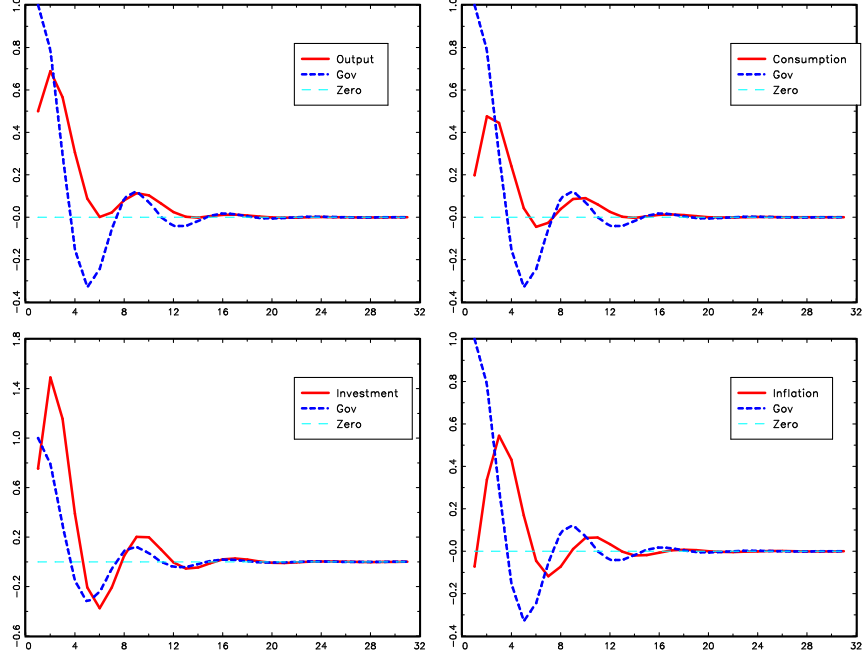


Figure 3: Impulse Responses to a Government Spending Shock (1 lag in VAR).

## 2.3 Panel Regression

We collect regional data from 29 provinces in China, including GDP ( $Y_{i,t}$ ), household consumption expenditures ( $C_{i,t}$ ), gross fixed capital formation ( $I_{i,t}$ ), and government consumption expenditures ( $G_{i,t}$ ) for each province  $i$  (except Chongqing and Tibet, because Chongqing became a province-level district in 1997 and there are too many missing data points for Tibet) from 1981 to 2011.<sup>10</sup> All variables are annual and nominal and we deflate them by provincial CPI for each province  $i$ . The data are from China Macro Database (Zhong Hong Shu Ju Ku).

The sum of all government spending from all provinces roughly equals the aggregate government spending in China. Because increases in government spending in one province may generate spill-over effects in other provinces, as the increased demand at the local level affects demand for the goods produced in neighboring provinces. Thus, we need to take into account such cross-province effects (externalities) into consideration in our panel regression analyses, which cannot be captured by standard panel regression with just a regional fixed-effect coefficient. To deal with the potential spill-over effects, we use spatial panel regression technique to estimate the multipliers by constructing a spatial weighting matrix that captures the cross-province effects.

<sup>10</sup>Data on provincial CPI earlier than 1981 are not available.

Defining the growth rate of a vector of variables  $X_t$  by  $\Delta x_t \equiv \ln X_t - \ln X_{t-1}$ , we run the following spatial panel regression:

$$\Delta z_t = \varphi W_A \Delta z_t + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta z_{t-2} + \beta \Delta g_t + \gamma + \varepsilon_t, \quad (17)$$

where  $\Delta z_t$  is a  $29 \times 1$  vector composed of the annual growth rates of variable  $Z_t$  in all 29 provinces, with  $Z = \{Y, C, I\}$ , respectively; similarly,  $\Delta g_t$  is a  $29 \times 1$  vector composed of the annual growth rates of real government expenditures in all provinces; and  $\gamma$  contains 29 dummies to control for fixed effects.

The term  $\varphi W_A \Delta z_t$  captures the cross-province spill-over effect, in which  $W_A$  is a  $29 \times 29$  spatial weighting matrix that does not change over time. Following Case, Rosen, and Hines's (1993) method, we construct  $W_A$  as follows: its  $ij$ th element  $w_{ij} = \frac{1}{S_i}$  if province  $i$  and province  $j$  share a common border,  $w_{ij} = 0$  otherwise; and  $S_i$  equals the number of provinces who share a common border with province  $i$ . The coefficient  $\varphi$  means that if the growth rate of  $Z$  for all other provinces (except province  $i$ ) increases by 1 percentage point, province  $i$ 's variable  $Z$  will increase by  $\varphi$  percentage points. We control the fixed effect for each province by  $\gamma$ . The results are shown in the left panel in Table 3 where numbers in parentheses are standard errors (and by convention, "\*\*\*\*" denotes significance level at or above 1%).

Since we use "share a border or not" to define our spatial weighting matrix  $W_A$ , we may have ignored the spill-over effect between provinces that do not share a border. As an alternative, we also use geography proximity (distance between provincial capitals) to define the spatial weighting matrix. We construct the new matrix by setting  $w_{ij} = \frac{1}{d_{ij} S_i}$ , where  $d_{ij}$  is the distance between capital  $i$  and  $j$  and  $S_i = \sum_j \frac{1}{d_{ij}}$ . The newly defined matrix is called  $W_B$  and the associated results are reported in the right panel in Table 3 where numbers in parentheses are standard errors.

Table 3. Multipliers based on Panel Regressions

|               | Spatial Matrix $W_A$ |                     |                     | Spatial Matrix $W_B$ |                     |                     |
|---------------|----------------------|---------------------|---------------------|----------------------|---------------------|---------------------|
|               | $\Delta y_t$         | $\Delta c_t$        | $\Delta i_t$        | $\Delta y_t$         | $\Delta c_t$        | $\Delta i_t$        |
| $\varphi$     | 0.537<br>(0.031)***  | 0.405<br>(0.038)*** | 0.524<br>(0.032)*** | 0.735<br>(0.029)***  | 0.680<br>(0.040)*** | 0.743<br>(0.031)*** |
| $\alpha_1$    | 0.189<br>(0.028)***  | 0.155<br>(0.032)*** | 0.188<br>(0.029)*** | 0.150<br>(0.026)***  | 0.101<br>(0.031)*** | 0.133<br>(0.027)*** |
| $\alpha_2$    | 0.053<br>(0.027)***  | -0.028<br>(0.032)   | -0.035<br>(0.027)   | 0.028<br>(0.025)     | -0.063<br>(0.031)** | -0.034<br>(0.025)   |
| $\beta$       | 0.114<br>(0.013)***  | 0.047<br>(0.017)*** | 0.151<br>(0.033)*** | 0.107<br>(0.012)***  | 0.036<br>(0.016)**  | 0.122<br>(0.031)*** |
| SR Multiplier | 1.72                 | 0.25                | 0.74                | 2.83                 | 0.36                | 1.11                |
| LR Multiplier | 3.63                 | 0.34                | 1.23                | 6.51                 | 0.53                | 2.30                |

Table 3 shows that regardless which spatial weighting matrix is used, both the spill-over effects ( $\varphi$ ) and the direct effects of government spending ( $\beta$ ) are strong and highly significant for output ( $Y$ ), consumption ( $C$ ), and investment ( $I$ ). We can calculate the multipliers for output, consumption, and investment straightforwardly using the estimated coefficients in Table 3 and these implied multipliers are reported in the bottom rows in Table 3. For example, given that the average GDP-to-government spending ratio is 7, the short-run (SR) multiplier is  $7 \times \frac{\beta}{1-\varphi}$  and the long-run (LR) multiplier is  $7 \times \frac{\beta}{1-\varphi-\alpha_1-\alpha_2}$  (we drop  $\alpha_2$  if it is not significantly different from zero below the 10% confidence level). In particular, under spatial weighting matrix  $W_B$ , the coefficient on  $\Delta G_t$  is  $\beta = 0.107$  for the output equation, and the coefficient for the spill-over effect is  $\varphi = 0.735$ ; thus, the SR multiplier is 2.83 and the LR output multiplier is 6.51. The multipliers for consumption and investment are calculated analogously. Compared with Table 2, the estimated income multiplier using spatial panel techniques ranges from 1.72 to 2.83 in the short run and from 3.63 to 6.51 in the long run, which are broadly similar in magnitudes to those obtained under structural VARs based on aggregate time series data.<sup>11</sup>

### 3 The Model

How to rationalize the large multiplier effects of government spending and its role in driving the boom-bust cycles in China? More importantly, how do we know that the empirical estimates in the previous section are reliable? To answer these questions, this section provides a simple macro model to capture the stylized facts discussed previously and then use model-generated data to test if we can uncover the theoretical multiplier in the model by applying the same econometric procedures to the model-generated data.

We build several new features into a fairly standard neoclassical growth model to generate large multipliers and boom-bust cycles by adding the following assumptions:

1. We impose a wedge between potential output and actual output in the form of distortionary tax to capture any loss of potential output due to market failures, incomplete or missing markets, resource misallocations, corruptions, efficiency losses due to the existence of state-owned enterprises (SOEs) and imperfect competition, and many other forms of real frictions in the Chinese economy. This wedge is assumed to be a fixed portion  $\tau_0$  of the potential output  $Y^*$ , and we define  $\Phi \equiv \tau_0 Y^*$  as the deadweight

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<sup>11</sup>Using panel data from the United States, Shaog (1010) finds a fiscal multiplier of 2 across states.

cost to the economy each year. The potential output is defined as the steady-state output level in the absence of the deadweight cost. However, each individual firm must pay a fraction  $\tau_t$  of its current output  $y_t$  to cover this deadweight cost, so that  $\tau_t \int_{i=0}^1 y_t di = \Phi$ . Therefore, it is as if the economy commits a fixed portion of its aggregate output to pay for the distortions and market failures. Because this deadweight loss is shared by all firms as an implicit tax, it imposes a counter-cyclical distortionary tax  $\tau_t$  on firms when the actual output  $Y_t \equiv \int_{i=0}^1 y_t di$  fluctuates. This time-varying and countercyclical "tax" burden creates a shadow markup  $(1 - \tau_t)$  or externality in the economy, giving rise to incentives for firms to "over produce" in a boom and "under produce" in a recession. This wedge, combined with other forces, leads to endogenous boom-bust cycles.

2. Government spending helps to reduce the costs of firms' investment. This assumption implies that the benefits (costs) of doing business investment in China is highly correlated with government spending.<sup>12</sup>
3. Government spending is partially financed through money creation. This means that government spending is inflationary. However, since inflation causes social unrest, the government also tries to respond to inflation by reducing its expenditure when the economy is over-heated. So we assume that government spending follows a Taylor-type of feedback rule: it responds to lagged inflation negatively and lagged output positively. These assumptions make government spending and money supply partially endogenous in our model and thus amplify any endogenous boom-bust cycles.

We show that these features, combined together with variable capacity utilization and time-to-build, can generate the large multiplier effects and boom-bust cycles observed in China under reasonable parameter values. We then use the model as a true data generating process for structural VAR analysis. We find that standard VAR methods can reasonably uncover the theoretical multipliers in the model.

To perform structural VAR analysis, the theoretical model must have at least the same number of shocks as the number of variables in the VAR. Since ours is a closed-economy model with the accounting identity  $Y_t = C_t + I_t + G_t + \Phi$ , we will use a 4-variable VAR in our Monte Carlo analysis to avoid collinearity. The 4 variables are output ( $Y_t$ ), investment ( $I_t$ ),

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<sup>12</sup>In China, both the central and local governments deliberately provide a wide spectrum of incentives and public services to attract, facilitate, and promote private investment. This government behavior can be viewed as implicitly subsidizing private investment through lump-sum taxation.

government spending ( $G_t$ ), and inflation ( $\pi_t$ ). So our model has 4 mutually independent structural shocks, including a shock to government spending ( $\tilde{g}_t$ ), a shock to total factor productivity (TFP,  $A_t$ ), a shock to the marginal utility of consumption (preference shock  $\Delta_t$ ), and a shock to the velocity of money ( $V_t$ ). We assume a deterministic growth trend in the model and in the data. Any fluctuations in the model and in the data are treated as movements around a deterministic time trend. Hence, we will use the de-trended variables in levels (instead of growth rates) to estimate the multipliers in both the actual data and model-generated data, as in Ramey (2011a).

### 3.1 Government

Assume that total government expenditure  $G_t$  is financed partly by deficits and lump-sum taxes on household income, and partly by bank credit or money creation. To simplify the model, we assume that the net supply of government bonds is zero in equilibrium and that government prints money to finance part of its expenditures instead of borrowing credit from the banking sector. Denoting  $P_t$  as the aggregate price level and  $M_t$  as the stock of money at the end of period  $t$ , real government spending in each period is given by

$$G_t = \frac{(M_{t+1} - M_t)}{P_t} + T_t + B_{t+1} - (1 + t_t) B_t. \quad (18)$$

We assume that  $\phi$  fraction of government spending is financed by deficits and lump-sum taxes, and the rest is financed by printing money:

$$\phi G_t = T_t + B_{t+1} - (1 + t_t) B_t \quad (19)$$

$$(1 - \phi) G_t = \frac{M_{t+1} - M_t}{P_t} \quad (20)$$

For example, if government spending is financed entirely by lump-sum taxes ( $\phi = 1$ ), then the changes in money stock is zero. Equation (20) implies that the increase in money supply is endogenous in the model, depending on government expenditures  $G_t$ .

As in a New Keynesian model, we assume a Taylor-type rule for government spending—it responds endogenously to inflation and output,

$$\log G_t = \tilde{g}_t + \gamma_\pi \log \pi_{t-1} + \gamma_y \log Y_{t-1}, \quad (21)$$

where  $\tilde{g}_t$  denotes an exogenous shock process (component) in the observed government spending  $G_t$ , such as military spending,  $\pi_t \equiv \frac{P_t}{P_{t=1}}$  denotes period- $t$  inflation, and  $\gamma_\pi < 0$  denotes the inflation elasticity of government spending as a policy tool.

Clearly, under the above assumption the measured government spending  $G_t$  in our model is not completely exogenous. However, since inflation and output affect  $G_t$  with a lag, all other structural shocks in this model (except  $\tilde{g}_t$ ) can affect  $G_t$  only with a lag. This implication is consistent with the identification assumption in the structural VAR in the previous section where innovations in government spending  $G_t$  can affect other variables in the VAR on impact but innovations in other variables do not affect  $G_t$  in the impact period.

Therefore, when applying structural VAR to the model-generated samples, if we order government spending the last in the VAR, by design we would not be able to identify any "government spending shocks" that have a significant contribution to output fluctuations. It turns out that this is also the case in the Chinese data—namely, if we order government spending the last in the VAR, the identified "government spending shocks" explain less than 3% of total variance in GDP and other variables. This empirical feature of the data is also consistent with the Granger causality test shown in the previous section.

Finally, notice that our model does not directly or explicitly capture the Granger causality relations found in Chinese data.<sup>13</sup> However, as long as government spending  $G_t$  in our model does not respond to non-government shocks on impact, and all endogenous variables such as  $\{Y_t, I_t, C_t, \pi_t\}$  respond to government spending shock ( $\tilde{g}_t$ ), the identification assumptions in the structural VARs are valid for the model-generated data.

## 3.2 Household

As observed by Modigliani and Cao (2004), although China is not a full market-economy yet, standard economic models can nonetheless capture the Chinese household saving behaviors quite well. So this paper assumes a representative household that take prices as given when making consumption and saving decisions. Distortions are mainly on the government and the firm side. The household can hold several assets as store of value to smooth consumption, including government bonds ( $B_{t+1}$ ), money ( $M_{t+1}$ ), and firms' equity shares ( $S_{t+1}$ ). Labor supply is perfectly elastic, so the utility function is linear in leisure. Denoting  $Q_t$  as the price of equity (stock price) and  $D_t$  as dividend flows, the representative household solves

$$\max E \sum_{t=0}^{\infty} \beta^t \{ \Delta_t \log C_t - N_t \}$$

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<sup>13</sup>To capture Granger causality in a theoretical DSGE model requires very sophisticated information structures that are beyond the scope of this paper and is a challenge left for future research (see Wen, 1997).

subject to

$$C_t + \frac{(1 + \bar{g}_x) B_{t+1}}{1 + r_t} + (Q_t - D_t) (1 + \bar{g}_x) S_{t+1} + \frac{(1 + \bar{g}_x) M_{t+1}}{P_t} \leq \frac{M_t}{P_t} + Q_t S_t + B_t + W_t N_t - T_t \quad (22)$$

$$C_t \leq V_t \frac{M_t}{P_t} \quad (23)$$

where  $\bar{g}_x$  denotes the long-run potential growth rate of productivity,  $T_t$  denotes lump-sum taxes,  $W_t$  denotes real wage,  $\Delta_t$  denotes preference shock, and  $V_t$  denotes a shock to the velocity of money. Denoting  $\{\Lambda_t, \mu_t\}$  as the Lagrangian multipliers for equations (22) and (23), respectively, the first-order conditions for  $\{C_t, N_t, B_{t+1}, S_{t+1}, M_{t+1}\}$  are given by

$$\frac{\Delta_t}{C_t} = \Lambda_t + \mu_t \quad (24)$$

$$1 = W_t \Lambda_t \quad (25)$$

$$(1 + \bar{g}_x) \Lambda_t = \beta (1 + r_t) E_t \Lambda_{t+1} \quad (26)$$

$$(1 + \bar{g}_x) (Q_t - D_t) \Lambda_t = \beta E_t \Lambda_{t+1} Q_{t+1} \quad (27)$$

$$\frac{\Lambda_t}{P_t} = \frac{\beta}{1 + \bar{g}_x} E_t \frac{\Lambda_{t+1} + V_{t+1} \mu_{t+1}}{P_{t+1}} \quad (28)$$

Equation (27) implies that stock price (firm value) equals the present value of future dividends:

$$Q_t = E_t \sum_{j=0}^{\infty} \left( \frac{\beta}{1 + \bar{g}_x} \right)^j \frac{\Lambda_{t+j}}{\Lambda_t} D_{t+j} = E_t \sum_{j=0}^{\infty} \prod_{i=0}^j \left( \frac{1}{1 + r_{t+i}} \right) D_{t+j} \quad (29)$$

which will become the firm's objective function in the following subsection.

### 3.3 Firms

Firms are identical and are price takers. As mentioned previously, we impose a wedge on the economy in the form of distortionary income tax to capture the deadweight loss of output due to market failures, externalities, incomplete markets, resource misallocations, corruptions, the existence of SOEs and their monopoly power, and so on. The total deadweight loss is

$\Phi$  and is shared by all firms. To cover the deadweight loss, firms are taxed at the rate  $\tau_t$  of their revenues so that the aggregate tax revenue equal the deadweight cost,  $\tau_t Y_t = \Phi$ .<sup>14</sup>

There exists a labor augmenting technology that grows over time at a deterministic growth rate  $\bar{g}_x \geq 0$ . Since we focus on fluctuations around the balanced growth path, all non-stationary endogenous variables are normalized (scaled) by this technology trend. In the de-trended model, a representative firm combines labor and capital stock to produce output in each period. The production technology is given by

$$Y_t = A_t (e_t K_t)^\alpha N_t^{1-\alpha}, \quad (30)$$

where  $e_t \in [0, 1]$  denotes the rate of capacity utilization, and  $A_t$  denotes aggregate shocks to total factor productivity (TFP). The rate of private capital depreciates at a time-varying rate  $\delta_t$ , which depends on the rate of capacity utilization (Greenwood et al., 1988):

$$\delta_t = \frac{\delta_0}{1 + \theta} e_t^{1+\theta}, \quad \theta > 0. \quad (31)$$

So the private capital stock evolves according to the law of motion

$$(1 + \bar{g}_x) K_{t+1} = (1 - \delta_t) K_t + \chi_t I_t^\alpha I_{t-1}^{1-\alpha}, \quad (32)$$

where  $I_t$  denotes period- $t$  investment, and  $I_t^\alpha I_{t-1}^{1-\alpha}$  in equation (32) denotes time-to-build (Wen, 1998b). That is, it takes multiple (two) periods of investments to construct new capital. The parameter  $\sigma$  measures the elasticity of substitution across past and current investments in different periods. Wen (1998b) shows that this form of time-to-build requires commitment of future investment and can hence generate autocorrelated persistence in investment spending, unlike the original Kydland-Prescott (1982) specification (which generates sawtooth waves of investment that are inconsistent with data). This type of time-to-build also dampens investment responses to shocks because commitment is costly. More importantly, it avoids indeterminacy in the model caused by the existence of the fixed costs or tax burden  $\Phi$ . The variable  $\chi_t$  captures any exogenous movements in the costs of financing private investment (or efficiency shocks to private investment). When  $\chi_t$  is low, the costs (benefits) of investment is high (low). Since government expenditure in China is "business-friendly" and investment promoting, we assume

$$\chi_t = \chi_0 G_t^{\gamma_x} \quad (33)$$

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<sup>14</sup>This setup is similar to the model of Schmitt-Grohe and Uribe (1997). As shown by Wen (2001), the mechanism giving rise to endogenous cycles in the Schmitt-Grohe-Uribe model is similar to the Wen (1998a) model.

with  $\gamma_\chi > 0$  as a parsimonious way of capturing any direct and indirect effects of government spending on firms' investment returns or costs of doing business. To simplify the analysis, we assume  $\chi_t = 1$  in the steady state. This investment efficiency wedge is important for the model to capture the impact multiplier in China.<sup>15</sup>

We assume that firms are owned by households through the equity market. So the proper discounting factor of the firm is the market interest rate or the ratio of marginal utilities of the representative household. The firm's problem is to maximize the present value of future dividends by solving

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} \{ (1 - \tau_t) A_t (e_t K_t)^\alpha N_t^{1-\alpha} - W_t N_t - I_t \} \quad (34)$$

subject to (31) and (32). As assumed previously, each firm must take  $\tau_t \equiv \frac{\Phi}{Y_t}$  as given in maximizing profits. Non-negative profits requires  $\tau_t < 1$ , which is the assumption we make in this paper.

Denoting  $q_t$  as the Lagrangian multiplier for equation (32), firm's first-order conditions for  $\{e_t, N_t, I_t, K_{t+1}\}$  are given, respectively, by

$$(1 - \tau_t) \alpha \frac{Y_t}{e_t} = q_t \delta_0 e_t^\theta K_t \quad (35)$$

$$(1 - \tau_t) (1 - \alpha) \frac{Y_t}{N_t} = W_t \quad (36)$$

$$1 = \sigma q_t I_t^{\sigma-1} I_{t-1}^{1-\sigma} + (1 - \sigma) \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} q_{t+1} I_{t+1}^\sigma I_t^{-\sigma} \quad (37)$$

$$(1 + \bar{g}_x) q_t = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \left[ \alpha (1 - \tau_{t+1}) \frac{Y_{t+1}}{K_{t+1}} + (1 - \delta_{t+1}) q_{t+1} \right] \quad (38)$$

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<sup>15</sup> As an example of how government spending affects firm investment and local business, consider the story of Gu Zhen, a town of Guangdong province in China's south-east coast area. Gu Zhen was a poor village in the early 1980s but is now famous for its light-fixture products. In 1980s, the local government of Gu Zhen helped to bring in two light-fixture assembly companies from Hong Kong, from which the local entrepreneurs learned the production technology and business model of light-fixture industry. Once the local enterprises in light industries started to develop, local government offered a variety of support in financing, information provision, worker training, and technology transferring. From 1999 on, Gu Zhen's local government organizes international exhibition for the products of local firms each year to help local companies sell their products. All such services offered by Gu Zhen's local government are helpful for attracting and enhancing business investment and nurturing private enterprises through reducing their investment costs and other types of operation costs (Yang, 2010). In China, all layers of central and local governments are motivated to provide similar facilities and services to help attract business entry and private capital formation in China. There is at least one industrial park in each city of China built by the government to promote investment and economic growth.

Notice that if there is no time-to-build ( $\sigma = 1$ ), then equation (37) reduces to  $q_t = 1$ , as in a standard RBC model. Therefore, time-to-build introduces a dynamic wedge for Tobin's  $q$  ( $q_t \neq 1$ ), similar to a model with investment adjustment cost.

### 3.4 General Equilibrium

The general equilibrium of the model is characterized by the dynamic path of 14 endogenous variables,  $\{e_t, N_t, I_t, K_{t+1}, C_t, W_t, \Lambda_t, P_t, \tau_t, M_{t+1}, Y_t, \delta_t, G_t\}$ , which can be solved uniquely by log-linearising the following system of 14 equations around the steady state:<sup>16</sup>

$$(1 - \tau_t) \alpha \frac{Y_t}{e_t} = q_t \delta_0 e_t^\theta K_t \quad (39)$$

$$(1 - \tau_t) (1 - \alpha) \frac{Y_t}{N_t} = W_t \quad (40)$$

$$1 = \sigma q_t I_t^{\sigma-1} I_{t-1}^{1-\sigma} + (1 - \sigma) \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} q_{t+1} I_{t+1}^\sigma I_t^{-\sigma} \quad (41)$$

$$(1 + \bar{g}_x) q_t = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \left[ \alpha (1 - \tau_{t+1}) \frac{Y_{t+1}}{K_{t+1}} + (1 - \delta_{t+1}) q_{t+1} \right] \quad (42)$$

$$1 = W_t \Lambda_t \quad (43)$$

$$(1 + \bar{g}_x) \frac{\Lambda_t}{P_t} = \beta E_t \frac{\Lambda_{t+1} + \mu_{t+1} V_{t+1}}{P_{t+1}} \quad (44)$$

$$C_t = \frac{M_t}{P_t} \quad (45)$$

$$(1 + \bar{g}_x) K_{t+1} = (1 - \delta_t) K_t + \chi_t I_t^\alpha I_{t-1}^{1-\alpha}, \quad (46)$$

$$C_t + I_t + G_t = (1 - \tau_t) Y_t \quad (47)$$

$$\tau_t = \frac{\Phi}{Y_t} \quad (48)$$

$$(1 - \phi) G_t = \frac{(1 + \bar{g}_x) M_{t+1} - M_t}{P_t} \quad (49)$$

$$Y_t = A_t (e_t K_t)^\alpha N_t^{1-\alpha} \quad (50)$$

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<sup>16</sup>The existence of time-to-build rules out local indeterminacy, so the steady state is saddle-path stable.

$$\delta_t = \frac{\delta_0}{1 + \theta} e_t^{1+\theta} \quad (51)$$

$$\log G_t = \log g_t + \gamma_\pi \log \pi_{t-1} + \gamma_y \log Y_{t-1}, \quad (52)$$

subject to standard initial conditions and transversality conditions. The laws of motion for the 4 structural shock variables are specified as

$$\log \Delta_t = \rho_\Delta \log \Delta_{t-1} + \varepsilon_{\Delta t} \quad (53)$$

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{At} \quad (54)$$

$$\log g_t = \rho_g \log g_{t-1} + \varepsilon_{gt} \quad (55)$$

$$\log V_t = \rho_v \log V_{t-1} + \varepsilon_{vt}, \quad (56)$$

where the innovations  $\{\varepsilon_{\Delta t}, \varepsilon_{At}, \varepsilon_{gt}, \varepsilon_{vt}\}$  are i.i.d. with variances  $\{\sigma_\Delta^2, \sigma_A^2, \sigma_g^2, \sigma_v^2\}$ , respectively.

## 4 Monte Carlo Analysis

### 4.1 Theoretical Model as Data Generating Process

**Parameter Calibrations.** The model has more than 15 structural parameters. Notice that the capacity-depreciation elasticity parameter  $\theta$  in equation (51) is not an independent parameter, it is pinned down by the model's first-order conditions for the capital stock (42) and capacity utilization (39) in the steady state by the relation  $\theta = \frac{1+g_x-\beta}{\beta\delta}$ , where  $\delta$  is the steady-state depreciation rate.  $\delta_0$  in equation (51) can be chosen arbitrarily to match the steady-state capacity utilization rate  $e$ .<sup>17</sup>

We calibrate the remaining independent parameters in a way such that a selected set of the model's second (conditional) moments under government shocks broadly match those in the data. Although matching the Chinese data is not the main focus of this paper, it would be more comforting if the model-generated data broadly resemble the Chinese data, especially in terms of the large multipliers and the strong boom-bust cycles. We focus on the following model moments: the standard deviation of consumption, investment, inflation, and government spending relative to output, the correlations of these variables with output, and the first-order auto-correlations of these variables. Since all moments are relative to output, we normalize the STD of government spending shock  $\sigma_g^2 = 1$ .

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<sup>17</sup>See Wen (1998a).

Because boom-bust cycle is an important aspect of the data and it may significantly bias the estimation of the multipliers, we select two sets of parameter values, called "Calibration 1" and "Calibration 2", both of which allow the model to broadly match the second moments of the data (at least qualitatively); but by design Calibration 1 does not generate as strong a cyclical tendency in the model as Calibration 2. In particular, Calibration 1 generates only a hump-shaped impulse response of output to government shocks whereas Calibration 2 generates strongly oscillatory boom-bust cycles similar to those in the data. The two calibrations can help reveal whether boom-bust cycles in the data bias or hinders the estimation of multipliers and if so, to which direction.

Since our focus is on the fiscal multiplier and the conditional moments of the model under government shocks, we do not calibrate the three non-government shocks in a sophisticated manner since they are in the model only to avoid singularity of the model-generated data; thus, we are not very concerned about how they are calibrated. The only requirement we need to impose on them is that the three non-government shocks together cannot explain more than 40% of the STD of aggregate output, which is what we found in the Chinese data.<sup>18</sup> So for simplicity, we assume that the other three structural shocks are i.i.d. processes with  $\rho_A = \rho_\Delta = \rho_v = 0$  and  $\sigma_A = \sigma_\Delta = \sigma_v = 0.2$ . The persistence parameter for government spending shock is  $\rho_g = 0.6 \sim 0.8$ , consistent with Chinese data (see Table 6). The calibrated parameter values are reported in Table 4.<sup>19</sup>

All parameters jointly affect the theoretical multipliers in the model. In particular, the deadweight cost to output ratio ( $\frac{\Phi}{Y}$ ), the inflation feedback parameter  $\gamma_\pi$ , and the government impact parameter  $\gamma_\chi$  on firm investment, among others, jointly determine the size of the multipliers and the strength of the boom-bust cycle in the model. Since this is a parsimonious model, the parameter values or their difference from standard calibrations should be viewed as wedges between the Chinese economy and the U.S. economy or a standard RBC model.

The calibrated values of the parameters suggest that China is significantly different from the United States or a standard business-cycle model in many aspects. For example, (i) the implicit tax rate due to deadweight loss from resource misallocations, market failures, and other distortions in China is high, ranging from 25% to 35% a year, close to capital income tax in the United States;<sup>20</sup> (ii) government spending is highly responsive to inflation, with

<sup>18</sup>Based on variance decomposition in the structural VAR in the previous section, government shocks explain about 60% of GDP while the other 4 structural shocks together explain about 40% of GDP.

<sup>19</sup>Our Monte Carlo analysis reveals that the persistence and variance of the other structural shocks do not affect the consistence of the multiplier-estimators but will affect the standard errors (precision) of the estimators.

<sup>20</sup>Hsieh and Klenow (2009) estimate that resource misallocation due to incomplete or missing financial

an elasticity  $\gamma_\pi$  between  $-1$  and  $-2$ ; and (iii) government spending has a big impact  $\gamma_\chi$  on the cost of doing business or investment in China; everything else equal, a one percent increase in government spending can increase the rate of return to private investment by 10% to 35%.<sup>21</sup>

Table 4. Calibrated Parameter Values

| Parameter        | Calibration 1 | Calibration 2 | Note                                         |
|------------------|---------------|---------------|----------------------------------------------|
| $\alpha$         | 0.35          | 0.4           | capital's income share                       |
| $\beta$          | 0.985         | 0.9           | time discounting factor                      |
| $\delta$         | 0.1           | 0.9           | capital depreciation rate                    |
| $\sigma$         | 0.95          | 0.95          | time-to-build parameter                      |
| $\frac{\Phi}{Y}$ | 0.25          | 0.35          | dead weight loss as share of output          |
| $\phi$           | 0.4           | 0.5           | composition of government spending           |
| $g_x$            | 0.1           | 0.1           | long-run growth rate                         |
| $s_g$            | 0.1425        | 0.1425        | share of government spending                 |
| $\gamma_\pi$     | -1.0          | -2.0          | inflation coefficient in Taylor rule         |
| $\gamma_y$       | 0.5           | 0.5           | output coefficient in Taylor rule            |
| $\gamma_\chi$    | 0.35          | 0.1           | investment elasticity of government spending |
| $\rho_g$         | 0.8           | 0.6           | persistence in government shock              |
| $\sigma_g$       | 1.0           | 1.0           | STD of government shock                      |
| $\sigma_A$       | 0.2           | 0.2           | STD of TFP shock                             |
| $\sigma_\Delta$  | 0.2           | 0.2           | STD of preference shock                      |
| $\sigma_v$       | 0.2           | 0.2           | STD of velocity shock                        |

**Impulse Responses to Government Shock.** The impulse responses of the model to a one-standard deviation shock to the autonomous component  $\tilde{g}_t$  in government spending are graphed in Figure 4, where the dashed line in the top two windows is the actual government spending  $G_t$  in the model, the left column panel pertains to output, investment, and inflation Calibration 1 and the right column panel pertains to Calibration 2. Several features are worth noticing. First, under either calibrations, the model is able to generate positive and hump-shaped impulse responses in output and investment. Second, the model is able to generate a procyclical and highly persistent inflation rate (which lags the boom-bust cycle in output under Calibration 2) despite the lack of sticky prices. Third, the model can generate procyclical government spending  $G_t$  that exhibits the same boom-bust cycles as in output and investment. If we increase the value of  $\gamma_\pi$ , the model can also generate an impulse response function of government spending  $G_t$  that appears to lead the boom-bust cycle as in the data.

**Theoretical Multipliers.** The theoretical multipliers implied by the model's impulse response functions are reported in Table 5. We focus on income multipliers. The size of markets reduces China's TFP by 50% or more.

<sup>21</sup>These numbers reflect more of a wedge between the model and the data rather than a realistic description. We treat the time period  $t$  as a year. Notice that except the time discounting factor  $\beta$  and capital depreciation rate  $\delta$ , all parameter values are broadly similar across the two calibrations. The excessively high depreciation rate under Calibration 2 appears highly inconsistent with the actual rate of depreciation assumed in the literature. However, it is not so unthinkable given that the average lifespan of private enterprises is just 2.9 years in China, compared to 30 years in Japan and 40 years in the United States (see <http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20120221000077&cid=1502>).

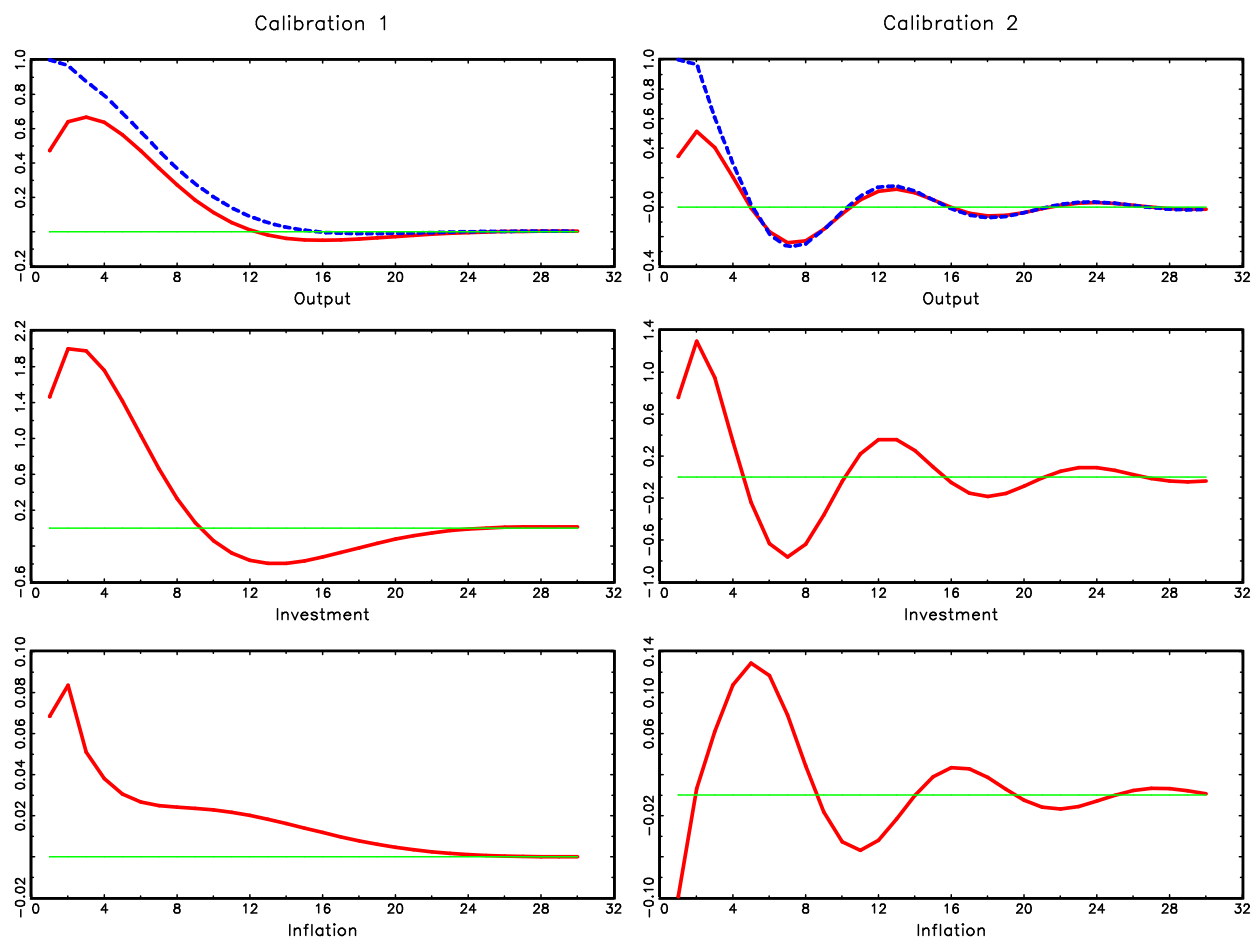


Figure 4: Impulse Responses to Government shock.

the income multiplier ranges from about 2.5 to 5, broadly similar in magnitudes to those found in the Chinese economy (but with a weaker dynamic multiplier in the model). The cumulative multiplier becomes significantly larger when based on the absolute values of the areas underneath the impulse response functions.

Table 5. Theoretical Multipliers

| Multiplier type  | Calibration 1 | Calibration 2 |
|------------------|---------------|---------------|
| Impact           | 3.30          | 2.41          |
| Peak             | 4.67          | 3.60          |
| Cumulative       | 4.42          | 2.73          |
| Cumulative (abs) | 5.10          | 4.61          |

\*Cumulative (abs) is based on the sum of the absolute value of the area underneath the impulse response function.

**Conditional Second Moments.** A selected set of second moments conditional on government shocks is reported in Table 6. In generating the predicted moments in the model, we simulate the model under government spending shocks for 1000 times and each time with a sample length of  $N = 33$ , as in the Chinese data. The model is simulated under the two alternative calibrations. After sampling, we form a convex combination of the two group of samples (each group has 1000 samples) by assigning a weight of 0.7 to the first group under calibration 1 and 0.3 to the second group under calibration 2, reflecting our prior on the parameters. This sampling strategy is a brutal (short-cut) way of capturing both parameter uncertainty and sampling uncertainty.

Table 6. Conditional Second Moments

|         | STD  |            | Correlation with $Y_t$ |            | Autocorrelation |            |
|---------|------|------------|------------------------|------------|-----------------|------------|
|         | Data | Model      | Data                   | Model      | Data            | Model      |
| $Y_t$   | 1    | 1          | 1                      | 1          | 0.69            | 0.91 (.06) |
| $C_t$   | 0.80 | 0.63 (.09) | 0.96                   | 0.61 (.14) | 0.68            | 0.95 (.05) |
| $I_t$   | 2.38 | 2.80 (.21) | 0.96                   | 0.97 (.01) | 0.68            | 0.89 (.06) |
| $\pi_t$ | 0.94 | 0.12 (.03) | 0.51                   | 0.64 (.20) | 0.58            | 0.79 (.10) |
| $G_t$   | 1.57 | 1.48 (.08) | 0.77                   | 0.97 (.01) | 0.60            | 0.84 (.10) |

\*Numbers in parentheses are standard errors.

Table 6 shows that the model has difficulty accounting for the volatility of inflation in China. Inflation is almost as volatile as output in the data, but it is only 12% as volatile as output in the model. However, the model broadly matches the data in many other aspects, such as the relative volatility of consumption, investment, and government spending, their correlations with output, and the highly procyclical and persistent inflation rate. For

example, the correlation of inflation with output is 0.51 in the data and 0.64 in the model, and the autocorrelation of inflation is 0.58 in the data and 0.79 in the model. Also, inflation rate under calibration 2 tends to lag output by 2-3 years (see the lower-right window in Figure 4). Generating a highly procyclical, persistent and lagged inflation rate has been a serious challenge for the New Keynesian models (see Christiano, Eichenbaum, and Evans, 2005). Here we achieved all of these targets through inflation-financed government spending (among other things) without even relying on sticky prices (as in Brandt and Zhu, 2000, 2001). The most extraordinary aspect of the model, however, is its ability to mimic the large multipliers and periodic boom-bust cycles found in China. Such an important property of the model provides the base for our Monte Carlo analysis in the next subsection.

## 4.2 How Good are Structural VARs

The multipliers found in Chinese data are surprisingly large and they are based on very short time series samples with only 33 data points. In addition, the structural VARs are based on the crucial assumption that government spending shocks can have immediate impact on other endogenous variables in the VAR but other structural shocks do not affect government spending instantaneously. This identification assumption is meant to capture the impact multiplier (see Ramey 2011a) but is nonetheless inconsistent with the standard VAR literature on how to identify the structural shocks (see e.g., Christiano, Eichenbaum, and Evans, 2005). Therefore, the reliability of this approach in identifying the multipliers deserves close scrutiny.

We use the model as a data generating process and simulate the theoretical model for 1000 times in each trial discussed below. Based on the simulated samples, we estimate the implied multipliers by the same structural VAR method with 2 lags (as in Section 2),

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + A_0 \varepsilon_t, \quad (57)$$

where  $X_t = [G_t, Y_t, I_t, \pi_t]'$  and  $A_0$  is lower triangular. The length of the simulated sample is denoted by  $N$ . We conduct two different experiments (trials) with two different sample length  $N = \{33, 66\}$ . In the first experiment the length of the artificial sample equals that in the data ( $N = 33$ ), and in the second experiment we increase the sample length to  $N = 66$ . In each experiment we simulate the model 1000 times under the two alternative calibrations, respectively. We compute the standard errors based on the 1000 simulations in each case.

The estimated impulse response functions to government shock are shown in Figure 5, where the solid line in each window is the mean impulse response function based on 1000

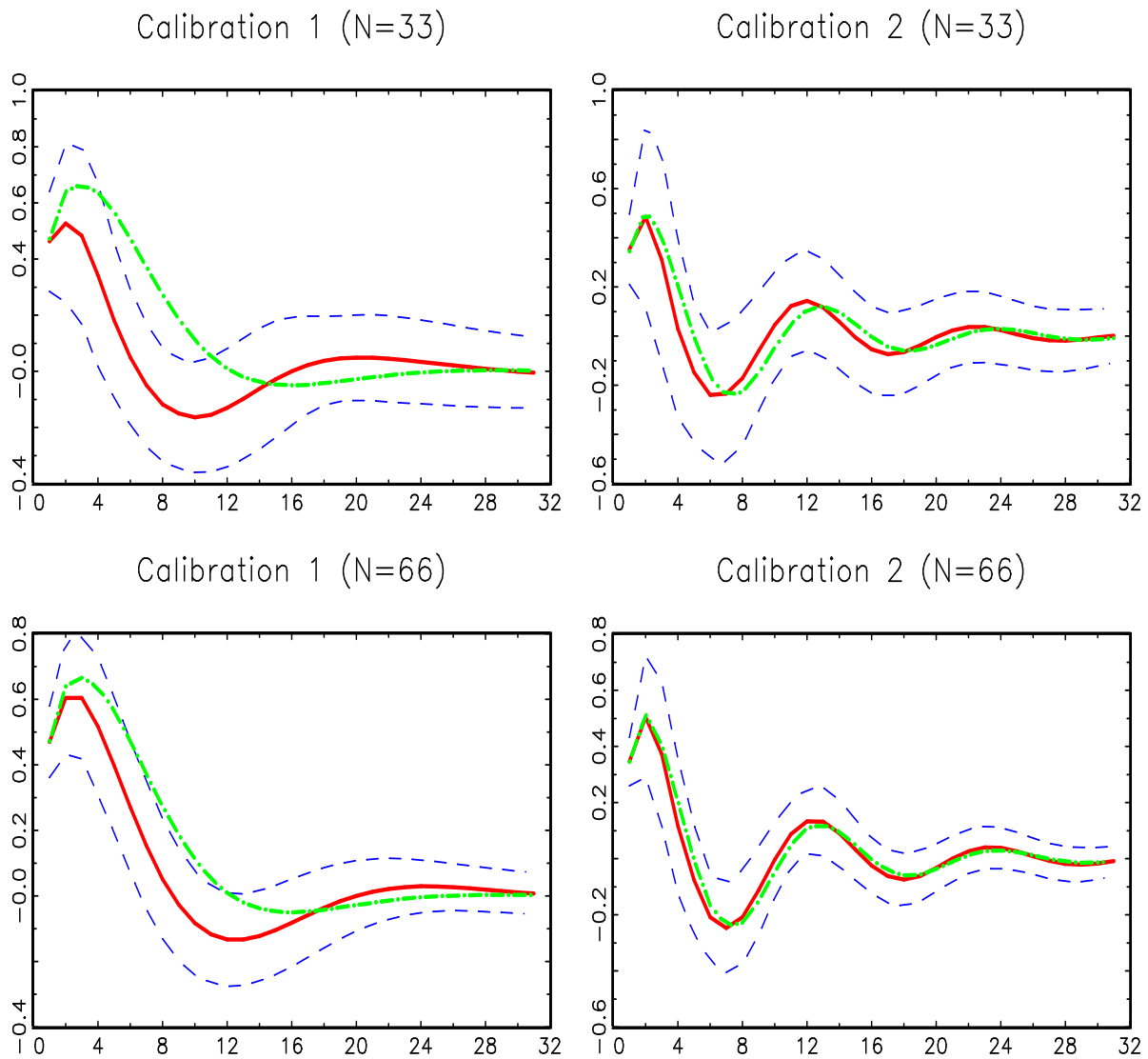


Figure 5: Estimated Impulse Responses of Output to a Government Shock (dot-dashed line = truth, solid line = mean, thin dashed lines = 1 STD error band).

simulations, the dashed lines are the corresponding one-standard error bands, and the dot-dashed line in each window is the truth (theoretical impulse response). The left column windows corresponds to Calibration 1 and the right column windows to Calibration 2. The top row windows correspond to the case with sample length  $N = 33$  and the lower row windows to the case with  $N = 66$ .

Several results stand out from Figure 5. First, under Calibration 1 (left column), the mean of the impulse response functions (solid line in each window) always lies below the true impulse response function (dot-dashed line in each window) in the initial phase of the boom-bust cycle. Therefore, the dynamic multiplier tends to be underestimated by structural VARs. Second, under Calibration 2 (right column) the mean of the impulse response functions (solid line) is very close to the truth (dot-dashed line) for  $N = 33$  and it becomes virtually indistinguishable from the truth for  $N = 66$ , suggesting that both the impact multiplier and the dynamic multipliers can be consistently estimated by structural VARs even when the sample length is as short as  $N = 33$ . This is however not the case under Calibration 1. This dramatic difference between Calibration 1 and Calibration 2 suggests that a stronger cyclical tendency in the data (sample) helps rather than hinders the identification of the multipliers. Third, regardless of the calibrations, the impact multiplier can always be consistently estimated because the mean impulse response function fits the true impulse response function closely in the impact period under either calibrations. Forth, as the sample length is doubled from  $N = 33$  to  $N = 66$ , the accuracy of the estimation improves significantly even under calibration 1, as the peak response now lies within the one-standard error band (see lower-left window).

It is however hard to eyeball the accuracy of the long-run cumulative multiplier, which is measured as the ratio of the sum of the impulse response function of output and the counterpart in government spending. So we report the numerical values of all measured multipliers in Table 7 for the case of  $N = 33$ , where numbers in parentheses are standard errors. The middle panel in Table 7 pertains to Calibration 1 and the right panel pertains to Calibration 2. Clearly, the cumulative multiplier cannot be precisely identified under either calibrations. Under both calibrations the standard errors of the cumulative multiplier are too large (6.19 and 44.3 respectively) to render the multiplier significantly different from zero. This is especially the case under calibration 2 where the strength of boom-bust cycle is so strong that there exist many periods of negative values in the impulse responses. However, if we use the absolute sum of the areas underneath the impulse response functions, the measured cumulative multiplier (labeled "cumulative (abs)" in the last row in Table 7) can

be quite precisely estimated with a relatively small standard error. Therefore, our Monte Carlo analysis suggests that for data exhibiting boom-bust cycles, the cumulative multiplier should be based on absolute sum rather than natural sum of the impulse responses.

Table 7. Estimated Multipliers ( $N = 33$ )

| Multiplier type  | Calibration 1 | Truth | Calibration 2 | Truth |
|------------------|---------------|-------|---------------|-------|
| Impact           | 3.29 (1.23)   | 3.30  | 2.41 (1.07)   | 2.41  |
| Peak             | 4.27(1.37)    | 4.67  | 3.43(1.32)    | 3.60  |
| Cumulative       | 4.06 (6.19)   | 4.42  | 1.49 (44.3)   | 2.73  |
| Cumulative (abs) | 5.74 (1.31)   | 5.10  | 4.74 (0.78)   | 4.61  |

\*Numbers in parentheses are STDs.

## 5 Conclusion

Keynes (1936) argued in his *General Theory* that government spending can have a multiplier ( $> 1$ ) effect on aggregate income when resources remain idle or under-utilized due to market (coordination) failures.<sup>22</sup> This Keynesian doctrine has been firmly embraced by the Chinese government since officials in China strongly believe that the multiplier principle should apply not only to advanced market economies during deep recessions, but also to developing countries where pervasive under-utilization of economic resources and market failures are believed to be a norm.

As a large developing economy, China possesses several important features that make China an idea laboratory for studying the potential multiplier effects of government spending: (i) resources are not always fully or efficiently utilized in China, (ii) wide spread market failures due to incomplete or missing markets and lack of the rule of law, (iii) a significantly greater degree of resource misallocations than developed countries, and (iv) various forms of externalities, among others. Our empirical analyses show that

1. There indeed exists fiscal multiplier far larger than 1, so that real GDP can always rise by more than the increase in government purchases. In this scenario, the added government spending also stimulates private consumption and investment even if public employees are just building roads that lead to nowhere.
2. However, such a large multiplier effect is not necessarily a free lunch, as government spending may also be itself an aggravating source of the boom-bust cycle. Consequently, the benefit of the multiplier may be largely offset by the cost of the conse-

<sup>22</sup>With market failures, it is aggregate effective demand that determines aggregate supply.

quent boom-bust cycles, especially when government purchases are financed by credit expansion and money creation.

Our theoretical model and Monte Carlo analysis support these empirical findings in China. Our theoretical model shows that the large multipliers are based (partially) on equally large market failures and deadweight costs from market frictions.

Understanding the effects of government spending in China can thus provide guidance or lessons to other developing countries in addressing their macroeconomic problems and development issues. If China can have a multiplier larger than 1, so can other developing nations. Poverty traps in developing countries may not be fundamentally different from the Great Depression in the 1930s experienced by developed countries. It may be coordination- and market failures, rather than backward technologies per se, that have prevented poor countries from taking off on the road toward economic prosperity. Technology adoption and business investment are endogenous decisions made by firms based not only on financial conditions and cost-benefit analysis but also on animal spirits, all of which can be influenced by the government. On the other hand, careless design of government spending programs, especially government spending through deficits and inflationary finance, can also be very costly. Such programs cause unwanted inflation and economic instability, thus aggravating structural problems in developing countries and hindering economic growth. Therefore, a large multiplier does not imply that any public spending goes: building roads that lead to nowhere or ghost towns that nobody wants to live can have severe detrimental consequences on economic development or economic recoveries.

As Remy (2011b) noted, none of the existing studies of the fiscal multiplier (including this paper) sheds light on the welfare consequences of increases in government spending to stimulate the economy. Our results in this paper, however, at least suggests that such an analysis is imperative in light of the boom-bust cycles, and this would require a better understanding of the mechanisms regarding how government spending is financed and where government purchases go in the economy.

## **6 Appendix: Further Robustness Analyses**

### **6.1 Granger Causality**

Because of the lack of individual price index for consumption, investment, and government spending, Section 2 deflates all variables, including GDP, by the CPI. To rule out the possibility that it may be CPI inflation, instead of government spending, that is driving the

observed Granger causality between real government spending and real GDP, here we use the GDP deflator to define real GDP and run the following three additional Granger causality tests.<sup>23</sup> First, we regress the re-defined real GDP growth  $\Delta y_t$  on its own lags  $\{\Delta y_{t-1}, \Delta y_{t-2}\}$  and lagged real government spending  $\Delta g_{t-1}$ . Second, we add lagged CPI inflation rate  $\Delta p_{t-1}$  as an independent variable into the first regression, so as to control the influence of lagged CPI in real government purchases on real GDP. Third, we replace real government spending  $\Delta g_{t-1}$  by nominal government spending  $\Delta G_{t-1}$  in the second regression while keep the lagged CPI inflation rate as an independent control variable. All results show that government spending Granger causes real GDP growth but the reverse is not true. The results are reported in the following equations (standard errors are in parentheses and the significance level "\*" is less than or equal to 5% with a  $t$ -value of  $\pm 1.96$ ):

$$\Delta y_t = \begin{matrix} 0.068 \\ (0.02)^* \end{matrix} + \begin{matrix} +0.29\Delta y_{t-1} \\ (0.19) \end{matrix} - \begin{matrix} 0.29\Delta y_{t-2} \\ (0.18) \end{matrix} + \begin{matrix} +0.29\Delta g_{t-1} \\ (0.11)^* \end{matrix}, \quad (58)$$

$$\Delta y_t = \begin{matrix} 0.069 \\ (0.02)^* \end{matrix} + \begin{matrix} +0.29\Delta y_{t-1} \\ (0.20) \end{matrix} - \begin{matrix} 0.24\Delta y_{t-2} \\ (0.21) \end{matrix} + \begin{matrix} +0.27\Delta g_{t-1} \\ (0.13)^* \end{matrix} - \begin{matrix} 0.04\Delta p_{t-1} \\ (0.13) \end{matrix}, \quad (59)$$

$$\Delta y_t = \begin{matrix} 0.069 \\ (0.02)^* \end{matrix} + \begin{matrix} +0.29\Delta y_{t-1} \\ (0.20) \end{matrix} - \begin{matrix} 0.24\Delta y_{t-2} \\ (0.21) \end{matrix} + \begin{matrix} +0.27\Delta G_{t-1} \\ (0.13)^* \end{matrix} - \begin{matrix} 0.31\Delta p_{t-1} \\ (0.14)^* \end{matrix}. \quad (60)$$

Notice that the third regression yields almost identical coefficient (up to the third digit) for the effects of government spending to the second regression, except that the coefficient on lagged inflation becomes larger and significant when nominal government spending  $\Delta G_{t-1}$  replaces real government spending  $\Delta g_{t-1}$  as an independent variable. These regression results reinforce our previous results that changes in government spending Granger causes changes in real GDP, regardless how real GDP is measured. In other words, government spending in China contains superior information not contained in lagged GDP in predicting future GDP movements.

## 6.2 Orders in the Structural VAR

When a variable is ordered the first in the structural VAR under a lower-triangular Choleski decomposition for the residuals, the identified structural shocks to the first variable may be contaminated by shocks to other variables ordered below the first variable. This is why the bulk of the structural VAR literature proposes to order the variable under interest the last in the VAR.

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<sup>23</sup>To reduce noise, we subtract net exports from GDP, so  $GDP = C + I + G$ .

So as a robustness check, we follow the existing monetary literature by ordering government spending the last in the VAR although this ordering is inconsistent with our theoretical model. In doing so, the impact multiplier is zero by assumption, but we may still be able to identify the dynamic (peak) multiplier if it exists in the data. The re-ordered vector  $X_t$  in equation (15) is now given by real GDP ( $Y_t$ ), real consumption ( $C_t$ ), real investment ( $I_t$ ), inflation ( $\pi_t$ ), and real government spending ( $G_t$ ). As before, all nominal variables are normalized by the CPI. The last shock in the vector  $\varepsilon_t$  now corresponds to government consumption shock. Using 2 lags and a linear-quadratic time trend in the VAR, the impulse responses of  $\{Y_t, C_t, I_t, \pi_t\}$  to a one-standard deviation shock to  $G_t$  are graphed in Figure 6.

The Figure shows that the pattern of the impulse responses look very similar to those in Figure 1 except that government shocks have no effect on the economy in the impact period. Hence, by design the impact multiplier is zero. However, there exist a dynamic multiplier and cumulative multiplier. Specifically, the dynamic multipliers for  $\{Y, C, I\}$  are given by  $\{3.21, 1.48, 3.40\}$ , respectively; and the cumulative multipliers (measured as the sum of the absolute value of the area underneath the impulse response functions) are given by  $\{2.6, 0.92, 3.27\}$ , respectively. The dynamic income multiplier of 3.2 is smaller than that reported in Table 2, but is still significantly larger than 1 and that found in the U.S. data.

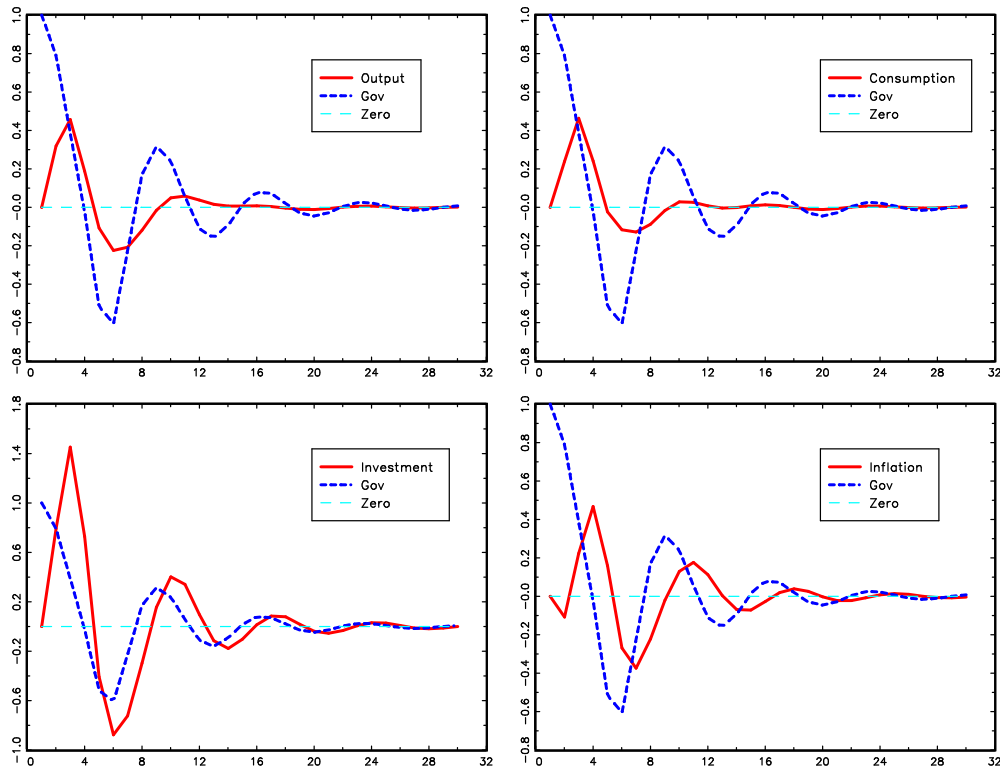


Figure 6. Impulse Responses to Government Shock (without Impact Multiplier).

However, as mentioned previously, if we order government spending the last in the VAR, then by variance decomposition government shocks now explain only about 3% of the variance in GDP, as opposed to more than 60% of the variance of GDP in the previous specification in equation (15). This result can be explained by the fact that government spending in China Granger causes GDP (and other variables in the VAR) but not vice versa. Therefore, it is a mis-specified model if government spending is ordered the last in the VAR because this ordering would imply that other variables "cause" government spending but not vice versa on the impact period of the shock.

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