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-- Evidence from China

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Abstract

Most empirical studies based on U.S. data suggest that the fiscal multiplier is less than 1 (e.g., Barro and Redlick, 2011). However, Keynes argued that the multiplier would be the largest when markets have failed to the greatest extent in coordinating economic activities (such as during the Great Depression with rampant unemployment and low capacity utilization). As a large developing country with high household saving rates, a large pool of rural labor force, 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 fiscal multiplier larger than 1 on aggregate income. Perhaps even more exceptional is China's extensive use of government spending as a major policy tool to stimulate the economy over the past three decades. Based on both aggregate time-series data and panel data from 29 Chinese provinces, we find that the fiscal multiplier in China is larger than 2. 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 the same multiplier and business cycles observed in China and use the model as a data-generating process to gauge whether structural vector autoregressions can yield consistent estimates of the theoretical multiplier in short samples. Our analysis supports the large multiplier found in China but also suggests that government spending may not necessarily be a free lunch despite the large multiplier.

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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 telecommunications) has been growing at the fastest rate in the world.[1] Vast improvements have been made during the past 30 years in irrigation systems, underground sewerage systems, streets and highway networks, air and rail transportation, electricity transmission grids, gas and oil pipelines, schools, hospitals, and so on. 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 an LPI comparable to that of industrial high-income nations in international shipments, infrastructure, custom services, logistics competence, tracking and tracing, and timeliness (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: Arvis et al. (2012).

2. However, government spending in China has also been reckless and highly inefficient (such as building roads leading to nowhere and ghost towns nobody wants to live). As a recent example, a significant fraction of the 4 trillion renminbi (RMB) government stimulus package, designed to counter the adverse impact of the worldwide financial shocks on China's export sector, went to the housing market and fueled a new housing bubble (Deng et al., 2011).[2] It is thus not surprising to note that China's big gov-

[1] From 1978 to 2008, China's infrastructure capital stock (in constant prices) grew by 12.3% per year while the real GDP grew by 9.5% per year.

[2] Wen and Wu (2013) argue that inefficient government expenditures in China can nonetheless serve as a coordination device to prevent recessions.

ernment spending programs have themselves often been a major source aggravating China's notorious boom-bust cycles.[3]

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 poverty traps. On the other hand, it may have severe adverse consequences, such as unintended inflation and boom-bust cycles. Such a 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 attempts to estimate the macroeconomic effects of government spending in China. As a large developing country with a high saving rate, large degrees of underutilized resources, 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 fiscal 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 consumption (not including government investment).[4] We find that the multiplier is consistently and significantly larger than 2—both at the national level and at the regional level. These estimates are in general far greater than those found in the United States or other developed countries.[5]

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 economic slowdowns and recessions even though the money may have been used to build roads to nowhere and homes for nobody. Nonetheless, the large multiplier effect in China is

[3] Since the start of economic reform in 1978, China's central government has relied heavily on inflationary deficit financing to stimulate the economy. Big stimulus packages often generate short-run booms followed by high inflation. The high inflation in turn causes widespread social and economic problems and then forces the central government to adopt severe measures to curtail 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 examples.

[4] This definition of government spending is consistent with the Keynesian notion of the multiplier and the existing empirical literature. We deal with the macroeconomic effects of government investment on infrastructure in a separate project.

[5] Empirical studies show that the estimated government spending multiplier for developed countries, such as the United States, is in general smaller than 1 or at most near 1 (Barro and Redlick, 2011; 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 competitive. However, during severe recessions, especially in a situation with a zero nominal interest rate, the multiplier in developed countries can be potentially far greater than 1 (see, e.g., 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, and Romer and Romer (2010) find a dynamic multiplier of nearly three in aggregate data. For a comprehensive literature review on empirical and theoretical studies of the fiscal multiplier, see Ramey (2011b).

not without serious costs or detrimental effects. Our empirical study shows that government spending in China has itself been a major aggravating source of inflation and business cycles.

We use Granger causality tests 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 strongly and positively correlated with GDP growth, unlike what is observed in the United States where inflation is negatively correlated with GDP growth. A main factor behind the positive correlation in China is government spending.

More specifically, China exhibits a clear pattern of 7- to 9-year periodic or semi-periodic boom-bust cycles in government spending, GDP, and inflation. During these cycles, government spending strongly leads and Granger-causes the booms and busts, and 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 curtail its spending, thereby 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 spending to jump-start the economy. Such a vicious cycle is a typical feature of the Chinese economy that has long been noted in the existing literature (see, e.g., Lin, Cai, and Li, 1996; Lin, 2009; 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 simultaneous increases in government deficits and money supply (Wen and Wu, 2013). The inflationary consequence of this huge stimulus program called for another round of credit tightening in China 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 the provision of 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 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 vector autoregressions (SVARs).

However, we do not intend to claim that our model is necessarily the right or perfect 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 SVARs based on finite samples and certain critical detrending procedures and identification assumptions. To assess the reliability and robustness of the empirical estimates, we need a theoretical model that can (i) generate data with similar properties and (ii) determine whether SVARs 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 (see, e.g., Blanchard and Perotti, 2002; Ramey, 2011a), our empirical estimation of the multiplier is based on SVARs 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, few existing works have provided Monte Carlo analyses to gauge whether multipliers so estimated are reliable, especially in short samples. Several major problems are involved in estimating the multiplier based on SVARs. First, how to detrend the nonstationary data? Using growth rates (i.e., applying the first-difference filter) tends to generate too much noise in the data, and using the detrended levels (i.e., applying the HP filter or assuming a deterministic linear-quatratic time trend) may tend to generate spurious cycles and thus unreliable multipliers.

Second, how to identify the truly exogenous government spending shocks? Government spending (even military spending) is unlikely to be completely exogenous and irresponsive to changes in aggregate income. When government spending is endogenous or partially endogenous, the typical approach to identifying government shocks is to rely on a lower-triangular Choleski decomposition by ordering government spending as the last variable 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 (see, e.g., Barro, 1981; Barro and Redlick, 2011; and Ramey, 2011a) proposes to use a proxy of government spending (such as military spending or news about such spending) that is more likely to be exogenous judged by formal or informal Granger causality testing, and orders the proxy variable before aggregate output and other variables in the VAR, so that "shocks" to government spending can affect output instantaneously. This is the only way to generate a nonzero output elasticity of government spending on the impact period. But how reliable the estimated multipliers are based on such an approach, especially in short samples, remains a question.

The third difficulty is how to compute multipliers based on the estimated impulse response functions in the SVARs. The conventional approach is to use 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 focuses 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 trigger multiple periods of output responses after the initial shock and may itself be persistent, as in the standard Keynesian IS-LM model in which 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 oscillate 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 and reliable measure of the long-run multiplier. For example, the sum of the areas below a sine wave may be zero, but this does not necessarily mean the lack of a long-run multiplier effect. In particular, the measured multiplier may be infinity if the denominator (the cumulative sum of government responses to its own shock) is zero.

One way to address these aforementioned difficulties is to (i) construct a theoretical model in which government spending is partially exogenous and partially endogenous but part of its underlying shock process (such as military spending) is consistent with the empirical identification assumptions, and (ii) use the model as a data-generating process to perform SVARs exactly as we do in the data. The theoretical part of this paper in Sections 3 and 4 follows this approach by first constructing a theoretical model that can generate similar multiplier effects and oscillatory fluctuations as in the Chinese data. The model allows us to exactly compute the short- and long-run multipliers based on the impulse response functions under government spending shocks. We then use the model as a true data-generating process to determine whether SVARs can uncover the truth based on short samples.

Using Monte Carlo analysis based on model-generated data with sample sizes identical to the 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 SVARs, 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, which 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 under the impulse response function, then the absolute cumulative multiplier can be consistently estimated even in short samples.[6]

4. For both the short-run (SR) and long-run (LR) 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 strong cyclical nature of the Chinese data, our theory-based Monte Carlo analyses suggest that the large fiscal multipliers found in China are consistently estimated without significant bias. Even after taking into account the nontrivial estimation errors in short samples, the impact multiplier is significantly larger than 1.5 and the dynamic multiplier significantly larger than 3.

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 uses the model to conduct Monte Carlo analysis to gauge the accuracy of SVAR methods in estimating the multipliers. Section 5 concludes the paper. Further analyses of robustness are provided in the Appendix.

[6] If both government spending and output oscillate together above and below their respective long-run trend, the economic meaning of the cumulative multiplier based on the ratio of the sums of absolute values is similar to that based on the sums of natural values.

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 private fixed capital formation, and government expenditures G by total government consumption spending. All data are taken from the National Bureau of Statistics of China (*China Statistical Yearbook*, 2012). Because it is difficult to find the price index for each of the individual variables in China, we normalize all variables by the consumer price index (CPI). We discuss the robustness of our results to price adjustment in the appendix.

Denote Δy as the annual growth rate of real GDP, Δc as real consumption growth, Δi as real investment growth, and Δg as real government expenditure growth. To document the causal relations among these variables, we first estimate the following equations by ordinary least squares[7]:

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

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

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

$$\Delta y_t = \underset{(0.018)^*}{0.057} \; \underset{(0.18)^*}{+0.615\Delta y_{t-1}} \; \underset{(0.18)}{-0.20\Delta y_{t-2}}, \qquad R^2 = 0.313 \tag{3}$$

$$\Delta c_t = \underset{(0.02)^*}{0.070} \; \underset{(0.19)}{+0.34\Delta c_{t-1}} \; \underset{(0.19)}{-0.19\Delta c_{t-2}}, \qquad R^2 = 0.117 \tag{4}$$

$$\Delta i_t = \underset{(0.027)^*}{0.086} \; \underset{(0.19)^*}{+0.54\Delta i_{t-1}} \; \underset{(0.19)}{-0.31\Delta i_{t-2}}, \qquad R^2 = 0.247 \tag{5}$$

[7] The growth rate is defined as the first difference of the 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 three or four lags are used.

$$\Delta y_t = \underset{(0.018)^*}{0.049} \; \underset{(0.22)}{+0.32\Delta y_{t-1}} \; \underset{(0.18)}{-0.11\Delta y_{t-2}} \; \underset{(0.15)^*}{+0.30\Delta g_{t-1}}, \qquad R^2 = 0.410 \tag{6}$$

$$\Delta c_t = \underset{(0.019)^*}{0.056} \; \underset{(0.18)}{+0.15\Delta c_{t-1}} \; \underset{(0.17)}{-0.14\Delta c_{t-2}} \; \underset{(0.11)^*}{+0.29\Delta g_{t-1}}, \qquad R^2 = 0.307 \tag{7}$$

$$\Delta i_t = \underset{(0.030)}{0.030} \; \underset{(0.20)}{+0.19\Delta i_{t-1}} \; \underset{(-0.16)}{-0.27\Delta i_{t-2}}, \; \underset{(0.32)^*}{+0.99\Delta g_{t-1}}, \qquad R^2 = 0.454. \tag{8}$$

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.[8] Compared with 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 history of output (consumption, investment) growth is taken into account. For example, a 1-percentage-point increase in government spending growth 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 in determining future output (consumption, investment) growth that the predictive power of the 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 in equations (6)-(8) are increased significantly in each case when past government spending growth is added to the regression. This result indicates that government spending, rather than the lagged growth of GDP (consumption, investment) contains superior information for predicting future economic activities in China. The most striking case is business investment. Equation (8) shows that a 1-percentage-point increase in government spending growth 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 over the past 30 years (in addition to direct government spending and total exports).

Equation (6) can also provide a rough idea of the magnitude of the income multiplier. Given that the average government spending-to-GDP ratio is $\frac{1}{7}$ in China, the implied SR

[8] 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 the LR multiplier is $\frac{2.1}{1-0.32+0.11} = 2.66$, assuming that Δg_t is i.i.d., completely exogenous, and does not affect output until one period later. Section 2.2 provides alternative estimations of the multiplier using SVARs.

For the reverse 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:

$$\Delta g_t = \underset{(0.021)^*}{0.070} \; \underset{(0.17)^*}{+0.42\Delta g_{t-1}} \; \underset{(0.15)}{-0.18\Delta g_{t-2}}, \qquad R^2 = 0.191 \tag{9}$$

$$\Delta g_t = \underset{(0.037)^*}{0.076} \; \underset{(0.24)}{+0.44\Delta g_{t-1}} \; \underset{(0.19)}{-0.18\Delta g_{t-2}} \; \underset{(0.62)}{-0.20\Delta y_{t-1}} \; \underset{(0.49)}{+0.08\Delta c_{t-1}} \; \underset{(0.25)}{+0.05\Delta i_{t-1}}$$
$$R^2 = 0.194. \tag{10}$$

Regression (9) indicates that the steady-state growth rate of government spending is 9.2% per year.[9] Compared with equation (9), equation (10) suggests that past output, consumption, and investment growth have no significant effect on current government spending growth. Specifically, taking into account past growth in these other variables does not improve the prediction for future government spending statistically and economically. The R^2 value 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-cause GDP growth, consumption growth, and investment growth, but not vice versa. This unidirectional causal relation is in sharp contrast to the dynamic pattern of the U.S. time-series data. In the United States, private consumption 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. The following Granger-causality test demonstrates this. Denoting inflation by Δp, we have

$$\Delta p_t = \underset{(0.012)}{0.022} \; \underset{(0.19)^*}{+0.93\Delta p_{t-1}} \; \underset{(0.18)^*}{-0.37\Delta p_{t-2}}, \qquad R^2 = 0.516 \tag{11}$$

[9] The unconditional mean of the raw sample is 9.3%.

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

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

Regressions (11) and (12) suggest that investment spending has significant explanatory power for future inflation. A 1-percentage-point increase in investment growth can raise the inflation rate by 36 basis points. Since investment growth in China responds to government expenditure growth 1 to 1, 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).

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

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 in regression (10) increases 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 1-percentage-point increase in the inflation rate reduces the growth rate of government spending by one-third of 1 percentage point. 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 points and investment growth by 1 percentage point in the short run.

2.2 The Multiplier

The multiplier is estimated by SVARs. The Granger-causality test performed in the previous section suggests that we can place government spending first in the following SVAR model based on the argument of Barro and Redlick 92011) and Ramey (2011a):

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

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

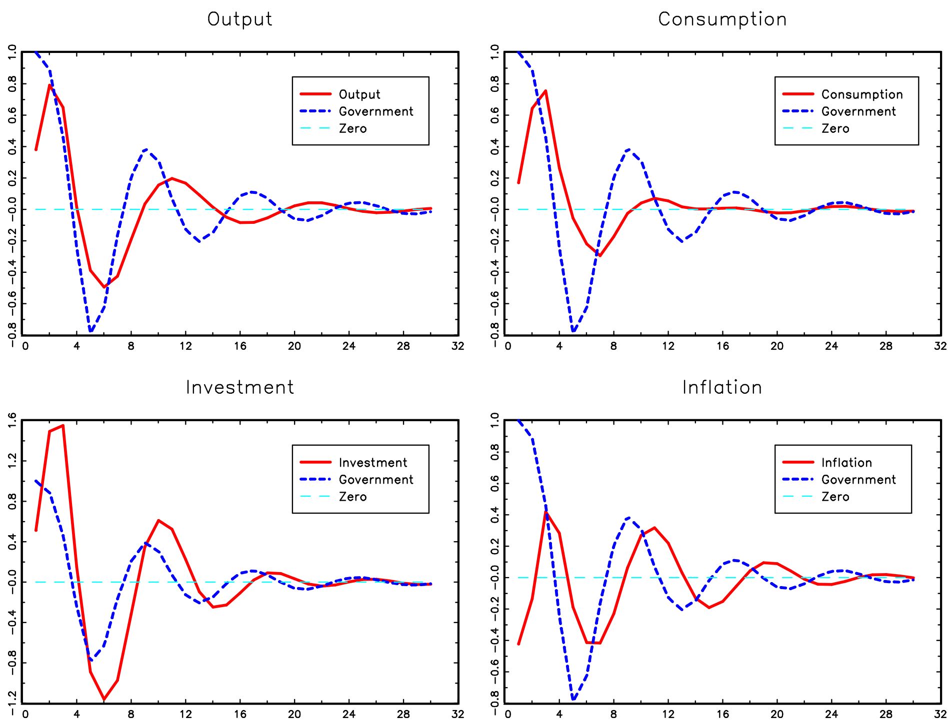

Figure 1: Impulse Responses to a Government Spending Shock.

structural shocks with an identity variance-covariance matrix. Since G_t is ordered first in the vector X_t, the first shock in ε_t is interpreted as the government spending shock. All variables are in real terms as in the previous subsection, and the inflation rate is expressed as 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 two lags included in the regression.

Figure 1 shows the impulse responses of the economy to a government spending shock. Several features of Figure 1 are worth noting. First, the Chinese economy exhibits strong periodic boom-bust cycles, with an average cycle length of 7 to 9 years. Second, government spending (the dashed line in each panel) is itself cyclical and, more importantly, it leads the boom-bust cycle in output (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 comoves 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 detrending method. For example, if we simply plotted the raw data series,

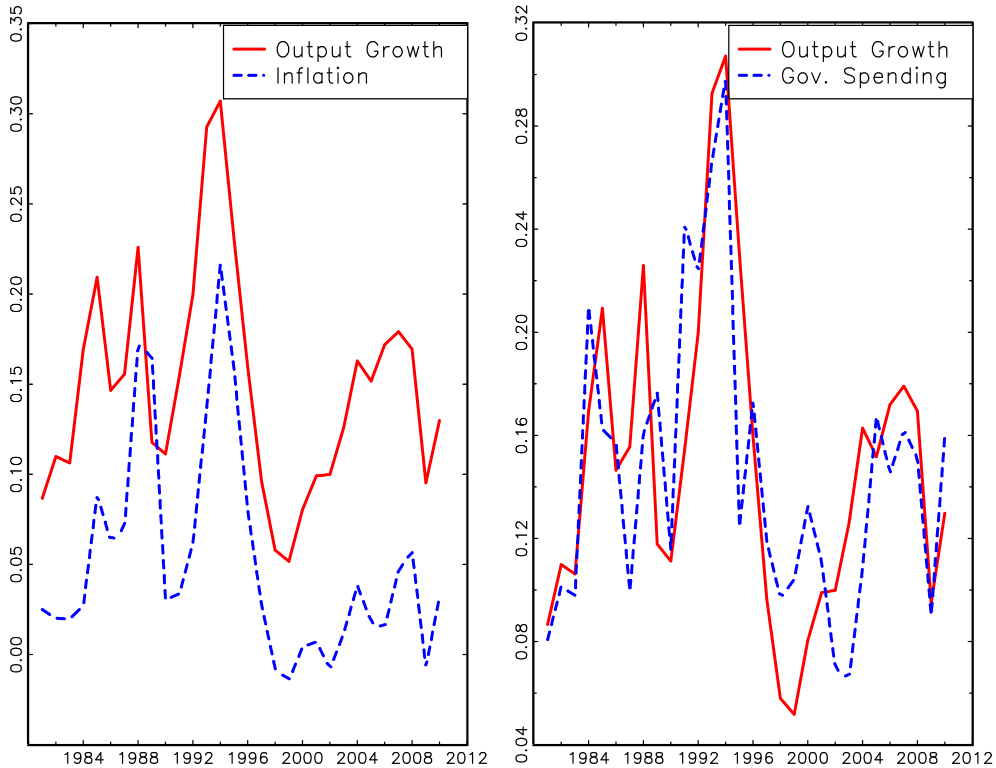

Figure 2: Data: Nominal GDP growth and CPI Inflation.

we would still observe a clear cyclical pattern. Figure 2 shows the nominal growth rate of GDP (the solid line in each panel), the CPI inflation rate (the dashed line in the left panel), and the growth rate of nominal government spending (the dashed line in the right panel). The figure reveals three important facts about China: (i) three well-known major boom-bust cycles were experienced in the 1980s, 1990s, and the more recent one around 2008 during the financial crisis; (ii) inflation is strongly procyclical but slightly lags nominal output growth in each boom-bust cycle (the lagging pattern is more evident if we use real GDP); and (iii) changes in government spending are strongly procyclical, as volatile as GDP, and tend to lead GDP over the business cycle (the leading pattern is more evident in real terms).

The existing literature adopts three different ways to compute the multiplier: the impact multiplier, the peak multiplier, and the LR 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 LR 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.[10] The multipliers for consumption and investment are computed similarly (the consumption-to-government spending ratio is 3.193 and the investment-to-government spending ratio is 2.337).

Table 2. Estimated Multipliers in China

Multiplier	Output	Consumption	Investment
Impact	2.68 (3.51)	0.54 (0.63)	1.20 (1.76)
Peak	5.55 (4.84)	2.41 (1.52)	3.63 (3.48)
LR	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, the consumption multiplier is between 0.5 and 3.4, and the investment multiplier is between 1.2 and 3.6. A 1 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 rows pertaining to peak and LR multipliers in Table 2. As a robustness check, we also report the estimated multipliers (see the numbers in parentheses in Table 2) when the number of lags is one in the SVAR in equation (15). The magnitudes are not significantly different and all point to large multipliers. In particular, the impact multiplier for output becomes even larger, rising from 2.7 to 3.5. The impulse responses to government spending shock with one lag in the SVAR 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 the method used to normalize the nominal variables, and (ii) the dynamic multiplier is equally large even if we order government spending as the last variable in the SVARs.

[10] Similar to Ramey (2011a), we define the multiplier m as the absolute increase in GDP level (Y_t) above its LR trend $\bar{Y}_t$ as a result of a 1 dollar temporary increase in government spending (G_t) above its long-run trend $\bar{G}_t$: $m \equiv \frac{d\left(Y_t - \bar{Y}_t\right)}{d\left(G_t - \bar{G}_t\right)}$. Suppose we take the natural logarithm on GDP and government spending, remove a linear-quadratic time trend, and define the detrended 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 β,

$$\hat{y}_t = \alpha + \beta \hat{g}_t + e_t. \tag{16}$$

Thus, β is the output elasticity of government spending. To convert this elasticity to the multiplier, we can use the following steps: (i) Let $\hat{y}_t = \beta \hat{g}_t$. (ii) Perform 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.

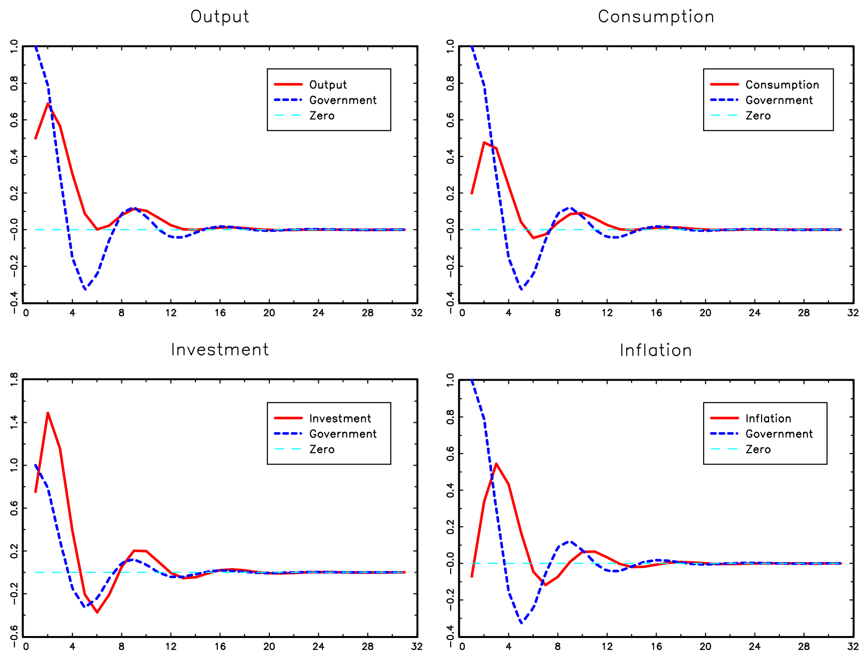

Figure 3: Impulse Responses to a Government Spending Shock (one lag in the SVAR).

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.[11] All variables are annual and nominal and we deflate them by provincial CPI for each province i. The data are from the China Macro Database (2012).

Increases in government spending in one province may generate spillover effects in other provinces, as the increased demand at the local level affects demand for the goods produced in neighboring provinces. Thus, in our panel regression analyses we need to account for such cross-province effects (externalities), which cannot be captured by standard panel regression with only a regional fixed-effect coefficient. More specifically, to deal with the potential spillover effects, we use a spatial panel regression technique to estimate the multipliers by constructing a spatial weighting matrix that captures the cross-province effects.

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

[11] Data on provincial CPIs earlier than 1981 are not available.

following spatial panel regression:

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

where Δz_t is a 29×1 vector composed of the annual growth rates of variable Z_t in all 29 provinces in each year t, with $Z = \{Y, C, I\}$, respectively; similarly, Δg_t is a 29×1 vector composed of the annual growth rates of real government expenditures in all 29 provinces; and γ contains 29 dummies to control for fixed effects.

The term $\varphi W_A \Delta z_t$ captures the cross-province spillover effect, in which W_A is a 29×29 spatial weighting matrix that does not change over time. Following Case, Rosen, and Hines's (1993) method, we construct W_A as follows: Its ijth 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 that share a common border with province i. The coefficient φ 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 φ percentage points. We control the fixed effect for each province by γ. The results are shown in the left panel in Table 3.

Since we use "share a border or not" to define our spatial weighting matrix W_A, we may have ignored the spillover effect between provinces that do not share a border. As an alternative, we also use geographic proximity (the 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.

Table 3. Multipliers Based on Panel Regressions

Coefficient	Spatial matrix W_A			Spatial matrix W_B		
	Δy_t	Δc_t	Δi_t	Δy_t	Δc_t	Δi_t
φ	0.537 (0.031)***	0.405 (0.038)***	0.524 (0.032)***	0.735 (0.029)***	0.680 (0.040)***	0.743 (0.031)***
α_1	0.189 (0.028)***	0.155 (0.032)***	0.188 (0.029)***	0.150 (0.026)***	0.101 (0.031)***	0.133 (0.027)***
α_2	0.053 (0.027)***	−0.028 (0.032)	−0.035 (0.027)	0.028 (0.025)	−0.063 (0.031)**	−0.034 (0.025)
β	0.114 (0.013)***	0.047 (0.017)***	0.151 (0.033)***	0.107 (0.012)***	0.036 (0.016)**	0.122 (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 of which spatial weighting matrix is used, both the spillover effects (φ) and the direct effects of government spending (β) are strongly positive 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; 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 SR multiplier is $7 \times \frac{\beta}{1-\varphi}$ and the LR multiplier is $7 \times \frac{\beta}{1-\varphi-\alpha_1-\alpha_2}$ (we drop α_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 ΔG_t is $\beta = 0.107$ for the output equation Δy, and the coefficient for the spillover 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; the ranges are broadly similar in magnitudes to those obtained under SVARs based on aggregate time-series data.[12]

3 The Model

How can we 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 estimated multipliers in the previous section are reliable? To answer these questions, this section provides a fully-fledged dynamic macro model to capture the stylized facts discussed previously and then uses the model-generated data to determine whether we can uncover the theoretical multipliers 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. These new features include:

1. We impose a wedge between potential output and actual output in the form of a distortionary tax to capture any loss of potential output resulting from market failures, incomplete or missing markets, resource misallocations, corruptions, efficiency losses related to the existence of state-owned enterprises and imperfect competition, and many other forms of real frictions in the Chinese economy. This wedge is assumed to be a fixed portion τ_0 of the potential output Y^*, and we define $\Phi \equiv \tau_0 Y^*$ as the deadweight 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 τ_t of its current output y_t to cover this deadweight cost,

[12] Using panel data from the United States, Shaog (1010) finds a fiscal multiplier of 2 across states.

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 fixed deadweight loss is shared by all firms as an implicit tax, it imposes a countercyclical distortionary tax τ_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 time-varying externality in the economy, giving rise to incentives for firms to "overproduce" in a boom and "underproduce" in a recession. This wedge, combined with other forces, leads to endogenous boom-bust cycles and a dynamic multiplier effect.

2. Government spending helps to reduce the costs of firms' investments. This assumption implies that the benefits (costs) of business investments in China are highly correlated with government spending.[13]

3. Government spending is partially endogenous and financed in part through money creation. This means that government spending is not only persistent but also inflationary, as in the data. Since inflation may cause social unrest, the government responds to inflation by reducing its expenditures whenever the economy is overheated. Thus, we assume that government spending follows a Taylor-type feedback rule: It responds to lagged inflation negatively and to lagged output positively. These assumptions make both government spending and the money supply partially endogenous in our model and thus help propagate any endogenous boom-bust cycles.

We show that these features, combined with variable capacity utilization and time to build capital, can generate the large multiplier effects and boom-bust cycles observed in China. We then use the model as a true data-generating process for SVAR analysis. We find that SVAR methods can uncover the theoretical multipliers in the model with reasonable precision even in short samples.

To perform SVAR 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 use a four-variable VAR in our Monte Carlo analysis to avoid collinearity. The four variables are output (Y_t), investment (I_t), government spending (G_t), and inflation (π_t). Thus, our model has four mutually independent structural shocks, including a shock to government spending $(\tilde{g}_t)$, a shock to total factor productivity

[13] 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.

(TFP, A_t), a shock to the marginal utility of consumption (preference shock Δ_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 use the detrended 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 Spending

Assume that total government expenditure G_t is financed partly by 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 the 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

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

We assume that ϕ fraction of government spending is financed by lump-sum taxes and the rest is financed by printing money:

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

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

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

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

where $\tilde{g}_t$ denotes an exogenous shock process (component) in 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 SVAR 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 the SVAR to the model-generated samples, if we order government spending last in the VAR, by design we would not be able to identify any government spending shocks that make a significant contribution to output fluctuations. This is also the case in the Chinese data—namely, if we order government spending last in the VAR, the identified government spending shocks explain less than 3% of the total variance in GDP and other variables. This empirical feature of the data is also consistent with the Granger causality test discussed in the previous section.

Finally, notice that our model does not directly address the Granger causality relations found in Chinese data even though the model can generate lead-lag relations similar to the data.[14] 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 the government spending shock ($\tilde{g}_t$), the identification assumptions in the SVARs are valid for the model-generated data. In other words, that government spending Granger causes output is a sufficient but not necessary condition to validate the identification assumptions in the SVAR.

3.2 Households

As observed by Modigliani and Cao (2004), although China is not yet a full market economy, standard economic models can nonetheless capture the Chinese household saving behaviors. Therefore, 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 a store of value to smooth consumption, including government bonds (B_{t+1}), money (M_{t+1}), and firms' equity shares (S_{t+1}). The labor supply is perfectly elastic, so the utility function is linear in leisure. Denoting Q_t as

[14] A lead-lag relationship is not identical to Granger causality. Capturing Granger causality in a theoretical DSGE model requires more sophisticated information structures (see Wen, 2007).

the price of equity (stock price) and D_t as dividend flows, the representative household solves

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

subject to

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

$$C_t \leq V_t \frac{M_t}{P_t}, \tag{23}$$

where $\bar{g}_x$ denotes the LR potential growth rate of productivity, T_t denotes lump-sum taxes, W_t denotes the real wage, Δ_t denotes the 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

$$\frac{\Delta_t}{C_t} = \Lambda_t + \mu_t \tag{24}$$

$$1 = W_t \Lambda_t \tag{25}$$

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

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

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

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

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

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 a distortionary income tax to capture the deadweight loss of output resulting from market failures, externalities, incomplete markets, resource misallocations, corruptions, the existence of state-owned-enterprises and their monopoly power, and so on. The total deadweight loss is Φ and is shared by all firms. To cover the deadweight loss, firms are taxed at the rate τ_t of their revenues so that the aggregate tax revenue equals the deadweight cost, $\tau_t Y_t = \Phi$.[15]

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 nonstationary endogenous variables are normalized (scaled) by this technology trend. In the detrended model, a representative firm combines labor and capital stock to produce output in each period. The production technology is given by

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

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

$$\delta_t = \frac{\delta_0}{1+\theta} e_t^{1+\theta}, \qquad \theta > 0. \tag{31}$$

The private capital stock evolves according to the law of motion:

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

where I_t denotes period-t investment and $I_t^{\alpha} I_{t-1}^{1-\alpha}$ in equation (32) denotes time-to-build technology (Wen, 1998b). That is, it takes multiple (two) periods of investments to construct new capital. The parameter σ measures the elasticity of substitution across past and current investments in different periods. Wen (1998b) shows that this form of time-to-build technology 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 inconsistent with the data). This type of

[15] This setup is similar to the balanced-government-budget 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 that in the Wen (1998a) model.

time-to-build model also dampens investment responses to shocks because commitment is costly. More importantly, it avoids indeterminacy in the model caused by the existence of the deadweight cost Φ. The variable χ_t captures any exogenous movements in the costs of financing private investment (or efficiency shocks to private investment). When χ_t is low, the costs (benefits) of investment are high (low). Since government expenditure in China is business friendly and investment promoting, we assume

$$\chi_t = \chi_0 G_t^{\gamma_\chi}, \tag{33}$$

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, joined with other features, is important for the model to capture the multiplier effects of government spending in China.[16]

We assume that firms are owned by households through the equity market. Thus, 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

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

subject to equations (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 require $\tau_t < 1$, which is the assumption we make in this paper.

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

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

[16] As an example of government spending effects on firm investment and local business, consider the story of Gu Zhen, a town of Guangdong province in China's southeast 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 the light-fixture industry. Once the local enterprises in light industries started to develop, the local government offered a variety of support in financing, information provision, worker training, and technology transfer assistance. Since 1999, Gu Zhen's local government has organized an annual international exhibition for the products of local firms to help companies sell their products. All such services offered by Gu Zhen's local government are helpful in attracting and enhancing business investment and nurturing private enterprises by reducing their investment costs and other types of operation costs (Yang, 2010). In China, all levels of central and local government are motivated to provide similar facilities and services to help attract business entry and private capital formation. There is at least one government-built industrial park in each Chinese city to promote investment and economic growth.

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

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

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

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

3.4 General Equilibrium

The general equilibrium of the model is characterized by the dynamic path of 13 endogenous variables, $\{e_t, N_t, I_t, K_{t+1}, C_t, W_t, \Lambda_t, P_t, q_t, M_{t+1}, Y_t, \delta_t, G_t\}$, which can be solved uniquely by log-linearization of the following system of 13 equations around the steady state[17]:

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

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

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

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

$$1 = W_t \Lambda_t \tag{43}$$

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

$$C_t = \frac{M_t}{P_t} \tag{45}$$

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

$$C_t + I_t + G_t = (1-\tau_t) Y_t \tag{47}$$

[17] The existence of time to build rules out local indeterminacy, so the steady state is saddle-path stable.

$$(1-\phi)\,G_t = \frac{(1+\bar{g}_x)\,M_{t+1} - M_t}{P_t} \tag{48}$$

$$Y_t = A_t\,(e_t K_t)^{\alpha}\,N_t^{1-\alpha} \tag{49}$$

$$\delta_t = \frac{\delta_0}{1+\theta} e_t^{1+\theta} \tag{50}$$

$$\log G_t = \log g_t + \gamma_\pi \log \pi_{t-1} + \gamma_y \log Y_{t-1}, \tag{51}$$

where $\tau_t = \frac{\Phi}{Y_t}$, subject to standard initial conditions and transversality conditions. The laws of motion for the four structural shock variables are specified as

$$\log \Delta_t = \rho_\Delta \log \Delta_{t-1} + \varepsilon_{\Delta t} \tag{52}$$

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{At} \tag{53}$$

$$\log g_t = \rho_g \log g_{t-1} + \varepsilon_{gt} \tag{54}$$

$$\log V_t = \rho_v \log V_{t-1} + \varepsilon_{vt}, \tag{55}$$

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 The Theoretical Model as a Data-Generating Process

Parameter Calibrations. The model has more than 15 structural parameters. Notice that the capacity-depreciation elasticity parameter θ in equation (50) is not an independent parameter; it is pinned down by the model's first-order conditions for the capital stock in equation (42) and capacity utilization in equation (39) in the steady state by the relation $\theta = \frac{1+g_x-\beta}{\beta\delta}$, where δ is the steady-state depreciation rate. The value of δ_0 in equation (50) can be chosen arbitrarily to match the steady-state capacity utilization rate e.[18]

We calibrate the remaining independent parameters 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 our paper, it would be more reassuring if the model-generated data broadly resembled the Chinese data, especially in

[18] See Wen (1998a).

terms of the large multipliers and the strong boom-bust cycles. We focus on the following model moments: the standard deviation (SD) of consumption, investment, inflation, and government spending relative to output; the correlations of these variables with output; and the first-order autocorrelations of these variables. Since all moments are relative to output, we normalize the SD of the government spending shock $\sigma_g^2 = 1$.

Because boom-bust cycling is an important aspect of the data and may significantly bias the estimation of the multipliers, we select two sets of parameter values ("Calibration 1" and "Calibration 2"). Both calibrations 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 hinder the estimation of multipliers and if so, in 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 overly concerned about how they are calibrated. The only requirement we impose on them is that the three non-government shocks together cannot explain more than 40% of the SD of aggregate output, which is what we found in the Chinese data.[19] 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.[20]

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 γ_π, and the government impact parameter γ_χ 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

[19] Based on variance decomposition in the SVAR in the previous section, government shocks explain about 60% of GDP while the other four structural shocks together explain about 40% of GDP.

[20] 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 do affect the standard errors (precision) of the estimators.

model.

The calibrated values of the parameters suggest that China's economy differs significantly from that of the United States or a standard business cycle model. For example, (i) the implicit tax rate related to the deadweight loss from resource misallocations, market failures, and other distortions in China is high—ranging from 25% to 35% a year—close to the capital income tax in the United States.[21] (ii) Government spending is highly responsive to inflation, with an elasticity γ_π between -1 and -2. (iii) Government spending has a big impact γ_χ on the cost of doing business or investment in China; everything else equal, a 1% increase in government spending can increase the rate of return to private investment by 0.1% to 0.35%.[22]

Table 4. Calibrated Parameter Values

Parameter	Calibration 1	Calibration 2	Note
α	0.35	0.4	Capital's income share
β	0.985	0.9	Time discounting factor
δ	0.1	0.9	Capital depreciation rate
σ	0.95	0.95	Time-to-build parameter
$\frac{\Phi}{Y}$	0.25	0.35	Dead weight cost-to-output ratio
ϕ	0.4	0.5	Composition of government spending
g_x	0.1	0.1	LR growth rate
s_g	0.1425	0.1425	Share of government spending
γ_π	-1.0	-2.0	Inflation feedback parameter
γ_y	0.5	0.5	Output coefficient in Taylor rule
γ_χ	0.35	0.1	Government impact parameter
ρ_g	0.8	0.6	Persistence of government shock
σ_g	1.0	1.0	SD of government shock
σ_A	0.2	0.2	SD of TFP shock
σ_Δ	0.2	0.2	SD of preference shock
σ_v	0.2	0.2	SD of velocity shock

Impulse Responses to a Government Shock. The impulse responses of the model to a 1 SD shock to the autonomous component $\tilde{g}_t$ in government spending are graphed in Figure 4, where the dashed line in the top row shows the actual government spending G_t in the model; the left panels pertain to output, investment, and inflation for Calibration 1; and the right panels pertain to the same variables for Calibration 2. Several features are noteworthy. First, under either calibration, the model can generate positive and hump-shaped impulse responses in output and investment (as well as consumption—not reported). Second, the

[21] Hshieh and Klenow (2009) estimate that resource misallocation resulting from incomplete or missing financial markets reduces China's TFP by 50% or more.

[22] 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 for the time discounting factor β and capital depreciation rate δ, all parameter values are broadly similar across the two calibrations. The excessively high depreciation rate under Calibration 2 appears highly inconsistent with the conventional assumption in the literature. However, it is not unthinkable given that the average life span of private enterprises is just 2.9 years in China, compared with 30 years in Japan and 40 years in the United States (see "Unsuccessful Successors: China's Struggling Family Businesses." *Want China Times*, February 21, 2012; http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20120221000077&cid=1502).

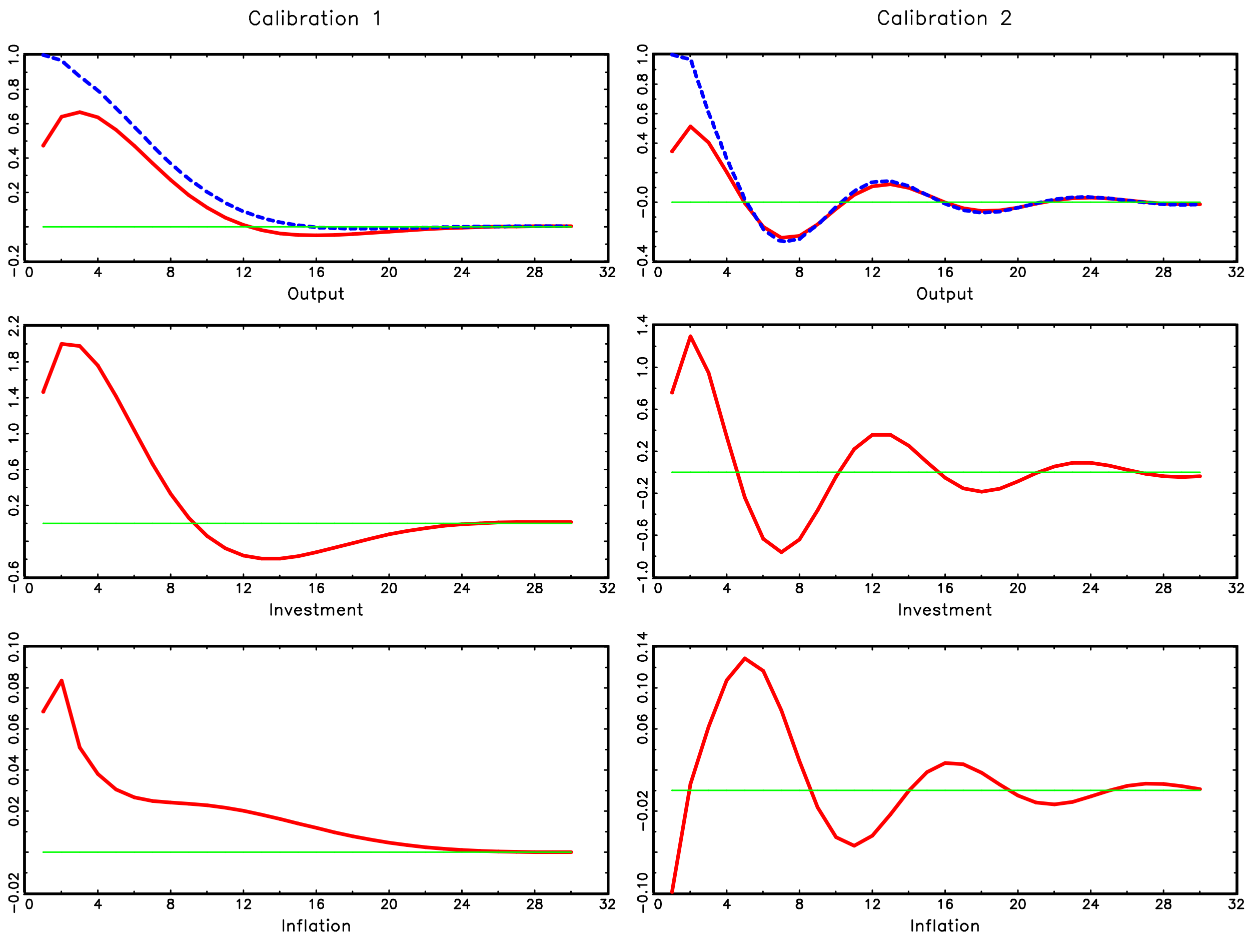

Figure 4: Impulse Responses to Government shock.

model can 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.[23]

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 the income multiplier ranges from about 2.4 to 4.7, broadly similar in magnitudes to those found in the Chinese economy (but with a slightly weaker dynamic multiplier in the model).

[23] For a sufficiently high value of γ_π, the model can also generate an impulse response function of government spending G_t that appears to lead the boom-bust cycle and is more volatile than output as in the data (see Figure 1).

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

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 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 (shortcut) way of capturing both parameter uncertainty and sampling uncertainty.

Table 6. Conditional Second Moments

	SD		Correlation with Y_t		Autocorrelation	
Variable	Data	Model	Data	Model	Data	Model
Y_t	1.0	1.0	1.0	1.0	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)
π_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 strong 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, the inflation rate under Calibration 2 tends to lag output by 2 to 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 New Keynesian models (see Christiano, Eichenbaum, and Evans, 2005). Here we achieved all these targets through inflation-financed government spending (among other things) without relying on sticky prices. The most remarkable aspect of the model, however, is its ability to mimic the large multipliers and periodic boom-bust cycles 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 SVARs ?

The multipliers in the Chinese data are surprisingly large and are based on very short time-series samples with only 33 data points. In addition, the SVARs are based on the crucial assumption that government spending shocks can have an 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 may overestimate the true multiplier—as it is 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 1000 times in each trial discussed below. Based on the simulated samples, we estimate the implied multipliers by the same SVAR method with two lags (as in Section 2),

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + A_0 \varepsilon_t, \tag{56}$$

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 ($N = 33$). 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 a government shock are shown in Figure 5, where the solid line in each window is the mean impulse response function based on 1000 simulations, the thin dashed lines are the corresponding 1-SD error bands, and the dot-dashed line in each window is the truth (theoretical impulse response). The windows on the left correspond to Calibration 1 and the windows on the right 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 the mean of the impulse response functions (the solid line in each window) always lies below the true impulse

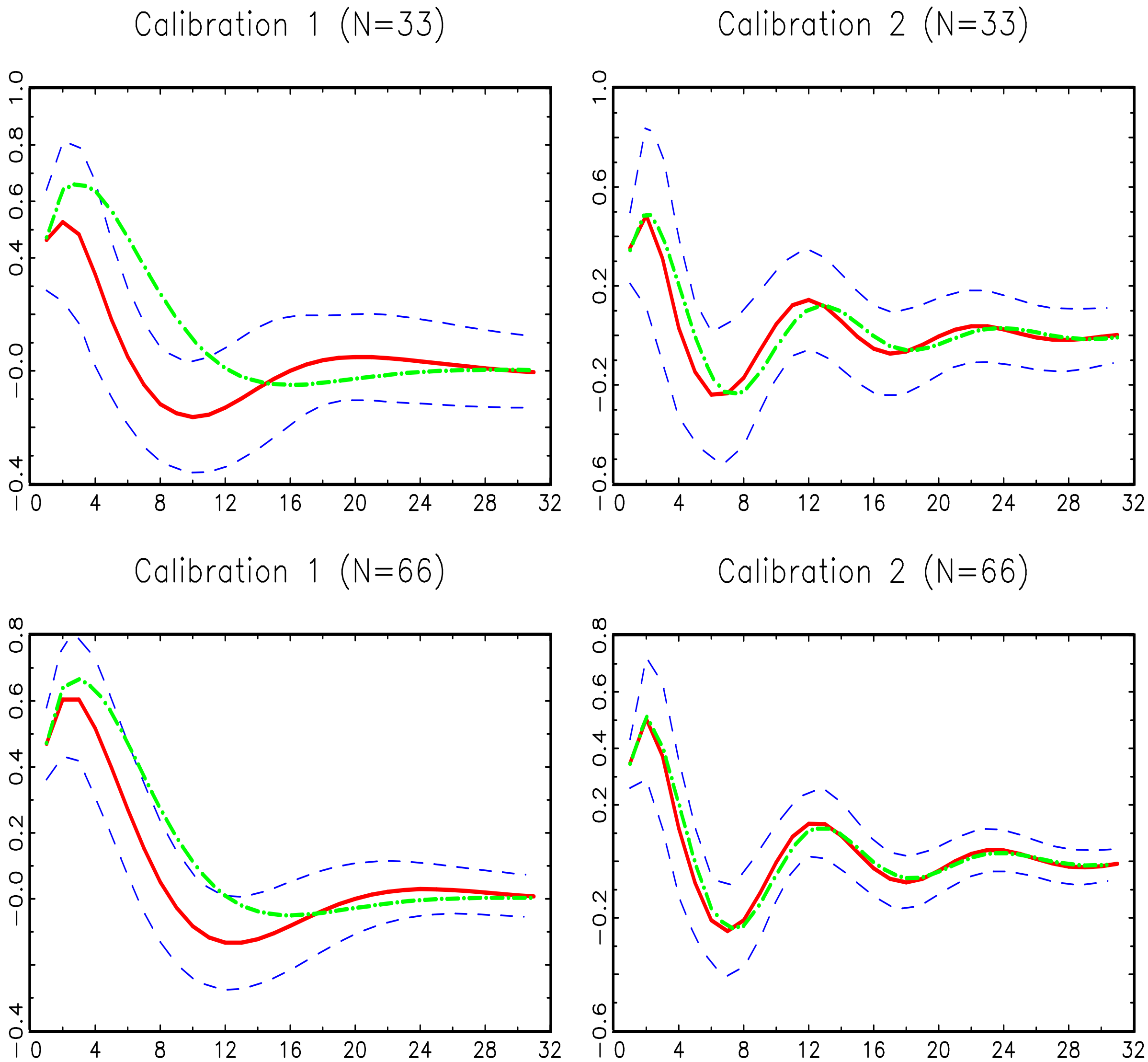

Figure 5: Estimated Impulse Responses of Output to a Government Shock (dot-dashed line = truth; solid line = mean; thin dashed lines = 1-SD error band).

response function (the dot-dashed line in each window) in the initial phase of the boom-bust cycle. Therefore, the dynamic multiplier tends to be underestimated by SVARs. Second, under Calibration 2 the mean of the impulse response functions (the solid line) is very close to the truth (the dot-dashed line) for $N = 33$ and becomes virtually indistinguishable from the truth for $N = 66$, suggesting that both the impact multiplier and the dynamic multipliers can be consistently estimated by SVARs even when the sample length is as short as $N = 33$. However, this is 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 calibration. Fourth, 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 1-SD error band (see the lower-left window).

It is difficult, however, to eyeball the accuracy of the LR cumulative multiplier, which is measured as the ratio of the sum of the impulse response function of output and the counterpart in government spending. Therefore, 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 calibration. 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 boom-bust cycle is so strong that many periods have negative values in the impulse responses. However, if we use the absolute sum of the areas under 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 may be better based on the absolute sum rather than the natural sum of the impulse responses.[24]

[24] As noted previously, since the cumulative multiplier is the ratio of two sums, the economic meaning of the multiplier does not change when absolute values are used, provided that both output and government spending comove together over the boom-bust cycles.

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 SDs.

5 Conclusion

Keynesian theory argues that government spending can have a multiplier greater than one on aggregate income when resources remain idle or underutilized as the result of market (coordination) failures.[25] 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 underutilization of economic resources and market failures are believed to be the norm.

As a large developing economy, China possesses several important features that make it an idea laboratory for studying the potential multiplier effects of government spending: (i) Resources are not always fully or efficiently utilized in China, (ii) widespread market failures resulting from information frictions, the lack of the rule of law, and various forms of externalities, (iii) incomplete or missing financial markets, and (iv) a significantly greater degree of resource misallocations than in developed countries, among others. Perhaps more importantly, China has been very active in using government spending as a policy tool to stimulate the economy in the past three decades. Our empirical analyses show that

1. The fiscal multiplier in China is indeed significantly larger than 1, so that real GDP

[25] The Keynesian theory argues that, with market failures, aggregate effective demand determines aggregate supply, not vice versa. However, studies by Barro and Redlick (2011) and Ramey (2011) fail to find a large multiplier effect in the United States during the World War II. Presumably, with high unemployment and low capacity utilization during the Great Depression and before the war, government spending should have a multiplier effect larger than 1 on the economy. But this literature fails to find it. A possible explanation is that the multiplier effect of government spending is subject to diminishing returns because the multiplier exists only as long as the economy is slack. Suppose the economy has only 10% slackness in output (say equivalent to a $1 billion gap between actual output and potential output at full employment or the natural rate) and the multiplier is 2. Then only a $0.5 billion increase in government spending would be enough to bring output to its potential, and any extra spending would have little multiplier effect. During World War II, total government spending (federal plus state) rose from 20 percent of GDP before the war to nearly 53 percent of GDP in 1945. Similarly, military defense spending rose from less than 5% of GDP up to more than 40% of GDP (see http://www.usgovernmentspending.com/). However, nominal GDP in 1939 was only about 10% below its 1929 peak right before the Great Depression. Therefore, we should not expect to find a multiplier larger than 1 when the actual increase in government spending during World War II was far larger than needed to bring GDP back to its potential level at the natural rate (see http://www.usstuckonstupid.com/).

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 workers are just building roads to nowhere and homes for nobody.

2. However, such a large multiplier is not necessarily a free lunch, as government spending itself may also be an aggravating source of the boom-bust cycle in China. Consequently, the benefit of the multiplier may be largely offset by the cost of the subsequent 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. In particular, our theoretical model suggests that the large multiplier effects of government spending are based (at least partially) on equally large market failures and deadweight costs from market distortions.

Understanding the effects of government spending in China can provide guidance or lessons to other developing countries in addressing their macroeconomic problems and development issues. Poverty traps in current developing countries may not be fundamentally different from those experienced by developed countries during the Great Depression of the 1930s. It may be 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 but also on expected demand, 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 quite 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 form of public spending is beneficial: Building roads that lead to nowhere or ghost towns where nobody wants to live can have severe detrimental consequences on economic development.

As Ramey (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 here suggest that such an analysis is imperative in light of the boom-bust cycles in China. An analysis of this nature would require a better understanding of the mechanisms regarding how government spending is financed and where government purchases are targeted in the economy.

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A Appendix: Further Robustness Analyses

A. 1 Granger Causality

Because of the lack of individual price indices 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.[26] First, we regress the re-defined real GDP growth Δy_t on its own lags $\{\Delta y_{t-1}, \Delta y_{t-2}\}$ and lagged real government spending Δg_{t-1}. Second, we add the lagged CPI inflation rate Δp_{t-1} as an independent variable into the first regression to control the influence of lagged CPI in real government purchases on real GDP. Third, we replace real government spending Δg_{t-1} by nominal government spending ΔG_{t-1} in the second regression while keeping the lagged CPI inflation rate as an independent control variable. All results show that government spending Granger-causes real GDP growth but not vice versa. The results are reported in the following equations (standard errors are in parentheses):

$$\Delta y_t = \underset{(0.02)^*}{0.068} \; \underset{(0.19)}{+0.29\Delta y_{t-1}} \; \underset{(0.18)}{-0.27\Delta y_{t-2}} \; \underset{(0.11)^*}{+0.29\Delta g_{t-1}}, \tag{A.1}$$

$$\Delta y_t = \underset{(0.02)^*}{0.069} \; \underset{(0.20)}{+0.29\Delta y_{t-1}} \; \underset{(0.21)}{-0.24\Delta y_{t-2}} \; \underset{(0.13)^*}{+0.27\Delta g_{t-1}} \; \underset{(0.13)}{-0.04\Delta p_{t-1}}, \tag{A.2}$$

$$\Delta y_t = \underset{(0.02)^*}{0.069} \; \underset{(0.20)}{+0.29\Delta y_{t-1}} \; \underset{(0.21)}{-0.24\Delta y_{t-2}} \; \underset{(0.13)^*}{+0.27\Delta G_{t-1}} \; \underset{(0.14)^*}{-0.31\Delta p_{t-1}}. \tag{A.3}$$

The first regression yields essentially the same result as in equation (6); namely, lagged real government spending is the main explanatory variable for current real GDP growth and is far more significant in predicting GDP growth than the history of GDP growth. The implied multiplier is also similar in magnitude to that obtained before. The second regression shows that lagged CPI inflation is not significant in predicting current real GDP growth. Furthermore, the third regression yields an almost identical coefficient with an identical significance level (up to the third digit) for the effects of government spending as in the second regression, except that the coefficient on lagged inflation becomes larger when nominal government spending ΔG_{t-1} replaces real government spending Δg_{t-1} as an independent variable. These regression results reinforce our previous results that changes in

[26] To reduce noise, we subtract net exports from GDP, so total output $Y = C + I + G$.

government spending Granger causes changes in real GDP, regardless of how real GDP is measured. In other words, government spending in China does contain superior information not contained in lagged GDP in predicting future GDP movements.

A. 2 Orders in the SVAR

When a variable is ordered first in the SVAR 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 SVAR literature proposes ordering the variable of interest as the last in the VAR.

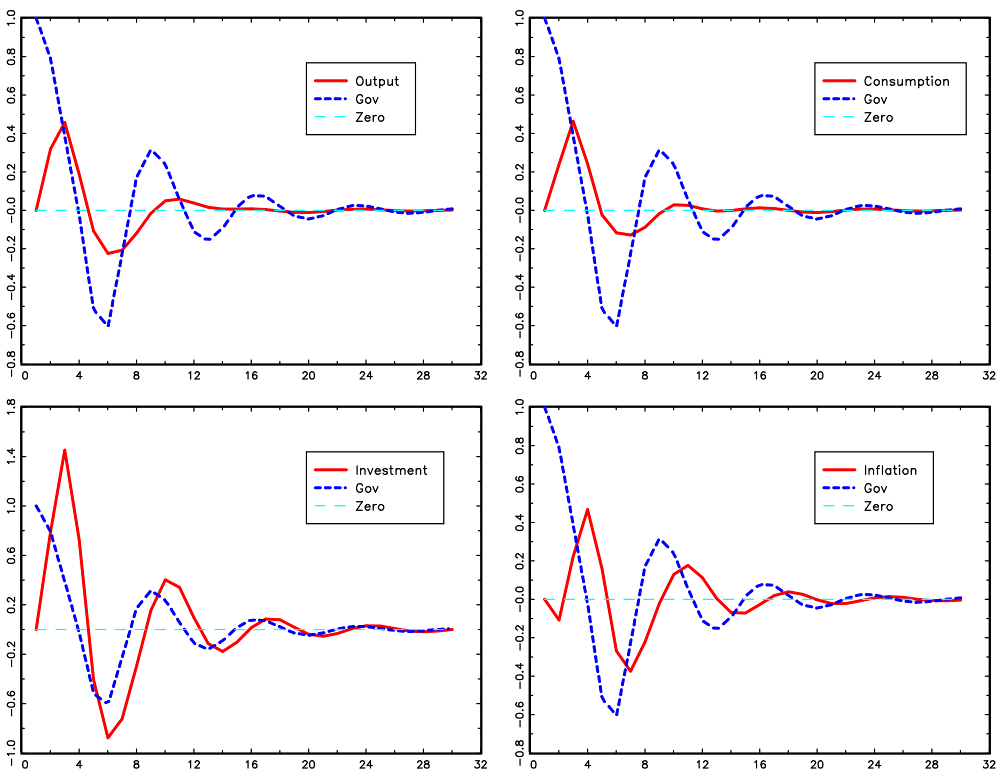

Figure A. Impulse Responses to a Government Shock (without the Impact Multiplier).

As a robustness check, we follow the existing monetary literature by ordering government spending last in the VAR even though this ordering is inconsistent with our theoretical model and the accounting identity of the national income.[27] 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 reordered vector X_t in equation (15) is now given by real GDP (Y_t),

[27]However, it is possible that an increase in government spending (G) crowds out net exports (NX) by exactly the same amount, so the remaining variables $\{Y, C, I\}$ in the accounting identity, $Y = C+I+G+NX$, are not affected.

real consumption (C_t), real investment (I_t), inflation (π_t), and real government spending (G_t). As before, all nominal variables are normalized by the CPI. The last shock in the vector ε_t now corresponds to a government consumption shock. Using two lags and a linear-quadratic time trend in the SVAR, the impulse responses of $\{Y_t, C_t, I_t, \pi_t\}$ to a 1-SD shock to G_t are graphed in Figure A.

The pattern of the impulse responses looks 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, both dynamic and cumulative multipliers exist. 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 under 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 it is still significantly larger than 1 and that found in the U.S. data.

However, as mentioned previously, if we order government spending 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 misspecified model if government spending is ordered last in the VAR because this ordering would imply that other variables "cause" government spending but not vice versa during the impact period of the shock.