Effects of Government Spending on Private Investment

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Abstract

In this paper, I investigate the time-varying effects of government spending on private investment in the U.S. for the time period spanning 1947-2018. I find strong evidence that fiscal spending has significant positive effects on private investment in the pre - 1980s subsample, whereas it has negative effects in the post - 1980s subsample. I build a DSGE model with fiscal considerations and featuring productive government spending in the production function to help understand these empirical results. The variation in estimated model parameters between the two subsamples, along with model-based counterfactual analysis, suggest that diminished productivity of government spending, shorter persistence of government spending together with different financing decisions are the prime determinants of the observed heterogeneity across time.

1 INTRODUCTION

The effects of government spending on private investment remain a controversial issue in the macroeconomic field. According to one view, increased government spending could potentially depress private investment. Debt-financed expansionary fiscal spending could lead to a rise in the interest rate. In turn, the higher interest rate raises the cost of borrowing, and discourages private investors from borrowing and investing in new factories or new equipment. Tax financed increased public expenditure could lead to negative wealth effects, also depressing private investments. On the other hand, an increase in fiscal spending may potentially crowd in private investment, if government spending (or public capital) and private investment in private capital have a complementary relationship in production. Suppose government spending can increase the marginal productivity or lower the production cost of private capital. In that case, it can attract more private investment because of the higher rate of return.

In this paper, I study the effects of government spending on private investment – most notably whether it is positive or negative on average; whether these effects are consistent across all the time; and if there are the heterogeneous effects in the U.S. history, then what are the main factors that can explain these differences across time. I first investigate the time-varying effects of government spending on private investment in the U.S. from historical data. Then by matching the theoretical impulse response functions to empirical ones, I estimate the model parameters in a theoretical model over different subsamples. Lastly, I conduct model-based counterfactuals to narrow down the factors in the economy that drive the changing effects of public spending on private investment.

There are four main findings and contributions of this paper. Firstly, I find the time-varying effects of government spending on private investment for two subsamples: In the pre - 1980s period increased public spending leads to a rise in private investment while in post-1980 period it has negative effects. Secondly, I provide new evidence that the transmission of government spending shock in the U.S. has changed substantially, in particular for investment, since the early 1980s. Third, I attempt to explain the observed heterogeneity of this transmission by considering a DSGE model, and find that it is driven by the changes of a set of parameters including the diminished public spending productivity, lower government spending persistence, different implementation of government expenditure, more active monetary policy, and higher asset market participation rate. Finally, by a counterfactual experiment, I identify that the first three elements are the most critical factors that drive this observed heterogeneous effects on private investment across time.

The literature provides mixed evidence for the effects of government spending on private investment. Many existing empirical studies support the "crowding out" hypothesis. With annual data from 1953-1986, Aschauer (1989b) concludes that net effects of increased public investment expenditure are a relatively small fall in private investment. Monadjiemi (1993) finds that both government investment and consumption crowd out private investment expenditure in Australia and the United States employing quarterly data spanning 1976-1987. Barro and Redlick (2011) documents that temporary defense spending has significant crowding out effects on investment over

1930-2006. Ramey (2011) shows that government spending adversely affects residential and non-residential investment when considering a sample period of 1939-2008. [1]

At the same time, some theoretical literature and empirical evidence also show a "crowding in" phenomena in the U.S. Barro (1990) divides government spending into non-productive and productive expenditure in his model. One of the implications of his theory is that non-productive government spending has a negative relationship with private investment, while productive expenditure plays a positive role in private investment. Ramey (2011) shows government spending has positive effects on residential and nonresidential investment initially when using a subsample period 1947-2008. Empirical results reported in Pereira and Andraz (2003) suggest that a positive relationship between public and private investment is found at the aggregate level, public investment seems to affect industries differently, and industries react differently to different components of public investment. For instance, public investment in infrastructures in the U.S. tends to boost private investment in manufacturing, public utilities, communications, etc. Moreover, by using 1955-2014 quarterly data with a monetary model including two different monetary-fiscal policy regimes, Leeper, Traum, and Walker (2017) how two possibilities: Investment multipliers with respect to government spending are strongly negative in an active monetary policy regime combined with passive fiscal policy, but are more likely to be positive in an active fiscal policy regime together with passive monetary policy, particularly in the long term.

Aforementioned previous studies concerning government expenditure effects on the private economy, usually estimate aggregate government spending or government investment effects on average during the sample period. If they investigate the heterogeneous effects of government spending, they tend to discuss the heterogeneity across different categories of government spending by disaggregating its components, for example, Boehm(2020) and Pereira et al.(2003). Instead, in this paper, I focus on potential heterogeneity across time by considering the time-varying responses of private investment to total government expenditure.

More specifically, the analysis proceeds in three steps. In the first step, I begin with finding the empirical evidence on heterogeneous government spending effects on private investment by estimating SVAR model with U.S. historical data from 1947Q1-2018Q4. I conduct time-varying rolling window estimates of a SVAR model over the sample period from 1947Q1-2018Q4 and show that before 1980, private investment had a positive response to increased government spending, while in the later period, private investment starts to show an opposing response to increased fiscal expenditures. [2] This leads me to consider two subsamples, S1: 1947Q1-1979Q2 and S2:

[1] Other studies include Cohen, Coval, and Malloy (2011) who show that government spending reduces investment during the 1967-2008 period. Kim and Nguyen (2019) verify that increases in federal expenditures reduce firms' investment using 1980-2008 data. With a quarterly panel of OECD countries from 2003 to 2016, Boehm (2020) shows that the response of private investment is significantly negative after a government investment shock.

[2] Mihov (2003) also suggests that the transmission of fiscal shocks changed substantially in the early 1980s, and Bilbiie, Meier, and Muller (2008) provide evidence for this argument when they study the effects of government spending on consumption for different subsamples of 1957-1979 and 1983-2004.

1983Q1-2008Q1, to study the potentially different effects of government spending on private investment. [3]

In the second step, I develop a New Keynesian model that features a share of consumers who follow a rule of thumb (ROT) and only consumer their disposable income, as in Gali, Lopez-Salido, and Valles (2007). In addition, the model features a production function with productive government spending, in order to examine the equilibrium responses to a government spending shock under baseline and alternative calibrations. Unlike Gali et al. (2007), who are mainly concerned about the positive consumption responses to government spending, I focus on the responses of investment and how the changes of key parameter values can impact the impulse responses of investment to government spending.

In the third step, I match the impulse response functions from the model to the impulse response functions from empirical analysis, by utilizing the minimum distance strategy. This procedure helps me estimate the model for two subsamples, thereby allowing us to compare the differences of parameters in these two samples and explain the different historical effects of fiscal spending. Several previous papers have employed this estimation method. The most prominent examples include Rotemberg and Woodford (1997), Christiano, Eichenbaum and Evans (2005), and Bilbiie et al.(2008). When estimating the model for both samples, I allow policy parameters and a few key parameters which may have significant impacts on investment to vary, while fixing other structural parameters such as preferences and technology parameters. After obtaining parameter estimates for both subsamples, I conduct a model-based counterfactual analysis to identify the leading factors of heterogeneous investment responses across time.

The paper proceeds as the following: Section II provides empirical analysis by using recursive VAR. Section III lays out the model setting and calibration. Section IV matches the empirical results to the model results and offers a concise analysis. Section V performs a counterfactual experiment based on the model. Section VI summarizes the main findings.

2 EMPIRICAL ANALYSIS

2.1 SVAR estimation model

Since the work of Sims (1980), SVAR model has evolved into one of the most widely used models in empirical research in macroeconomics. Similar to Fatas and Mihov (2001) and Blanchard

[3]The main reason to exclude the period from 1979Q3 to 1982Q4 is due to large monetary policy changes enacted by Paul Volcker, then Chair of the Federal Reserve, which saw federal funds rate (FFR) reach 11% and even exceeds 20% in 1980. In addition, we encounter a ZLB period after 2008. Previous empirical literature regarding government spending multipliers find that the government spending multiplier is much larger in the ZLB period than in the normal period, and I do not want these effects to bias my results.

and Perotti (2002), which developed the recursive identification for SVAR approach in order to implement the analysis of fiscal policy, I use the recursive identification strategy and Cholesky decomposition to identify the government spending shock and quantify the economic consequences of this shock, including responses of private investment.

The basic framework of the SVAR is as follows:

$$B_0 Y_t = B(L) Y_{t-1} + \omega_t$$

Its corresponding reduced form:

$$Y_t = A(L) Y_{t-1} + u_t$$

Where B_0 is the matrix of coefficients of the endogenous variables, $A(L) = B_0^{-1} B(L)$, $u_t = B_0^{-1} \omega_t$, and $\omega_t \sim N(0, \Sigma_\omega)$ and $u_t \sim N(0, \Sigma_u)$. Y_t in the baseline VAR model consists of quarterly government spending, GDP, real wage, private consumption, private investment, and debt. The first 5 variables are in the real per capita logarithm form deflated by GDP deflator and population, while the debt variable is the debt-output ratio. And A(L) and B(L) are polynominal terms in the lag operator, I include 4 lags of each variable following Bilbiie et al. (2008). ω_t is the structure residuals and u_t is reduced-from residuals. In addition, I include the constant and linear time trend in the VAR system for each variable.

Notice that the recursive identification of SVAR approach, which assumes B_0 is a lower triangular matrix of coefficients, relies on identifying assumptions to identify shocks and investigate the policy effects. In the most related literature, e.g. Gali et al.(2007), and Bilbiie et al.(2008), etc., government spending shocks have been identified on the assumptions that government spending is not contemporaneously affected by the other variables included in the SVAR model and all other variables in the SVARs are allowed to respond contemporaneously to government spending shocks in order. These assumptions ensure that government spending shocks can be identified using the Choleski decomposition method in a VAR system where government spending is ordered before all other variables. I rely on the same identifying assumptions so that I estimate a recursive SVAR where government spending is ordered first, and other interested variables are following behind. The order of other variables follows Bilbiie et al (2008), except for private investment, because they do not take effects of government spending on private investment into account. Under the budget constrain, people usually decide their investment strategies after their consumption plans, hence I put private investment after private consumption, which is also the common practice in literature, e.g. Ramey (2011). Since the debt variable is the end of period value, it is reasonable to put it at the end of the list of all variables.

2.2 Data and Sources

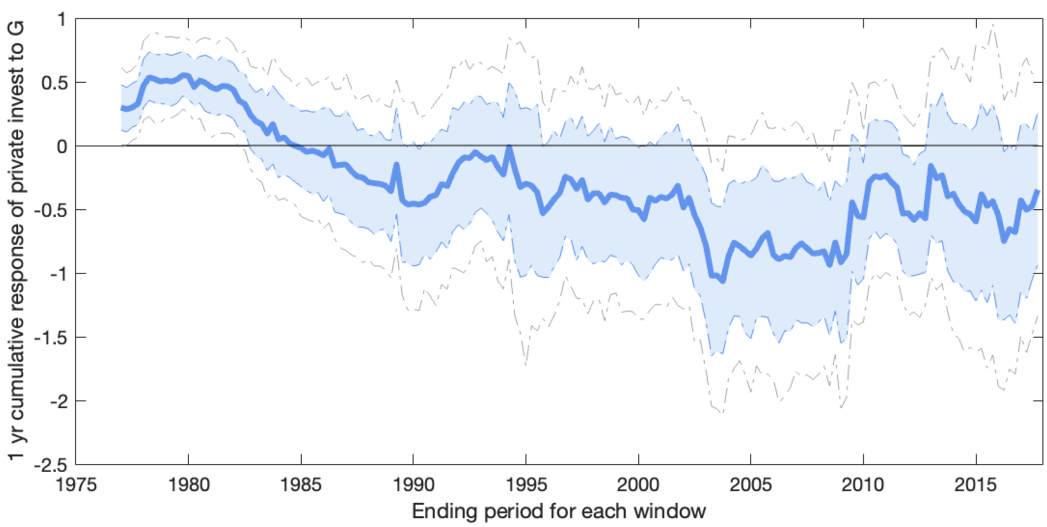
In the empirical analysis, the historical series used are quarterly data from 1947Q1 to 2018Q4. The raw database is comprised of government spending, which is government consumption expenditures and gross investment; GDP; real wage, which is nonfarm business real compensation per hour; private consumption; private fixed investment; end-of-period privately held gross federal debt; GDP deflator (2012=100); CPI (2012=100); population; 3-Month treasury bill: Secondary market rate; personal current tax. Privately held gross federal debt is downloaded from the website of Federal Reserve Bank of Dallas, population and 3-Month treasury bill rate data are downloaded from FRED, all other variables are directly from the NIPA table. And I transform the nominal data to real level by using GDP deflator. Moreover, scaled by the population, the aggregate variables are converted into the per capita format. The debt and tax variables are transformed to be the debt-output and tax-output ratio respectively.

2.3 Rolling window results

Bilbiie et al. (2008) demonstrates that the transmission of fiscal shocks changed substantially in the early 1980s when they study the effects of government spending on consumption for different subsamples of 1957-1979 and 1983-2004. Enlightened by their research, I suspect that the fiscal shocks may also have a time-varying effect on private investment. To investigate, I plot the 30-year time-varying rolling window estimates from SVAR model shown in Figure 1. And the rolling window estimates illustrate that the heterogeneous effects indeed exist: Cumulative responses of private investment with respect to government spending are significant postive in early samples, however, responses have declined when including more data after 1980, so average responses fall when adding more post-1980 data. And fiscal spending started to show nonpositive effects after around 1983. Hence, instead of focusing on the full sample analysis as illustrated in previous literature, I estimate two subsamples, S1: 1947Q1-1979Q2 and S2: 1983Q1-2008Q4, to study the different effects of government spending.

More specifically, S1 and S2 are the appropriate samples for this study, because of the time-varying rolling window estimation of VAR model showed in Figure 1. Figure 1 shows the 1-year cumulative effects of investment on government spending, which is calculated from the 4 quarters cumulative private investment responses divided by 4 quarters cumulative government spending responses. The reason to report the 1-year cumulative responses other than impact responses is that the investment usually takes a while to react to the government spending. This fact can be seen in the impulse response functions of private investment: In the first few quarters, private investment usually has insignificant responses to government spending shock in most of the rolling samples (Take Figure 2 as an example). Each year marked on X-axis corresponds to the ending time of every 30-years rolling sample. For instance, the value for 1980 is estimated by 1951Q1-1980Q1 period. Figure 1 offers a visualized evidence that the private investment response flipped over from positive to negative in the early 1980s – at the beginning, responses are significantly positive and relatively large; when the sample includes more observations after the 1980, the magnitudes of responses become smaller but still significant and positive on average; when it comes to 1983, the responses turn to insignificant positive at both 90% and 68 % confidence level; it remains either insignificant or significant negative since then. Therefore, I split the full sample in early 1980, and expect to observe time-variation of private investment responses across two subsamples.

Figure 1: One year cumulative response of private investment to government spending



NOTES: Y-axis presents 1-year cumulative effects of investment on government spending. Each year marked on the X-axis corresponds the ending time of every 30-years rolling sample. For instance, the value for 1980 is estimated from the 1951Q1-1980Q1 period. Blue shaded areas are 68% confidence interval and the larger band without shade represents 90% confidence interval.

Moreover, I abandon the period from 1979Q3 to 1982Q4. For this period, there was severe monetary policy change brought by Paul Volcker, then Chair of the Federal Reserve. The effective federal funds rate (FFR) reached 11% and even exceeded 20% in 1980, and the FFR went back to normal starting and was lower than 10% in 1983. The extremely high interest rate would significantly discourage private investment, and I would like to remove these negative effects not related to government spending change.

Finally, I choose to end the second subsample in 2008Q4 to remove ZLB period. As aforementioned, previous literature regarding government spending multipliers find that the government spending multiplier is different in the ZLB period from in the normal period, because the bounded nominal interest rate might encourage more private investment while there is inflation caused by extra government spending [4]. The monetary policy channel is one of the critical channels of private investment responses. When including ZLB in the second subsample, I need to assume that the monetary policy is consistent in this subsample, and the investment responses are similar between the ZLB and the normal period in empirical analysis, which might not be the truth. It might further bring in potential estimation bias when I attempt to estimate the model parameters. Therefore, for the post-1980, I exclude the ZLB period to avoid bias. [5]

2.4 Empirical impulse responses and cummulative investment responses

Figure 2 displays the impulse response functions of 6 variables to a 1% increase in real government spending for full sample and two subsamples. The solid lines indicate point estimates, the shaded area between two dashed lines represent symmetric 90% confidence intervals computed by boot strapping based on 1000 replications. And all the impulse responses are normalized by the first period response of government spending.

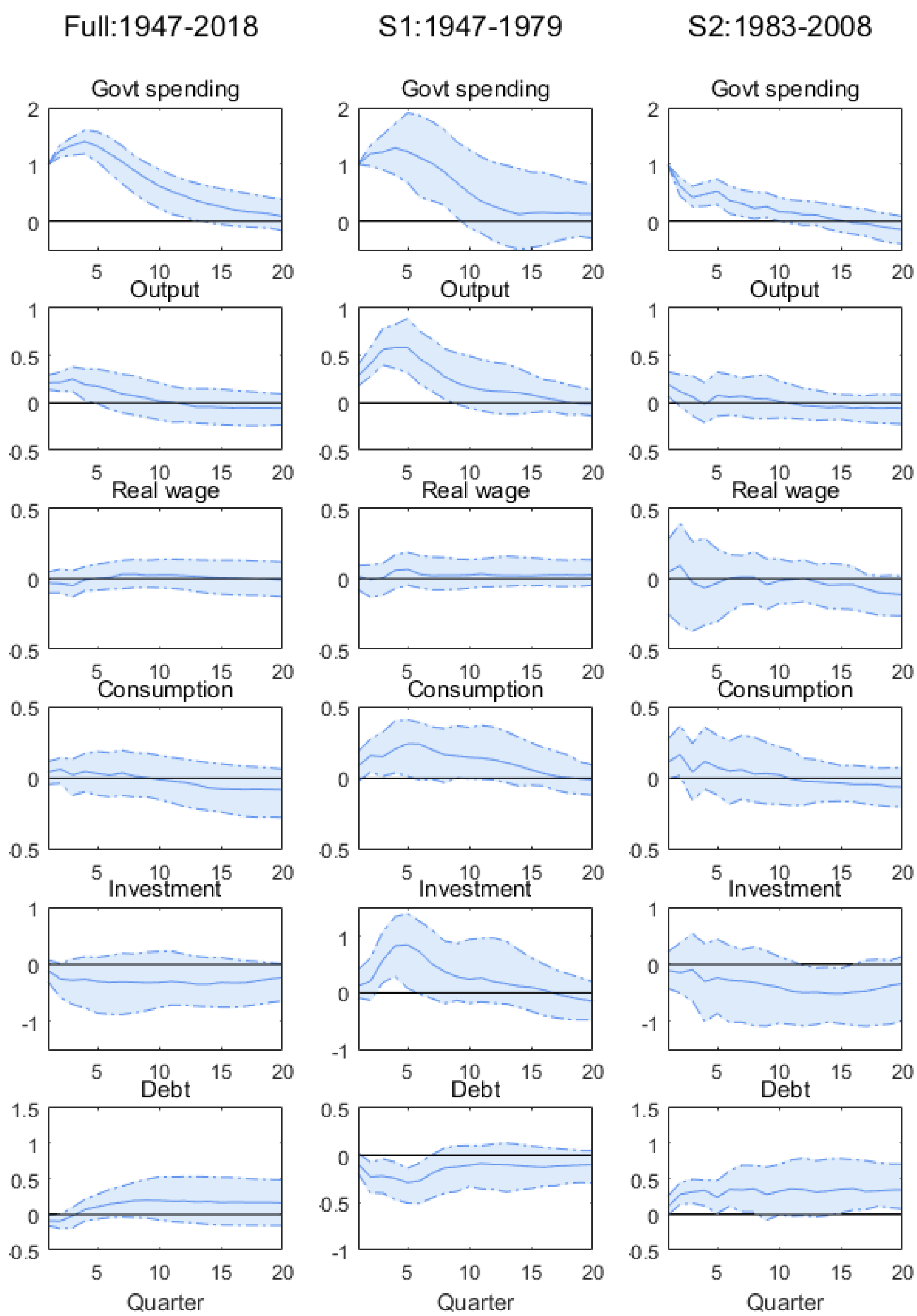
The full sample results shown in the left column of Figure 2. The results show that the output has significant positive responses within one year, and the other variables including private investment all have insignificant responses at 90% confidence level. Still, the point estimates indicate that the private investment has the negative responses in 5 years horizon.

Now compare the subsamples estimates shown in the second and third column of Figure 2. Above all, the positive government spending responses displayed in the first subplot appear to have greater persistence in S1 than in S2 (See point estimates), indicate the fiscal policy has longer persistency in the early period. Output plotted in the second row in S1 has larger and more long-lasting positive responses than in S2. Neither of the real wage (third row) responses in two subsamples is significant, which is in line with Ramey (2011), the real manufacturing wage does not have the

[4]On the other hand, the bounded nominal interest rate might reduce private investment if there is deflation caused by increasing government spending

[5]Note: The estimation results based on subsample 1983Q1-2018Q4 is in line with our main findings in this paper, which are: in the post-1980 period, there were negative responses of private investment; smaller government spending productivity; less persistent government spending shock; active monetary policy, etc.

Figure 2: Impulse response functions to government spending shock



NOTES: For figure 2: X-axis represents time which are quarters. The solid lines indicate point estimates of impulse response functions of 6 variables to a 1% increase in real government spending. The area between two dashed lines represent symmetric 90% confidence intervals computed by boot strapping based on 1000 replications.

significant responses when using 1939-2008.[6] The responses of consumption (fourth row) are significantly positive in the first few quarters in S1 and only 2 quarters in S2. These results are basically consistent with the previous findings.

Furthermore, it comes to the most important variable at the center of the stage, the private investment responses depicted in the fifth row. In the earlier sample, the private investment has a significant positive response starting from the 3rd quarter and ending in the 6th quarter, while in the more recent sample, it has negative responses and becomes significantly negative from the 12th to 16th quarters. Here are two main takeaways about private investment responses from these plots: One is before 1980, fiscal spending can boost private investment while government spending dampens private investment after 1980; the other is the government spending effects on private investment usually need time to achieve, regardless of crowding in or crowding out effects.

Last but not least, the debt responses showed in the last subplot are opposite to each other for subsamples: The debt ratio in S1 falls significantly, whereas in S2 it increases significantly. This fact may indicate that fiscal authority prefers to finance expenditure by taxation in earlier days and tends to pay expenditure by debt in later periods.

Table 1: **Cumulative investment responses to government spending:**

Horizon	S1	S2	S2-S1
4	0.3655	-0.2548	-0.6204
8	0.4366	-0.5138	-0.9503
12	0.4540	-0.9563	-1.4103
20	0.4280	-1.6082	-2.0362

NOTES: Lists cumulative investment responses to government spending for two subsamples in different horizons, 1 year (4 quarters), 2 years (8 quarters), 3 years (12 quarters) and 5 years (20 quarters).

Table 1 lists cumulative investment responses to government spending for two subsamples in different horizons, 1year, 2 years, 3 years, and 5 years. Obviously, S1 has consistently positive investment responses to government spending for different horizons. S2 always has negative investment responses to government spending, but smaller in shorter horizons and larger in longer horizons.

Overall, the comparison of two subsamples confirms a substantial change in the transmission of government spending shocks since early 1980. More importantly, significant heterogeneity of government spending effects on private investment is found across the two subsamples.

[6]Bilbiie et al. (2008) has the first sample from 1957-1979, the real wage can have significant positive responses. If I use this shorter sample period, I can get significant positive responses as well.

2.5 Robustness check for the empirical impulse responses

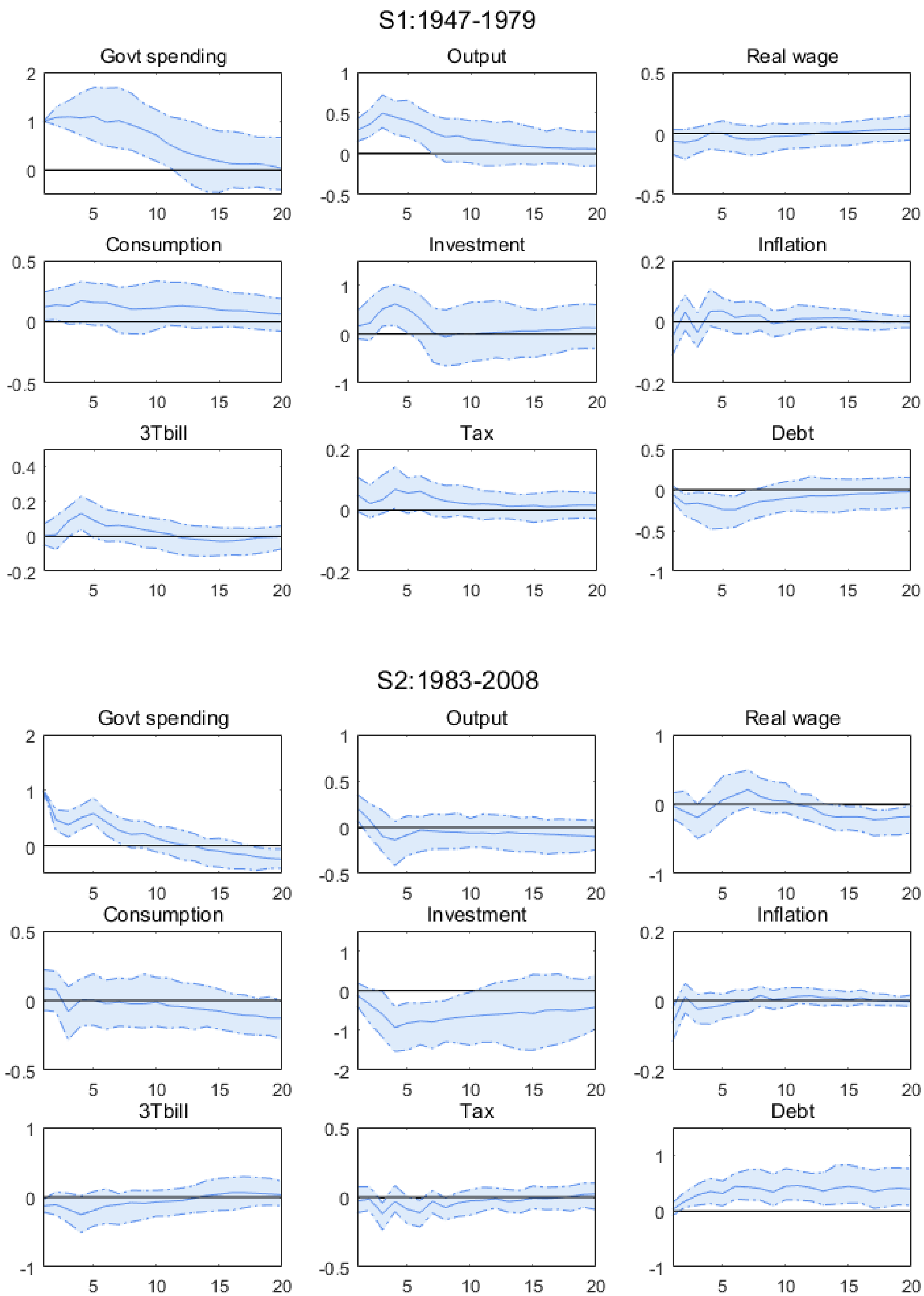
In order to ensure that the investment responses to government spending shocks are not the causal effects of changes in monetary policy or other fiscal policy within the subsample, I bring in other 3 variables for robustness check of impulse response estimations. I add inflation and nominal interest rate to control the monetary policy and add tax variable to control the alternative fiscal policy in addition to public debt issuance. I report results in Figure 3 by adding change rate of GDP deflator as inflation, 3-Month Treasury bill rate as nominal interest rate, tax-output ratio as tax variable. The investment responses keep the similar direction as in the baseline VAR model, i.e. heterogeneous effects still exist.

About heterogeneous effects on tax. When there is a government spending shock, similar to the second and third column in Figure 2, debt responds significantly negative in S1 but significantly positive in S2 overall. As opposed to directions of debt responses to government spending shock in different subsamples, tax responds significantly positively in S1 and insignificantly negative in S2. These heterogeneous responses of debt and tax indicate that government spending is more likely to be financed by tax rather than by debt before 1980, but later government tends to finance its spending by debt. Estimation with a theoretical model in section IV also confirms the different financing decisions across subsamples.

About heterogeneous effects on the interest rate. The heterogenous responses of nominal interest rate (significantly positive in S1 and not significantly different from zero in S2) and the relationship between positive real interest rate responses (positive nominal interest rate and insignificant inflation response) and positive investment responses in S1, are counterintuitive and counter-theory. The potential possibility might be: On the one hand, economy has passive monetary policy in S1, thus the monetary policy channel does not effectively affect short-run nominal interest rate; on the other hand, government spending stimulates private investment because of its marginal productivity effects on private output, and in turn those increased investment by loans raises nominal interest rate. For S2, the active monetary policy pulls up the nominal interest rate to avoid potential inflation while the decreased investment leads to lower nominal interest rate. These two effects cancel out with each other that result in the insignificant responses of nominal interest rate.[7] Other than 3-Month treasury bill rate, I also use CPI to construct inflation and FFR to be the nominal interest rate, or include BAA rate to construct real interest rate, the shape and direction of investment responses are robust in all these different VARs.

[7]Perotti (2005) points out the long-term interest rate can be included in VAR system because it is arguably a more important determinant of private consumption and investment than the short-term interest rate. For this reason, instead of 3-Month Treasury Bill rate, I also apply long run interest rate, which is 10-year Treasury Bill rate to be the nominal interest rate and this nominal interest rate can give negative responses in S1 and positive responses in S2, and the private investment still have the similar responses in the baseline model, which is in line with Perotti (2005) and the theory. I choose to report short-term interest rate version because the main point of the robustness check section is to control the monetary policy and other fiscal policy when estimating impulse responses of investment to government spending shocks, and the short-term nominal interest rate is more representative as the monetary policy than long-term nominal interest rate.

Figure 3: IRobustness check: Impulse response functions



NOTES: For figure 3: X-axis represents time which are quarters. The solid lines indicate point estimates of impulse response functions of 9 variables to a 1% increase in real government spending. The area between two dashed lines represent symmetric 90% confidence intervals computed by boot strapping based on 1000 replications.

3 THE MODEL

The model, which draws on Gali et al.(2007), Bilbiie et al.(2008) and Baxter and King (1993), is a standard DSGE model with sticky prices and rule of thumb households, but involving the government spending in production function. The economy consists of two types of households, a continuum of firms producing differentiated intermediate goods with a production function including government spending as input, a perfectly competitive firm producing a final good, a central bank in charge of monetary policy, and a fiscal authority implementing fiscal policy.

3.1 Households

A continuum of infinitely lived households, indexed by $i \in [0,1]$. $1-\lambda$ fraction of households who have access to capital markets, named as 'Optimizing' households. λ fraction of households who only consume and do not own any assets or any liabilities, refers to 'Rule of Thumb' households.

Optimizing households. For each optimizing household, let C_t^o and L_t^o (or N_t^o) are the consumption and leisure (or hours of work); $\beta \in (0,1)$ is the discount factor; $U(C_t^o, N_t^o)$ is the one period utility. The period utility is common to all households and has the form as $U(C,L) = logC - \frac{N^{1+\varphi}}{1+\varphi}$, where $\varphi \geqslant 0$. The optimizing household seeks to maximize the life-time utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^o, N_t^o) \tag{1}$$

Subject to the budget constraint:

$$P_t(C_t^o + I_t^o) + R_t^{-1} B_{t+1}^o = W_t P_t N_t^o + R_t^k P_t K_t^o + B_t^o + D_t^o - P_t T_t^o \tag{2}$$

And the capital accumulation equation:

$$K_{t+1}^o = (1-\delta) K_t^o + \phi\left(\frac{I_t^o}{K_t^o}\right) K_t^o \tag{3}$$

where P_t is the price level, I_t^o is the investment in real terms; W_t is real wage, R_t^k is the real rental cost if renting his capital holdings K_t^o, B_t^o is the quantity of nominally riskless one-period bonds carried over from period t-1, R_t is the gross nominal return on bonds purchased in period t, D_t^o is dividends from ownership of firms, T_t^o denotes lump-sum taxes paid by household. Capital adjustment costs are introduced through the term $\phi(\frac{I_t^o}{K_t^o})K_t^o$, which determines the change in the capital stock induced by investment spending I_t^o. And assume $\phi' > 0$ and $\phi'' \leq 0$, with $\phi'(\delta) = 1$ and $\phi(\delta) = \delta$.

The first order conditions for the optimizing consumer's problem can be written as:

$$1 = R_t E_t \left\{ \Lambda_{t,t+1} \frac{P_t}{P_{t+1}} \right\}, \tag{4}$$

$$Q_t = E_t \left\{ \Lambda_{t,t+1} \left[R^k_{t+1} + Q_{t+1} \left((1-\delta) + \phi_{t+1} - \left(\frac{I^o_{t+1}}{K^o_{t+1}} \right) \phi'_{t+1} \right) \right] \right\} \tag{5}$$

$$Q_t = \frac{1}{\phi' \left(\frac{I^o_t}{K^o_t} \right)} \tag{6}$$

where $\Lambda_{t,t+k}$ is the discount factor for real K-period ahead payoffs given by

$$\Lambda_{t,t+k} \equiv \beta^k \left(\frac{C^o_{t+k}}{C^o_t} \right)^{-1} \tag{7}$$

Where Q_t is the shadow value of capital, namely, Tobin's Q. And the elasticity of the investment-capital ratio with respect to Q (at steady state) is given by

$$\eta \equiv -1/\phi''(\delta)\delta$$

Notice that I apply the non-competitive labor market setting from Gali et al.(2007), which means the hours are assumed to be determined by firms instead of being chosen by households, given the prevailing wage determined by an economy-wide labor union. [8]

Rule of thumb households. They fully consume their current labor income and cannot smooth their consumption path in the face of fluctuations in labor income. For each Rule of thumb household, let C^r_t and L^r_t (or N^r_t) are the consumption and leisure (or hours of work). T^r_t is the lump-sum taxes paid by rule of thumb household. The problem the rule of thumb households seek to maximize the one period utility:

$$U(C^r_t, N^r_t) \tag{8}$$

Subject to the budget constraint:

$$P_t C^r_t = W_t P_t N^r_t - P_t T^r_t \tag{9}$$

Then we have:

$$C^r_t = W_t N^r_t - T^r_t \tag{10}$$

[8] The main reason of applying non-competitive labor market is that the model can provide positive consumption responses to government spending shock when $\lambda < 0.5$, which helps to match for the second subsample where there is the lower $\lambda(< 0.5)$ and still positive consumption reaction.

Aggregation. Aggregation consumption, hours, investment ,capital and tax are given by a weighted average of corresponding variables for each consumer type:

$$C_t \equiv \lambda C_t^r + (1-\lambda) C_t^o \tag{11}$$
$$N_t \equiv \lambda N_t^r + (1-\lambda) N_t^o \tag{12}$$
$$I_t \equiv (1-\lambda) I_t^o \tag{13}$$
$$K_t \equiv (1-\lambda) K_t^o \tag{14}$$
$$T_t \equiv \lambda T_t^r + (1-\lambda) T_t^o \tag{15}$$

The wage schedule. Assume the wages are determined according to the schedule of the form $W_t = H(C_t, N_t)$. Given the wage, each firm decides how much labor to hire and allocates its labor demand uniformly across households, independently of their type. Accordingly, we have $N_t^r = N_t^o = N_t$ for all t.

3.2 Firms

A final goods firm. The final good is produced by a representative, perfectly competitive firm with a constant returns technology:

$$Y_t = \left(\int_0^1 X_t(j)^{\frac{\epsilon_p - 1}{\epsilon_p}} dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

Where $X_t(j)$ is the quantity of intermediate good j used as an input and $\epsilon_p > 1$. Profit maximization, taking as given the final goods price P_t and the prices for the intermediate goods $P_t(j)$, all $j \in [0,1]$, yields the set of demand schedules

$$X_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon_p} Y_t$$

and the zero-profit condition:

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon_p} dj \right)^{\frac{1}{1-\epsilon_p}}$$

Intermediate goods firms. The production function of a representative intermediate goods firm:

$$Y_t(j) = K_t(j)^{\alpha} N_t(j)^{1-\alpha} G_t(j)^{\alpha_g} \tag{16}$$

$K_t(j)$ and $N_t(j)$ are the capital and labor services hired by firm j; $G_t(j)$ is the government spending used by firm j. This production function assumes that government spending G_t can affect a firm's production characterized by a parameter α_g, which represents the degree of government expenditure externality or output elasticity of public expenditure. Or could say it measures the productivity of government spending in private sector. G_t includes government investment on public capital and government consumption expenditures which are the spending to produce and provide goods and services to the public. [9] [10]

Similar setting of G_t and α_g is used in Ma (2019). Bringing in G_t as an input in the production function can give us a channel in that when government spends more, the marginal productivity of private capital will be higher, inducing more private investment.

By cost minimization, it can have:

$$\frac{K_t(j)}{N_t(j)} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{W_t}{R_t^k}\right)$$

Further having real marginal cost is common to all firms and given by:

$$MC_t = \Psi(R_t^k)^{\alpha}(W_t)^{1-\alpha}(G_t)^{-\alpha_g}$$

Where $\Psi \equiv \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$.

Price setting. Intermediate goods firms are assumed to set nominal prices in a staggered fashion according to Calvo (1983). Each period $1-\theta$ of producers reset their prices, while a fraction θ keep their prices unchanged. The firms need to solve the following profit maximization problem to set optimal P_t^*:

$$E_t \sum_{t=0}^{\infty} \theta^k E_t \left\{\Lambda_{t,t+k} Y_{t+k}(j)(P_t^*/P_{t+k}) - MC_{t+k}\right\}$$

subject to the demand constrain:

$$Y_{t+k}(j) = X_{t+k}(j) = (P_t^*/P_{t+k})^{-\epsilon_p} Y_{t+k}$$

The first order condition for this problem is

$$\sum_{t=0}^{\infty} \theta^k E_t \left\{\Lambda_{t,t+k} Y_{t+k}(j)(P_t^*/P_{t+k}) - \mu_p MC_{t+k}\right\} = 0$$

[9] According to BEA, government consumption expenditures include spending by governments to produce and provide services to the public, such as national defense and education. Government gross investment consists of spending on fixed assets that directly benefit the public, such as highway construction, or that assist government agencies in doing their jobs, such as military hardware.

[10] Alternatively, I could only input government capital Gk_t into the production function and α_g represents the productivity of public capital; the log-linearized government capital is accumulated by a normal path: $Gk_t = Gi_t + (1-\delta)Gk_{t-1}$; further assumes that government investment $gi_t = \gamma_{gi} g_t$ with $\gamma_{gi} = 0.2$ from data; market clearing with $g_t = gi_t + gc_t$. I will have the larger estimated α_g in S1 and S2 than the estimates in the paper. Still, α_g in S2 is lower than in S1, which is in line with results in the paper.

where $\mu_p \equiv \epsilon_p/(\epsilon_p - 1)$ is the gross frictionless price markup. Finally the aggregate price level is given by:

$$P_t = \left[\theta P_{t-1}^{1-\epsilon_p} + (1-\theta) P_t^{*1-\epsilon_p}\right]^{\frac{1}{1-\epsilon_p}} \tag{17}$$

3.3 Monetary authority

The central bank is assumed to set the nominal interest rate $r_t \equiv R_t - 1$ every period according to a simple Taylor rule of interest rate:

$$r_t = r + \phi_\pi \pi_t \tag{18}$$

where $\phi_\pi > 1$; r is the steady state nominal interest rate; $\pi_t \equiv P_t/P_{t-1}$ is the inflation rate.

3.4 Government

The government budget constraint is

$$P_t T_t + R_t^{-1} B_{t+1} = B_t + P_t G_t \tag{19}$$

Letting $g_t \equiv (G_t - G)/G$, $t_t \equiv (T_t - T)/Y$ and $b_t \equiv (B_t/P_t - B/P)/Y$, $\gamma_g = G/Y$, assume a fiscal policy rule of the form:

$$t_t = \phi_g \gamma_g g_t + \phi_b b_t \tag{20}$$

where ϕ_g and ϕ_b are positive constants.

Finally, in order to have the hump-shape impulse response of government spending, assume that government spending follows an exogenous AR(2) process [11],

$$g_t = \rho_{g1} g_{t-1} + \rho_{g2} g_{t-2} + \epsilon_t \tag{21}$$

where $0 < \rho_{g1} + \rho_{g2} < 1$ and ϵ_t represents an iid government spending shock with constant variance σ_ϵ^2.

[11] For government spending, Gali assumes it follows AR(1), I use AR(2) because it can give a hump-shaped government spending impulse responses which is also showed in the empirical results.

3.5 Market clearing

The market clearing conditions are as follows:

$$N_t = \int_0^1 N_t(j)dj,$$

$$K_t = \int_0^1 K_t(j)dj.$$

$$G_t = \int_0^1 G_t(j)dj.$$

$$Y_t(j) = X_t(j)\, for\, all\, j,$$

$$Y_t = C_t + I_t + G_t. \tag{22}$$

3.6 Log-linearization conditions

A local approximation of the model around steady states delivers a system of linear formed equations. Unless otherwise noted, lower-case letters denote log-deviations with respect to the corresponding steady state values, i.e. $x_t \equiv log(X_t/X)$. *Households.*
The Tobin's Q and investment:

$$q_t = \beta E_t\{q_{t+1}\} + [1-\beta(1-\delta)]E_t\{r^k_{t+1}\} - (r_t - E_t\{\pi_{t+1}\}) \tag{23}$$

$$i_t - k_t = \eta q_t \tag{24}$$

The capital accumulation equation:

$$k_{t+1} = \delta i_t + (1-\delta)k_t \tag{25}$$

The intertemporal equilibrium condition for aggregate consumption:

$$c_t = E_t\{c_{t+1}\} - \sigma(r_t - E_t\{\pi_{t+1}\}) - \Theta_n E_t\{\Delta n_{t+1}\} + \Theta_t E_t\{\Delta t^r_{t+1}\} \tag{26}$$

Where $\sigma \equiv (1-\lambda)\Phi\gamma_c\mu_p$; $\Theta_n \equiv \lambda\Phi(1-\alpha)(1+\varphi)$; $\Theta_t \equiv \lambda\Phi\mu_p$, $\Phi \equiv (\gamma_c\mu_p - \lambda(1-\alpha))^{-1}$, $\gamma_c = C/Y = (1-\gamma_g) - \frac{\delta\alpha}{(\rho+\delta)\mu_p}$ is the steady state consumption-output ratio, and $\rho \equiv \frac{1}{\beta} - 1$ is the steady state interest rate.

The imperfect labor market wage setting schedule:

$$w_t = c_t + \varphi n_t \tag{27}$$

Firms.
Dynamics of inflation:

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \lambda_p \hat{\mu}^p_t \tag{28}$$

Where $\lambda_p = (1-\beta\theta)(1-\theta)\theta^{-1}$, and

$$\hat{\mu}_t^p = (y_t - n_t) - w_t \tag{29}$$
$$\hat{\mu}_t^p = (y_t - k_t) - r_t^k \tag{30}$$

Aggregate production function:

$$y_t = (1-\alpha)n_t + \alpha k_t + \alpha_g g_t \tag{31}$$

Market clearing:

$$y_t = \gamma_c c_t + \gamma_i i_t + \gamma_g g_t \tag{32}$$

Fiscal policy.
Government budget constraint and plug in fiscal rule:

$$b_{t+1} = (1+\rho)(1-\phi_b)b_t + (1+\rho)(1-\phi_g)\gamma_g g_t \tag{33}$$

And finally, the exogenous government spending (21).

3.7 Baseline estimation

The choice of parameters is one of the main features of analysis as it must represent economic features and to ensure the stability of the system. My parameters follow the standard literature, and to be more precise, they are chosen from Gali et al.(2007). In the baseline model, I set $\alpha_g = 0$ and $\rho_{g2} = 0$, therefore the estimation should be similar to Gali et al.(2007). Table 2 contains the calibrated parameters, and dynamic effects of a government spending shock are in Figure 4.

Figure 4 has the similar shape and direction of responses for all 6 variables to Gali et al. (2007). My baseline model has the smaller responses since my shock is 1% of steady state government spending, they use 1% of steady state output, about 5 times larger than my shock. The story of Figure 4 is: In an economy that (1) half of the consumers are non-asset holders; (2) government spending offers no help to the marginal productivity of firms; and (3) government spending follows AR(1) process, i.e. after a government spending shock, the responses of output, real wage, and consumption are positive but the private investment is crowded out by government spending financed by issuing debt.

3.8 Sensitivity analysis

After estimating the baseline model, I move to the sensitivity analysis for responses of private investment to different parameters setting. I choose to check the effects of changing parameters by

Table 2: **Calibrated parameters for baseline model:**

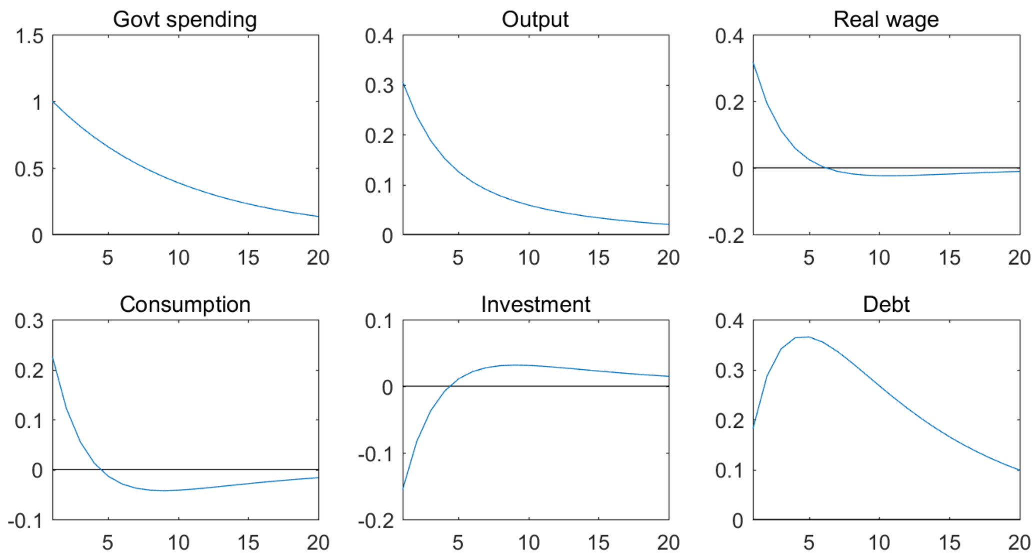
Parameters	Explanation	Value
β	Discount factor	0.99
α	Capital share	1/3
δ	Depreciation rate	0.025
μ^p	SS Markup	1.2
η	Elasticity of investment with respect to q	1
θ	Calvo Price probability	0.75
φ	Elasticity of wages with respect to hours	0.2
γ_g	Share of government spending in GDP	0.2
γ_c	Share of consumption in GDP	0.6
γ_i	Share of investment in GDP	0.2
α_g	Government spending productivity	0
ϕ_π	Taylor rule elasticity of interest rate to inflation	1.5
ϕ_g	Weight on government spending in fiscal rule	0.5
ϕ_b	Debt stabilization motive	0.33
ρ_{g1}	Persistence of government spending	0.9
ρ_{g2}	Persistence of government spending	0
λ	Share of RoT consumer	0.5

changing one at a time. Key parameters concerned are the following, α_g, ϕ_π, ϕ_g, ϕ_b, ρ_g and λ, which are chosen based on Gali et al.(2007).

First subplot of Figure 5 depicts private investment responses to government spending as a function of α_g, the parameter determines the productivity power of government spending. As expected, when it goes up from 0 to 0.5, since the marginal productivity of government spending goes up, the investment responses changes from small negative to large positive. This indicates that α_g can be one of the main determinants for heterogenous private investment behaviors.

Second subplot of Figure 5 depicts private investment responses as a function of monetary policy indicator ϕ_π, the monetary policy parameter. The more active monetary policy is, the more negative private investment response becomes, since the larger ϕ_π will give higher real interest rate under a determined inflation level, and further crowd out private investment. According to equations (23) and (24), basically, investment tends to rise with q_t, and q_t has the negative response to the real interest rate.

Figure 4: The impulse response functions to a government spending shock: Baseline model



NOTES: The X-axis shows quarters, and Y-axis is the impulse responses of each variable

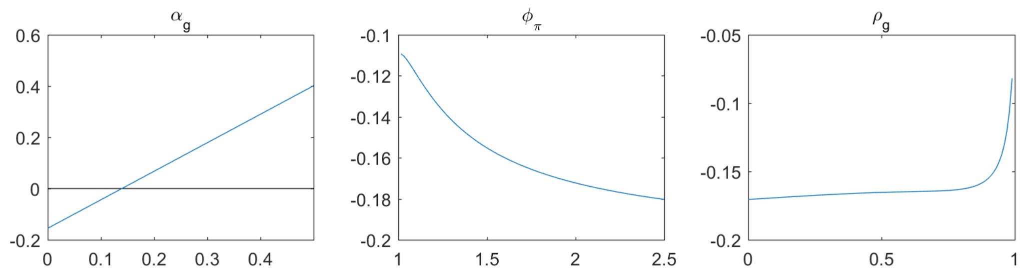
Final subplot of Figure 5 depicts private investment responses as a function of ρ_{g1} that represents the persistency of government spending. The more persistent government spending changes are, the less the government spending crowds out private investment. The permanent changes (extreme case if $\rho_{g1} = 1$) in government purchases may focus on increasing the steady state growth, therefore it might have less crowding out effects on private investment than temporary changes of government spending.

Fiscal policy parameters ϕ_g and ϕ_b do not show significant different effects (always negative and change is relatively small) on responses of private investment in baseline model. [12] So does λ. [13] I still allow flexibility of these three parameters and estimate them when matching the empirical impulse response to model impulse responses, since previous literature show that these three parameters should not be the same between the two subsamples.

[12] ϕ_g and ϕ_b are the fiscal policy indicators. According to equations (20) and (33), higher ϕ_g means that the government spending is more financed by tax than by debt. We know that tax may cause negative wealth effect, while debt may induce higher real interest rate, and both of them can lead to negative effects on private investment. However, in the baseline model the negative private investment responses tend to be smaller, when responses of tax to current government spending (higher ϕ_g) is larger, it indicates that tax may have less crowding out effects on private investment than debt. Within the range of ϕ_b, the investment responses do not change much, smaller than 0.02, which indicates that it does affect the private investment responses, but not much in the baseline model.

[13] $\alpha_g = 0$, when λ increases, it will lead to larger negative investment responses (When α_g creates the positive investment responses, then if λ increases, it will have smaller positive investment responses).

Figure 5: The private investment impact responses as a function of α_g, ϕ_π and ρ_g



NOTES: Impact responses of private investment: Sensitivity to key parameters (α_g, ϕ_π and ρ_g). The X-axis shows values of each parameter and Y-axis is for the impact responses corresponding to different values of parameters.

4 MATCHING AND ESTIMATION

In this section, I match the empirical and theoretical impulse responses in order to obtain estimates for all the aforementioned key parameters of the model for different subsamples.

4.1 Estimation strategy

Rotemberg and Woodford (1997) were the first to use the minimum distance technique. And several previous literature applied this approach, e.g. Christiano et al. (2005) and Bilbiie et al (2008) to matching empirical and theoretical impulse response.

Obtain an estimation for the vector of interested parameters Θ, by minimizing the weighted distance between empirical and theoretical impulse response functions, i.e. Ψ^e and $\Psi^t = \Psi(\Theta)$:

$$\hat{\Theta} = argmin(\Psi^e - \Psi(\Theta))'W(\Psi^e - \Psi(\Theta))$$

Where the weighting matrix W is a diagonal matrix with the reciprocal values of sample variances of the empirical impulse responses along the diagonal, in order to give greater weight to impulse responses that are more precisely estimated in VARs. Same as Bilbiie et al (2008), I include all 6 variables with 16 periods responses, since all the responses after 4 years are not significant in VARs. And Θ contains α_g, ϕ_π, ϕ_g, ϕ_b, ρ_{g1}, ρ_{g2}, and λ.

4.2 Estimation results

Table 3 reports the information of point estimated parameters for different subsamples. First, α_g in S1 is much larger than S2. [14] The large government spending productivity in S1 is consistent with the previous literature, and Aschauer (1989a) found nonmilitary public capital productivity is 0.38 to 0.56 (military capital has an insignificant relationship to private productivity), by using 1949 to 1985 annual data. Although there is a lack of previous literature estimation results for S2 to compare with, in another working paper for my research, I estimate the public capital productivity for the post-1980 period and find empirical evidence that this period has insignificant negative productivity. The component changes of the government spending might also partially explain the results that the aggregate government spending productivity shrinks after 1983: The government investment-GDP ratio shrinks from 6% to 4%; the structure and equipment expenditure which is considered to be productive components takes 20% (peak at 25%) on average of total government spending before 1980, and after 1983 this number shrinks to 15%. Intuitively the government investment, especially investment in the structure and equipment are productive parts of government spending, thus the decrease of these components may lead to diminished productivity of aggregate government spending.

Table 3: **Estimated model parameters**

	α_g	ϕ_π	ϕ_g	ϕ_b	ρ_{g1}	ρ_{g2}	λ
S1 : 1947-1979	0.3835	1.1044	1.7999	0.9645	1.1814	-0.2509	0.5000
S2 : 1983-2008	0.0010	1.7877	0.1755	0.1049	0.6554	0.1409	0.4000

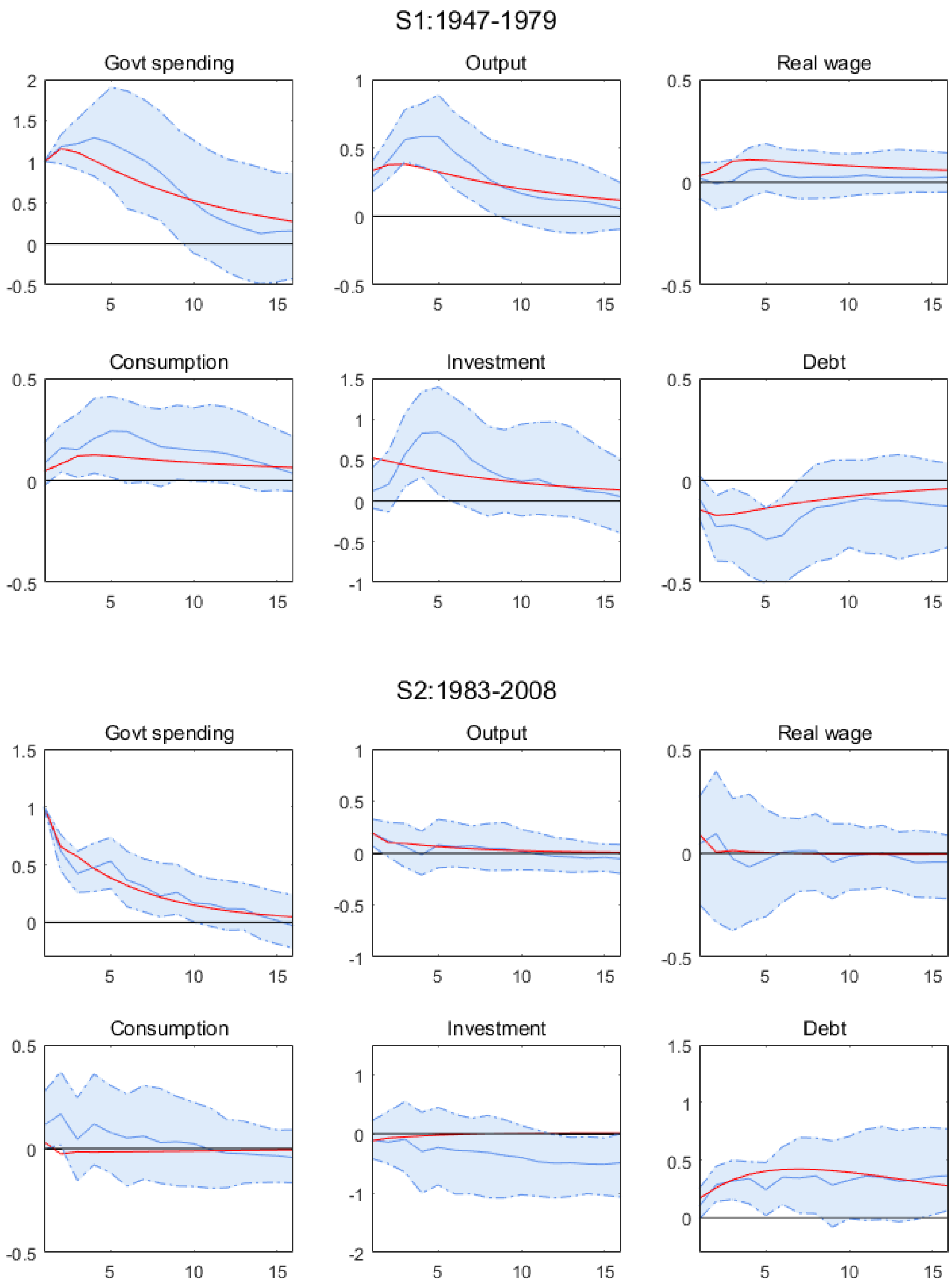
Second, ϕ_π is larger in S1 and smaller in S2, which is consistent with Bilbiie et al. (2008) and the economic history: Passive monetary policy in the pre-1980s and active monetary policy in the post-1980s.

Third, from equation (33) ϕ_g can reflect the debt response to the current government spending deviation. The VAR results in S1 show that debt has the negative response to government spending shock, so $1 - \phi_g$ should be very negative in S1 because $1 + \rho$ is positive, thus $\phi_g > 1$ in pre-1980s makes sense. ϕ_b in S1 is 0.96, it means that in this period, the future debt does not respond to the current debt deviation much. And large ϕ_g and ϕ_b means that tax responds significantly (positive) to the government spending and debt deviation. There are lack of previous literature to compare these two parameters precisely, but these characteristics of tax and debt all can be reflected by impulse response functions from data [15]. ϕ_g and ϕ_b in second sample should be smaller than 1, and the value is similar to the Gali et al. (2007) using 1960-2003 sample (overlapping 20 years as S2).

[14] Although negative α_g can provide a better matching for S2, I restrict α_g to be non-negative when matching since negative government spending productivity has not clear economic meaning.

[15] Perroti (2005): Tax response positive in pre-1980s and negative in post-1980s.

Figure 6: Matching results



NOTES: Figure 6 shows the matching results for the two samples. the blue line is the VAR impulse responses and the red line is DSGE responses, and the dash line shows the 90% confidence interval for empirical impulse responses. The blue shadowed areas represent the 90% confidence band for estimated VAR responses.

Finally, estimates of ρ_g show that the S1 has longer persistence than S2, also consistent with Bilbiie et al. (2008) and Perroti (2005). λ is larger in S1 than in S2, and have the similar estimation as in Bilbiie et al. (2008), but a higher level in S2 than their results.

Figure 6 plots the matching results for the two samples. the blue line is the VAR impulse responses and the red line is DSGE responses, and the dashed line shows the 90% confidence interval for empirical impulse responses. The blue shadowed areas represent the 90% confidence band for estimated VAR responses. Basically, the matched DSGE responses can be nested in the 90% confidence band of VAR responses. Although the private investment in S2 has the huge negative responses in the long run which are difficult to match well, the estimates for S2 have a perfect match for impact negative response.

The matching estimation of key parameters indicates that changes of transmission of fiscal policy on the economy might come from the lower public capital productivity (α_g), more active monetary policy(ϕ_π), different fiscal financing decision reflected by fiscal policy (ϕ_b and ϕ_g), different degrees of persistency of government spending (ρ_{g1} and ρ_{g2}) and higher asset market participation rate(λ). Among these factors, the final mission of this paper is to identify which are the main causes of the heterogenous government spending effects on private investment, given all these different parameters between the two samples.

5 COUNTERFACTUAL ANALYSIS

Based on the theoretical model, my study fulfills a counterfactual experiment which allows to identify the main factors that can explain the heterogenous effects of government spending on investment. Similar to Bibiie et al. (2008) and Boivin and Giannoni (2006), I explore the possible causes for changes in investment responses to government spending across two samples from investigating different estimated parameters – while keeping the deep parameters and basic model structure unchanged across samples, I focus on specific changes in each (or each pair of) estimated parameters.

Specifically, to quantify the differences in fiscal transmission across samples, I firstly compute the sum of squared distances between original model-based S1 and S2 responses for each of the variables, by

$$\Delta_{variable} = (\Psi_{variable}(\hat{\theta}_2) - \Psi_{variable}(\hat{\theta}_1))'(\Psi_{variable}(\hat{\theta}_2) - \Psi_{variable}(\hat{\theta}_1))$$

where $\Psi_{variable}(.)$ is the impulse response function for each variable, including: Government spending, output, real wage, consumption, private investment and debt.

Secondly, I vary one (or one pair of) parameter at a time from its estimated S2 value to S1 value while leaving all other parameters unchanged, and compute the new distances between impulse responses from counterfactual S2 and original model-based S1 as the counterfactual experiment results. Finally compared to the original distances, if the computed counterfactual distance of investment responses gets smaller, then the varied specific parameter must be one of the important reasons that lead to the heterogeneity of private investment behavior across time. This procedure of analysis also applies to responses from other variables to government spending shocks.

Table 4: Counterfactual experiment results on differences between S1 and S2

$(\hat{S}2 - \hat{S}1)^2$	Govt spending	Output	Investment
$\Delta_{variable}$	3.1870	0.8390	2.0198
$\Delta_{variable}(\alpha_g)$	3.1870	0.3567	0.6879
$\Delta_{variable}(\rho_g)$	0.0000	0.9929	0.6222
$\Delta_{variable}(\phi_g, \phi_b)$	3.1870	0.9910	1.7885
$\Delta_{variable}(\phi_\pi)$	3.1870	0.6955	1.8308
$\Delta_{variable}(\lambda)$	3.1870	0.8102	2.1510

NOTES: Differences are computed based on the sum of squared distances equation for 16 quarters after the shock. Counterfactual distance measures comparisons between S1 impulse responses and those obtained for a counterfactual "S2" where one parameter is set at its S1 estimate while the other parameters are kept at their S2 estimates. Except for ρ_g, I report the distance between counterfactual S1 and original S2.

Results for counterfactual analysis are listed in Table 4. Each column provides the distance measures for each variable. The first row shows $\Delta_{variable}$ computed as distances between original model responses at S1 and S2. The second row shows $\Delta_{variable}(\alpha_g)$, which measures the new distances between constructed counterfactual S2 and original S1. The counterfactual distance is calculated when α_g in S2 (0.0010) is replaced by its value in S1 (0.3835), maintaining all other parameters the same in S2. This analysis quantifies the effects of a huge counterfactual increase in government spending productivity in the later sample. The main focus should be on the third column about distances of investment responses between two samples: Originally, the squared difference of model responses at S1 and S2 is 2.0198 for investment; when government spending productivity in S1 changes to be as low as S2, the squared difference shrinks to only 0.6879. And this number can drop to 0.11 when I calculate the distance between counterfactual S1 and original S2. [16] Hence, the shrinking distances strongly recommend that the productivity of government spending must be one of the critical factors that can explain differences in private investment responses across two samples, regardless of other economic conditions. In the meantime, α_g can also account for the differences of output because the distances decrease when replacing α_g. The Simple story here could be: The crowding in effects of government spending on GDP and private investment from government spending productivity is vanishing as time goes by, because govern-

[16]The counterfactual S1 is calculated when α_g in S1 is replaced by its value in S2, maintaining all other parameters the same in S1.

ment spending productivity diminishes over time.

Counterfactual results regarding the persistency of fiscal policy is in the third row of Table 4. It shows that the distances of investment reduce from 2.0198 to 0.6222. It indicates that the different persistency of fiscal policy can also explain the heterogeneous investment responses. However, I need to mention that for counterfactual experiment regarding ρ_g, I report the distance between counterfactual S1 and original S2. Remember that in the post-1980 period, government spending tends to be financed by debt. Thus, the more persistent government spending might lead to higher debt, and more debt can higher the interest rate, in the end, crowds out more investment. As a result, under the debt financing implementation policy in post-1980, the higher persistency of fiscal policy may cause more negative effects on investment to stretch the distance. [17] To avoid these complex effects on investment not only through variation of ρ_g but also from ϕ_g and ϕ_b, for ρ_g counterfactual analysis, I change its S1 value to S2 and obtained the counterfactual S1, and compare the differences between this counterfactual S1 and original S2.

The fourth and fifth row, representing the counterfactual changes in financing decision of fiscal policy and the monetary policy ϕ_π respectively, shows that these two factors also partially explain the heterogeneous investment responses from the reduced value of computed distances. Moreover, it is worth mentioning that when I change monetary policy (ϕ_π) and fiscal financing policy (ϕ_g and ϕ_b) together into their S1 value, distances of investment responses fall to 1.7362, slightly smaller than only replacing fiscal financing policy. It indicates that the combination of budgetary financing and monetary policy has a relatively more explanatory power about heterogenous investment responses than each.

In short, the counterfactual analysis results suggest that changes in government spending productivity account for most of the heterogeneity of private investment responses across time. Meanwhile, the different persistence and financing methods of fiscal spending are other two primary factors that determine the heterogeneous effects. The changed monetary policies can justify the existing heterogeneity as well.

6 CONCLUSIONS

In this article, I discover the heterogeneity of government spending effects on private investment across time. By using SVAR model, I investigate effects in two different periods, pre-1980s with 1947Q1-1949Q2 and post-1980s with 1983Q1-2008Q4: In the pre-1980s, when the government spends more money, the private sector invests more as responses; whereas, in the post-1980s, gov-

[17]For ρ_g, when I calculate the spread between counterfactual S2 and original S1, I obtain a slightly higher number for investment (2.3909) and a much higher differences for debt (changes from 3.5894 for original distance to 12.8218). These numbers verify that the persistency of fiscal policy could help to explain the heterogeneous effects on investment, but it might depend on the financing method of government spending.

ernment spending significantly retards private investment.

Furthermore, by matching impulse response functions from SVARs to those from a DSGE model for both two subsamples, I obtain the key parameters that may explain the differences of government spending effects on investment between these two subsamples. The parameter estimation results suggest that compared to the early sample, the later sample has lower public capital productivity, a more active monetary policy, less persistent government spending, a different financing decision of fiscal policy, and a higher asset market participation rate. All these might account for the fact that government spending crowds out private investment in the later sample. Finally, within the framework of the model, I carry out a counterfactual analysis which, to some extent, decomposes the effects of these factors across two subsamples. This counterfactual experiment enables us to understand each of their roles in government spending transmission mechanism to private investment behavior. The counterfactual analysis results suggest that changes in government spending productivity account for most of the heterogeneous effects of government spending on private investment across time. Meanwhile, the different persistence and financing methods in fiscal expenditures together with monetary policy, to some extent, also can explain the existing heterogeneity.

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