Government Spending Multipliers: The Size of the Fiscal Shock Matters

Mustofa Mahmud Al Mamun[1]

Fordham University

Abstract

Do all types of government spending generate similar multiplier effects? A standard non-linear DSGE model predicts that both government consumption and government investment multipliers are much smaller than one in the short run. I test those predictions on US data using Structural Vector Auto Regression (SVAR) and Local Projections (LP) methods. In order to estimate multipliers accurately, I isolate unanticipated changes in government spending. For transitory spending shocks, I find that the government investment multiplier is larger than one in the short run, and the government consumption multiplier is near zero. I explore a few possible reasons for this difference. First, private investment gets crowded out substantially after a government consumption shock but not after a government investment shock. Second, linear and symmetric regression methods fail to capture the non-linear and asymmetric effects of consumption shocks, leading to an underestimation of the consumption multiplier. I also find evidence that additional spending by state and local governments is more effective in raising output than that by the federal government. This finding is related to the non-linear effects of consumption shocks.

Keywords: multiplier, crowding-out, non-linear effect
JEL Classification: C50, E62, H54

1 Introduction

Although government spending is one of the main components of Gross Domestic Product (GDP), the impact of various types of government spending on the economy is not yet well understood. Government spending can be separated into different categories, such as consumption vs. investment or federal vs. state. It is important for policymakers to know which part of government spending is more effective in increasing output. The government spending multiplier measures the direct and indirect effects of government spending on GDP, estimating how much GDP will increase for each additional dollar spent by the government. Though the aggregate government spending multiplier has been studied extensively, less attention has been given to disaggregated multipliers and their interconnections.

This study presents empirical evidence using US data that the government consumption multiplier is close to zero in the short run, while the government investment multiplier is larger than one. The paper contributes to the research on government spending multipliers by

[1]Ph.D. Candidate, Economics Department, Fordham University, 441 E Fordham Rd, New York, NY 10458. Email: mmamun@fordham.edu

offering a new explanation that clarifies the difference between consumption and investment multipliers. First, private investment gets crowded out substantially after a government consumption shock but not after a government investment shock. Second, linear and symmetric regression methods fail to capture the non-linear and asymmetric effects of consumption shocks, leading to an underestimation of the consumption multiplier. I also find evidence that additional spending by state and local governments is more effective in raising output than that by the federal government. This finding is related to the non-linear effects of consumption shocks. The effects from consumption shocks are not linearly scaleable; larger consumption shocks produce stronger multiplier effects. To my knowledge, this study is the first to use a VAR-based approach to document the non-linear effects of consumption shocks. State and local spending shocks have a much larger consumption component on average, which is why they produce a stronger multiplier effect than federal spending shocks.

Most studies on the stimulus effect of government spending measured multipliers for aggregate government spending (e.g., Ramey and Zubairy 2018; Ramey and Shapiro 1998; Blanchard and Perotti 2002;). The few studies that estimated separate multipliers used smaller US data or did not control the forecasted government spending (e.g., Perotti 2004; Ilzetzki et al. 2013; Boehm 2020). Auerbach and Gorodnichenko (2012) used the US data from 1947 to 2008 to estimate separate multipliers for government consumption and investment but did not add private consumption and private investment in their model. So, it is difficult to explain how government spending affects private activity. Brinca et al. (2019) investigated the non-linear effects of fiscal shocks using a heterogeneous agents model with labor income tax. My work differs from theirs in several ways. First, I show that a simple representative agent DSGE framework with a lump-sum tax can produce non-linear effects. Second, their empirical evidence is solely based on negative fiscal shocks from a narrative approach. Instead, I employed a VAR-based approach to tease out the exogenous component of the shocks and categorize them into different sizes and signs. Third, their regression model is missing several key macro variables.

A standard non-linear DSGE model provides insights regarding the multiplier effects for additional government consumption and investment spending. The model predicts that government consumption and investment multipliers are much smaller than one in the short run. I use the quarterly US data from 1966 to 2020 and the traditional SVAR framework to test those predictions. I also use the Local Projections (LP) method to check if the estimates differ. In order to estimate multipliers accurately, I isolate unanticipated changes in government spending. The empirical framework includes the fiscal variables, private consumption, investment, and GDP. The identification order follows the Blanchard and Perotti (2002) scheme that fiscal variables do not respond to macro variables within the same quarter. The model controls for relevant exogenous variables (e.g., export, import, federal funds rate, Consumer Price Index (CPI), debt, and forecasted government spending). I include the level of public debt because fiscal variables respond to the level of public debt (Favero and Giavazzi 2007).

I find the investment multiplier is larger than one in the short run, and the consumption multiplier is near zero. The main reason for the small consumption multiplier is that an increase in government consumption spending raises the real interest rate in the economy and crowds out private activity. Private consumption has a lower inter-temporal elasticity of substitution than private investment. Therefore, consumption reduces less, and investment reduces more to smooth consumption over time (Aiyagari, Christiano, and Eichenbaum 1992). Boehm (2020) argues that private investment gets crowded out after a government investment shock but not after a government consumption shock. If this were true, a government investment shock should generate an enormous crowding-out effect on private investment to be consistent with other empirical studies on US data.[2] Other reasons for the small consumption multiplier are related to the non-linear and asymmetric effects of consumption shocks. A larger increase in consumption spending produces larger multiplier effects. If most shocks are small, the average multiplier effect will fall. Also, the largest negative consumption shocks do not reduce output. It has a further diminishing effect on the average multiplier. For instance, if a negative shock reduces GDP less than a positive shock adds to the GDP, the linear regression method will underestimate the positive multiplier effect. On the other hand, a government investment shock can affect GDP directly via public capital stock and indirectly via private investment. I do not find strong evidence of a crowding-out effect on private investment after a government investment shock. My findings align more with the results of Auerbach and Gorodnichenko (2012) but oppose Boehm's (2020). The reason for such a difference may be related to using different data sources.[3]

In the short run, I find that the state and local spending multiplier is greater than one, whereas the federal defense and non-defense spending multipliers are less than one. Without the non-linear effect, it is difficult to explain this result because the consumption-to-investment ratio is relatively high for state and local spending. While small consumption shocks do not affect output, larger ones can produce a multiplier effect that exceeds one. Since state and local spending shocks have a much larger consumption component on average, it explains why they produce a stronger multiplier effect than federal spending shocks. Auerbach and Gorodnichenko (2012) found a smaller estimate for state and local spending multiplier, likely because they combined state and local spending with federal non-defense spending as total non-defense spending. Despite having a stronger multiplier effect, state and local spending in real terms has not grown since 2000, while federal spending has increased following its pre-2000 trends. It is possible that a change in the composition of government spending in recent decades may have contributed to the slowdown of the US economy.

The next section describes a benchmark DSGE model, which provides a set of theoretical predictions. I test those predictions on US data using macro-econometric methods. Section 3 details the data, and section 4 describes the empirical methods. Section 5 discusses the results, and Section 6 concludes.

[2] Investment comprises only a tiny fraction of total government spending. If an aggregate spending shock crowds out private investment one for one, a government investment shock should crowd out at least four for one. However, such a large crowding-out effect is not observed in the literature after an investment shock (e.g., Boehm 2020; Perotti 2004).

[3] Boehm used OECD data that includes 38 advanced economies while this study used only US data.

2 Theoretical Analysis

This section presents a standard DSGE framework to study the effects of additional government consumption and investment spending. The model provides a number of predictions regarding the size of consumption and investment multipliers. Following Ramey (2020), Boehm (2020), and others, government consumption adds to the utility function in a separable manner, and government investment goes into the production function. I present the baseline model assuming that public capital stock depreciates fully in each period, and a shock in public investment directly translates into a shock in public capital stock in the same period.[4]

2.1 Household

A representative household seeks to maximize lifetime utility subject to its budget constraint. The utility function depends on private consumption, labor choice, and government consumption so that marginal utility from each component will not depend on other components. The present value of a household's lifetime utility is,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(c_t)^{1-\sigma}}{1-\sigma} + \chi \frac{(g_t^c)^{1-\sigma}}{1-\sigma} + \gamma ln(l_t) \right] \tag{1}$$

subject to the budget constraint,

$$a_{t+1} + c_t + t_t = w_t n_t + \pi_t + (1 + r_t) a_t \tag{2}$$

where c_t, g_t^c, and l_t are private consumption, government consumption, and leisure choice by the household. t_t is a lump-sum tax imposed on the household to finance government spending g_t, π_t is the dividend the household receives from the firm, $\frac{1}{\sigma}$ represents the intertemporal elasticity of substitution and γ is the leisure share parameter.

2.2 Firms

The firms maximize their profits. The present value of a firm's profit is given by,

$$E_0 \sum_{t=0}^{\infty} \left[\frac{1}{1+r_t} \right]^t \Pi_t = E_0 \sum_{t=0}^{\infty} \left[\frac{1}{1+r_t} \right]^t [y_t - w_t n_t - i_t - (1 + r_t) b_t + b_{t+1}] \tag{3}$$

The production function depends on labor, private and public capital stock,

$$y_t = (k_t^g)^{\alpha_g} (k_t)^{\alpha} (n_t)^{1-\alpha} \tag{4}$$

Private capital accumulates following the motion,

$$k_{t+1} = (1 - \delta) k_t + i_t \tag{5}$$

[4] I carefully look at the results using a conventional setup where public capital stock builds up slowly. In this regard, I experiment with different depreciation rates and elasticity parameters for the public capital stock.

α and α_g are elasticities for the private and public capital stock, respectively. If $\alpha_g = 0$, the public capital stock does not affect output, and the production function follows constant returns to scale (CRS). If $\alpha_g > 0$, then the public capital stock positively affects output and production function following increasing returns to scale (IRS). Also, n_t and w_t denote labor hours and wage rate, respectively. Firm debt b_t is owned by the household so that $b_t = a_t$. The firm has to pay interest r_t on its debt b_t in each period. k_t is given before the beginning of each period.

2.3 Government

Total government spending, $g_t = g_t^c + g_t^i$ is financed by a lump-sum tax imposed on the household so that $g_t = t_t$.[5] In this setup, public investment fully depreciates in each period ($\delta^g = 1$), and there is no accumulation of public capital stock. Therefore, a shock in public investment directly translates as a shock to the public capital stock.[6]

$$k_t^g = (1 - \delta^g) k_{t-1}^g + g_t^i \tag{6}$$

2.4 First Order Conditions

Euler equation,

$$E_t \left[\frac{c_{t+1}}{c_t} \right]^\sigma = \beta E_t (1 + r_{t+1}) \tag{7}$$

Labor Supply,

$$n_t = 1 - \frac{\gamma c_t^\sigma}{w_t} \tag{8}$$

Wage Rate,

$$w_t = \left(\frac{k_t}{n_t} \right)^\alpha (1 - \alpha) \left(k_t^g \right)^{\alpha_g} \tag{9}$$

The real rate of returns,

$$r_t = \left(k_t^g \right)^{\alpha_g} \alpha (k_t)^{\alpha - 1} (n_t)^{1 - \alpha} - \delta \tag{10}$$

2.5 Goods Market

Aggregate Demand,

$$y_t = c_t + i_t + g_t^c + g_t^i \tag{11}$$

Aggregate Supply,

$$y_t = \left(k_t^g \right)^{\alpha_g} (k_t)^\alpha (n_t)^{1 - \alpha} \tag{12}$$

[5] A permanent increase in government spending must be financed by a higher tax to be sustainable. However, a temporary increase in spending can be financed by public debt, given $E(\epsilon_t) = 0$. In that case, government budget constraint will be, $g_t = t_t + b_{t+1}^g - (1 + r_t) b_t^g$

[6] In an alternative attempt, public capital stock is kept fixed at $\bar{k}$. Public capital stock, $k_t^g = \bar{k} + (1 - \delta^g) k_{t-1}^g + g_t^i$ where $\bar{k}$ is set equal to 73 percent of GDP (BEA 2018). Traditionally, public capital stock accumulates following the motion, $k_{t+1}^g = (1 - \delta^g) k_t^g + g_t^i$ and the capital depreciation rate is less than or equal to 0.1. I also look at those cases, but they do not seem to produce a strong multiplier effect in the short run. More details are in the results section.

2.6 Shocks

Government spending follows AR(1) processes in logarithms,

$$ln(g_t^c) = (1-\phi)ln(s_{gc} \times y^*) + \phi ln(g_{t-1}^c) + \epsilon_t \tag{13}$$

$$ln(g_t^i) = (1-\phi)ln(s_{gi} \times y^*) + \phi ln(g_{t-1}^i) + \epsilon_t \tag{14}$$

2.7 Model Calibration

Baseline parameter values $\beta = 0.98$, $\alpha = \frac{1}{3}$, $\delta = 0.02$, $\sigma = 4$, $\alpha_g = 0.05$, $\phi = 0.75$, and $\gamma = 25$. γ shows the dis-utility from work and is adjusted so that the household's average working hours is approximately 1/3 of available time. s_{gc} and s_{gi} are set at 0.18 and 0.04, respectively, to be consistent with the data. α_g, δ_g, and ϕ are important parameters, and changing their values can affect results. I will discuss more in the results section.

Parameter	Value	Comments
β	0.98	Standard
δ	0.02	Standard
δ_g	1	
σ	4	Boehm (2020)
α	0.33	Boehm (2020)
ϕ	0.75	Data
s_{gc}	0.18	Data
s_{gi}	0.04	Data
A_t	1	Standard

Table 1: Moments targeted: Annual interest rate 4 percent, private capital depreciation rate 4 percent, public capital depreciation rate 100 percent, capital share of income 33 percent, average labor supply 40 hours per week, persistence parameter 0.75

2.8 Model Results

2.8.1 Stationary Output

Baseline results for steady-state and policy matrices are shown in Table 2 and Table 3, respectively. Table 2 shows that government consumption and investment are approximately 18 and 4 percent of GDP, respectively. Households work 40 hours a week, and the annual interest rate is 4 percent. Private consumption and investment represent approximately 62 and 16 percent of GDP, respectively. Table 3 shows a one percent increase in government consumption spending raises labor hours worked by 0.076 percent and output by 0.051 percent. Similarly, a one percent increase in government investment spending lifts the labor hours by 0.055 percent and output by 0.087 percent.

		Coefficient
k	Capital Stock	5.98
g_t^c	Government Consumption	0.13
g_t^i	Government Investment	0.03
r	Real Interest Rate	0.02
n	Labor Hours	0.33
w	Wage Rate	1.47
i	Private Investment	0.12
c	Private Consumption	0.45
y	Output	0.72

Table 2: The stationary equilibrium using the baseline parameters.

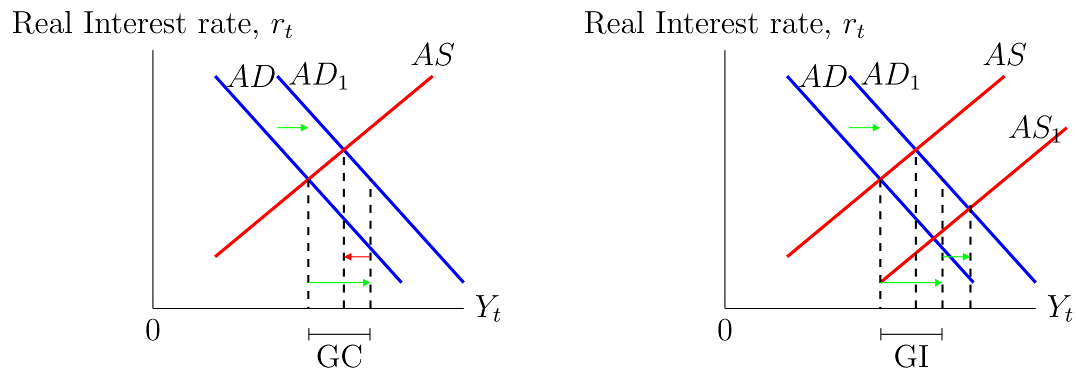
	Government Consumption (g_t^c)	Government Investment (g_t^i)
Real Interest Rate (r)	.101	.172
Labor Hours (n)	.076	.055
Wage Rate (w)	-.025	.032
Private Investment (i)	-.725	.278
Private Consumption (c)	-.016	.001
Output (y)	.051	.087

Table 3: The percentage deviation of each variable from the steady state in response to a one percent increase in shock variables: g_t^c and g_t^i

2.8.2 AD-AS Analysis

Government consumption and investment multipliers can differ substantially from each other in a simple AD-AS framework. Figure 1a shows that a positive government consumption shock increases aggregate demand and real interest rate. Since additional government consumption spending does not add to the production function, it does not affect the aggregate supply. As a result, private activity gets crowded out, and the multiplier effect should be smaller than one.[7] A positive government investment shock adds to the aggregate demand

[7]Since consumption has low inter-temporal substitution, it reduces less, and investment reduces more to smooth consumption over time (See in the Appendix for details A.3).



(a) A government consumption (GC) shock (b) A government investment (GI) shock

Figure 1: Effects of a GC shock and a GI shock

and raises the real interest rate in the economy (Figure 1b). In the long run, it can potentially boost productivity, lower the cost of production, and shift aggregate supply to the right. The combined effect may bring down the real interest rate in the economy and crowds in private activity. Therefore, the multiplier effect can be larger than one in the long run.

2.8.3 Impulse Response Functions (IRFs)

Figure 2 shows the effects of a one-dollar increase in government consumption and investment spending. Both shocks are transitory, and Figure 2c and 2d show the persistence of the shock variables. A one-dollar increase in government consumption adds 30 cents at impact, and a similar increase in government investment contributes 2 dollars at impact. As the shock variables dissipate, their effects on GDP also gradually fall (Figure 2e and 2f). The dynamic multiplier for government consumption is less than one, and government investment is around 2 (Figure 2a and 2b). The difference between these two shock variables is reflected in their effects on private investment. Private investment falls after an increase in public consumption and rises after an increase in government investment (Figure 2i and 2j). As a result, private capital stock falls and rises after increases in government consumption and government investment, respectively (Figure 2o and 2p). These changes in capital stock influence the output responses for both shocks.

Since additional taxes must finance additional government spending, increases in government consumption or investment spending raise the household tax burden. Due to the negative wealth effects, household increases labor supply to replace their lost income (Figure 2k and 2l). With an increased labor supply, real wage drops after a consumption shock (Figure 2m). Since a positive investment shock boosts labor productivity, real wage increases after an investment shock (Figure 2n). A positive public investment shock has a direct positive effect on output. It also has an indirect positive effect on output via private investment. A public investment shock elevates the real returns for private capital, which crowds in private investment and elevates the level of private capital stock (Figure 2r 2j 2p).

In a more conventional setup, where public capital builds up slowly, the investment multiplier in the short run is substantially small but grows larger later. I include the results from a version of the traditional setup with a standard depreciation rate, $\delta_g = 0.1$ (See Appendix Figure A.6). Though a change in the persistence parameter can narrow the gap between short- and long-term investment multipliers, the gap remains substantial. In this framework, private investment falls immediately after the public investment shock due to the consumption smoothing effect and the private capital stock dwindling. On the other hand, the public capital stock does not grow immediately after the investment shock but slowly accumulates with time. Therefore, its direct and indirect positive effects on output start to materialize slowly over time. The indirect effect of a public investment shock takes place via private investment. Since a higher public capital stock raises the returns to capital, private investment picks up. However, due to the slow build-up of public capital stock, this process does not take place fast enough to offset the initial drop in private investment. As a result, the gap between the short-run and long-run investment multipliers remains substantial (Appendix Figure A.7).

I calibrated the results using different depreciation rates for public capital stock to find a large investment multiplier in the short run. If the depreciation rate equals or exceeds the persistence parameter in the benchmark model, public capital stock reaches its peak quickly. Instead of slowly building up to its peak, it reaches the peak as soon as the second quarter, which gives a quick boost to returns to capital. Consequently, private investment, followed by private capital stock, increases quickly in the second quarter. As a result, the output may get a quick boost, and the multiplier effect can exceed one in the short run (See Appendix Figure A.4). However, it is difficult to argue for a high depreciation rate ($\delta_g = 0.75$) for average public capital stock. Even with such a high depreciation rate in the traditional setup, the economy does not get the boost on impact since an investment by the government does not add to the capital stock before the next period. Suppose a public investment shock does not affect the production technology in the same period or behaves like a technology shock. In that case, it is not easy to generate a strong effect on output in the short run. Ramey (2020) says, "Both public and private capital are relatively fixed in the short run, so if government spending does not affect total factor productivity (TFP) (A_t) in the short run, government spending can raise GDP in the short run only to the extent that it raises labor input." To explore a theoretical possibility for a strong investment multiplier in the short run, in my baseline model calibration, I assume that public investment adds to the capital stock in each period and fully depreciates before the next period. Given the setup, public investment in each period can be taken as maintenance costs for public infrastructures.[8] Therefore, an unanticipated rise in maintenance spending directly affects the production function in the same period. A shock to the government investment decision directly translates as a shock to the production function. As the shock slowly dissipates, the effect on output gradually declines. Empirical evidence that I find matches more closely with this type of framework.[9]

[8] In the case of public investment in intellectual properties, e.g., software, it can be taken as the subscription cost for software.

[9] In an alternative attempt, public capital stock is kept fixed at $\bar{k}$ where $\bar{k}$ is set equal to 73 percent of GDP (BEA 2018). The public investment adds to the capital stock in the same period and fully depreciates before the next period ($\delta^g = 1$). Therefore, $k_t^g = \bar{k} + (1-\delta^g)k_{t-1}^g + g_t^i$ and $k_t^g = (0.73 \times y^*) + g_t^i$. The baseline

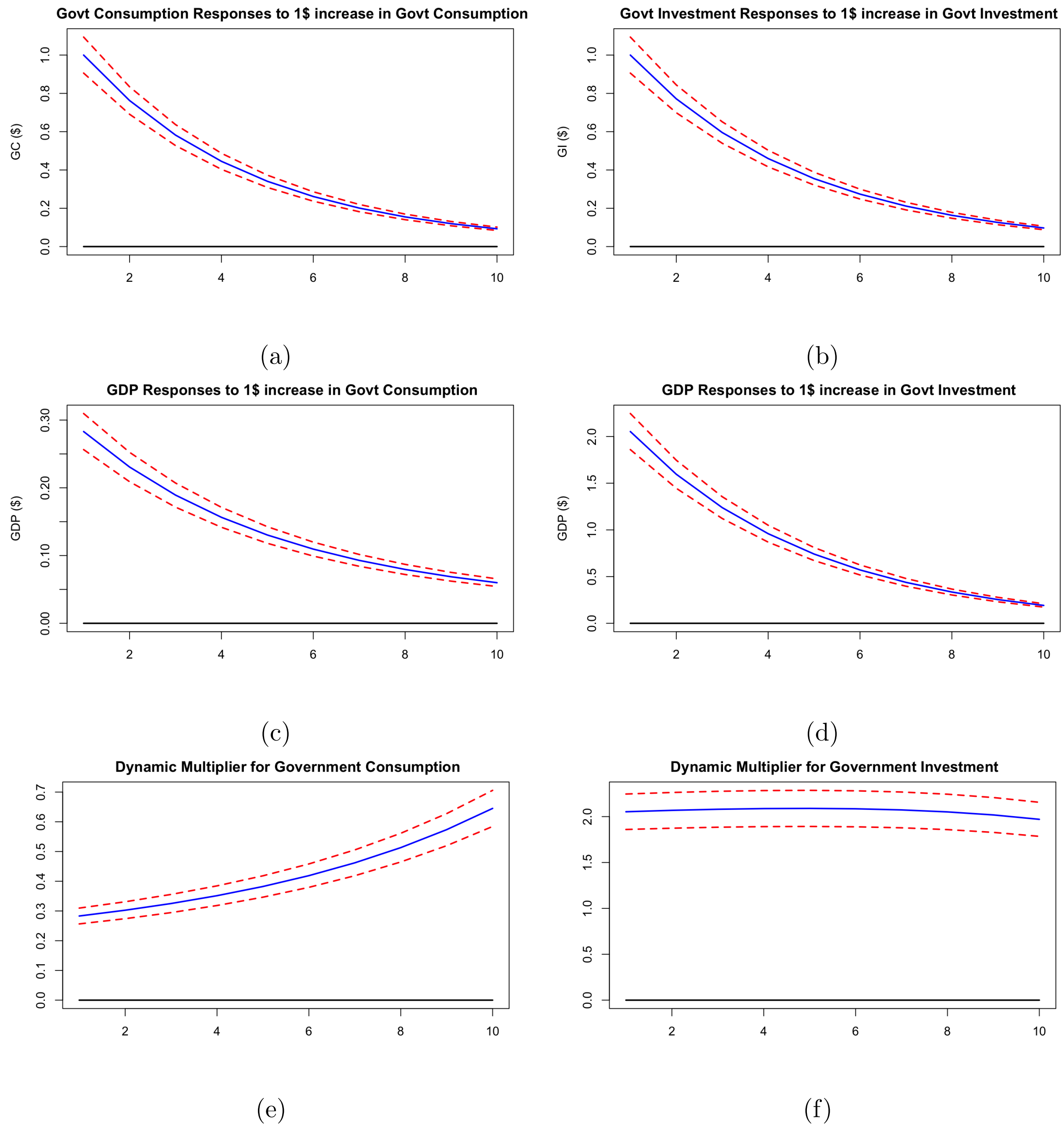


Figure 2: IRFs from the benchmark model with 90 percent confidence intervals ($\phi = 0.75$)

elasticity parameter for public capital stock ($\alpha_g = 0.05$) produces an investment multiplier on the impact of 0.48 before falling gradually. The elasticity parameter for public capital (α_g) needs to be greater than 0.2 to produce a multiplier effect larger than one though the more commonly accepted value in the literature is between 0.05 and 0.1.

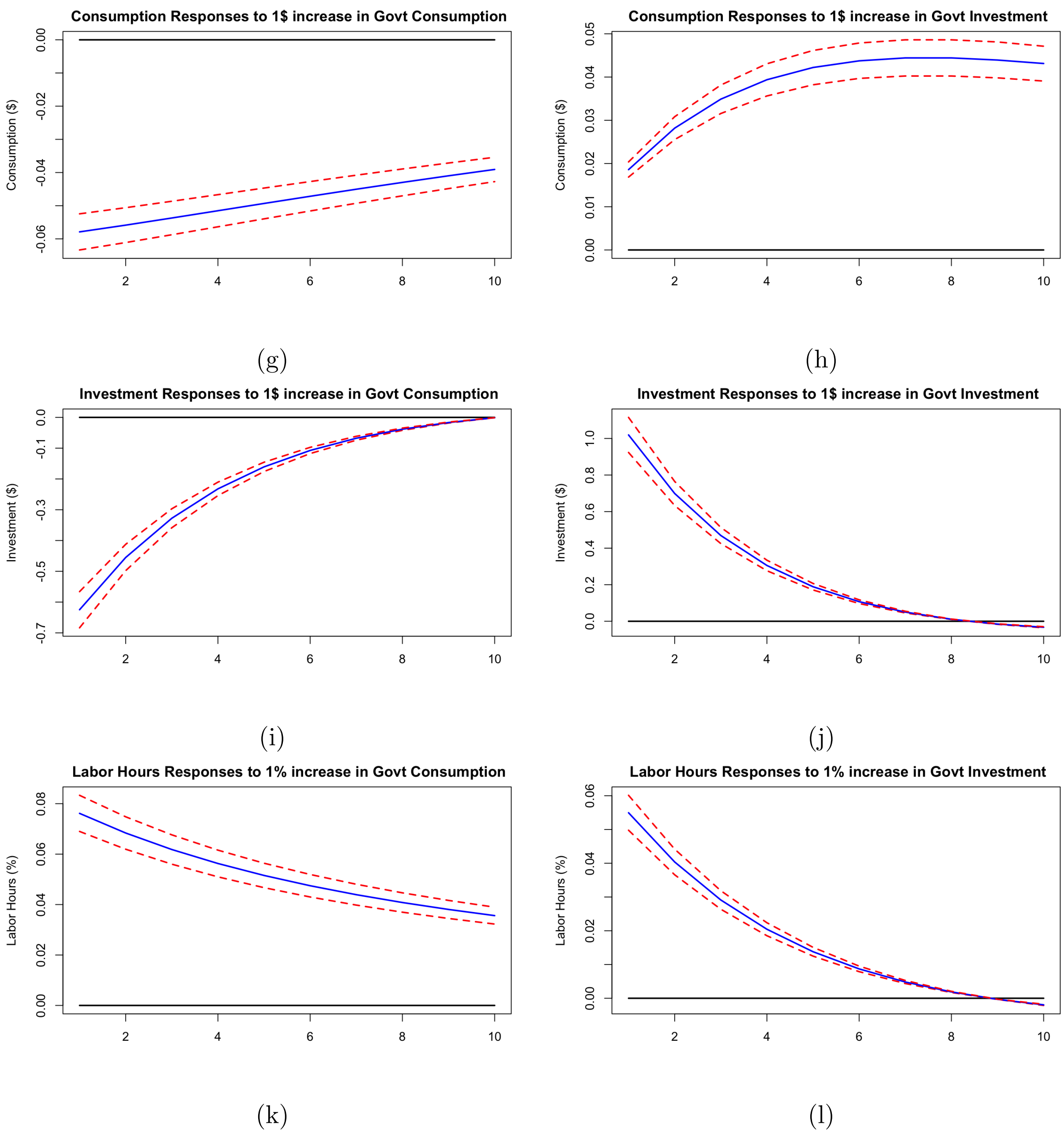


Figure 2: IRFs from the benchmark model with 90 percent confidence intervals ($\phi = 0.75$)

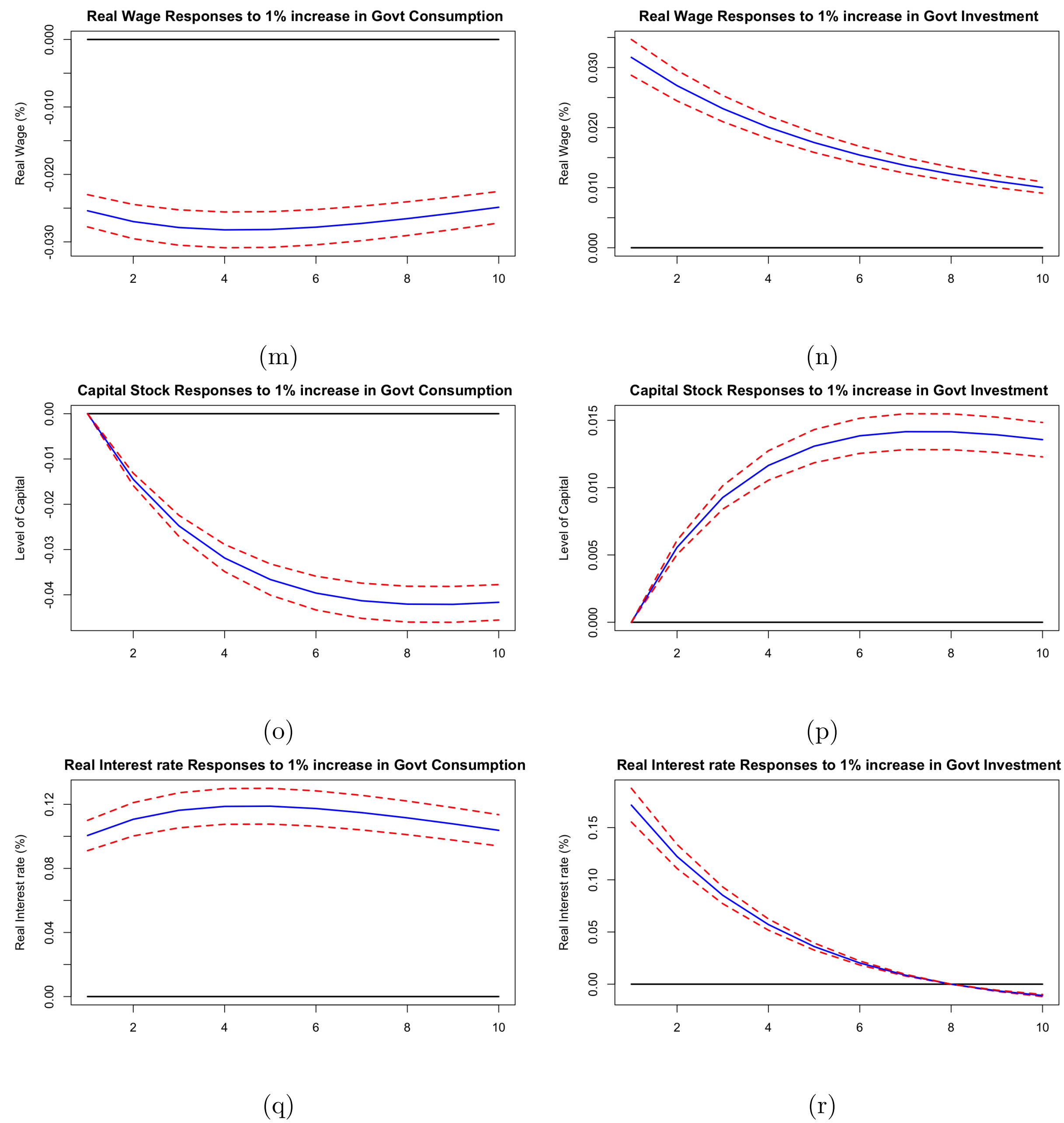


Figure 2: IRFs from the benchmark model with 90 percent confidence intervals ($\phi = 0.75$)

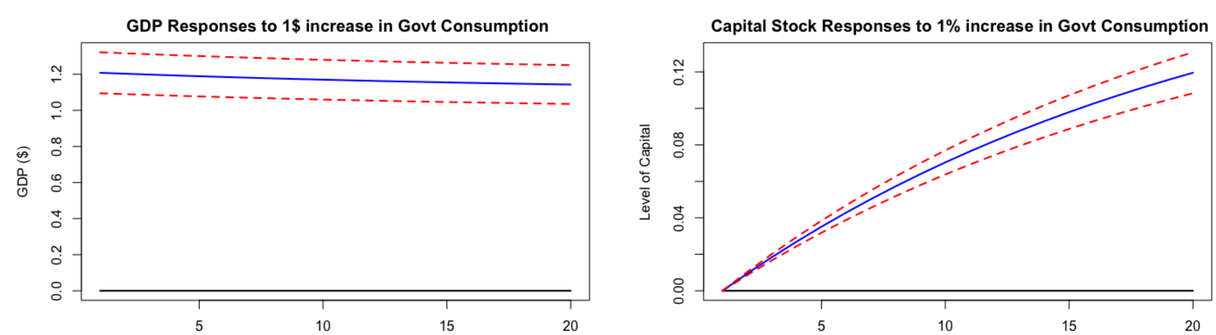
2.8.4 Persistence

Aiyagari, Christiano, and Eichenbaum (1992) used an AR(1) process for a government consumption shock and showed a more persistent consumption shock generates a larger multiplier effect. Though the multiplier effect is smaller than one for a transitory shock, Table 4 demonstrates how a highly persistent shock can produce a multiplier effect that exceeds one.

The consumption smoothing parameter (σ), known as the inter-temporal elasticity of substitution for private consumption, can smooth household consumption over time in response to a temporary increase in public spending. It does so by dwindling household savings or private investments. As the smoothing parameter rises, households increasingly draw their savings to keep consumption smoother.

However, the mechanism works increasingly less as the persistent parameter rises for any given consumption smoothing parameter (Table 4). The household tax burden also persists in response to a highly persistent change in public consumption spending. Households respond by adjusting their consumption and labor supply substantially. Increased labor supply boosts real returns to capital (r_t) and labor income ($w_t n_t$). Therefore, private investment goes up, followed by the private capital stock. This secondary effect from a higher level of capital increases output and produces a larger consumption multiplier (Figure A.5h).[10]

In contrast, the investment multiplier falls with the increase in the persistence parameter (Table 5). Labor productivity goes up with more persistent investment shock. As the wage rate increases, household prefers to work less, consume more, and invest less. Consequently, the capital stock will increase less with the rise in the persistence parameter, which leads to a smaller output response.



(a) (b)

Figure 3: IRFs from the benchmark model with 90 percent confidence intervals ($\phi = 0.99995$)

[10]See in the Appendix figure A.5 IRFs from the baseline model with a persistence parameter, $\phi = 0.99995$

Persistence (ϕ)	0.50	0.75 (Baseline)	0.90	0.99	0.99995
Interest Rate (r)	0.056	0.101	0.190	0.385	0.429
Labor Hours (n)	0.042	0.076	0.144	0.292	0.325
Wage Rate (w)	-0.014	-0.025	-0.048	-0.097	-0.108
Labor Income ($w * n$)	0.028	0.051	0.096	0.194	0.216
Private Investment (i)	-0.763	-0.623	-0.342	0.268	0.406
Private Consumption (c)	-0.032	-0.058	-0.109	-0.222	-0.247
GDP (y)	0.158	0.284	0.537	1.087	1.211

Table 4: ϕ is the persistence parameter for the shock variable, government consumption (g_c). The top half of the table shows the percentage deviations from the steady state due to a one percent increase in g_t^c under various levels of persistence. The bottom half shows the deviations in USD from the steady state in response to a one USD increase in g_t^c.

Persistence (ϕ)	0.50	0.75 (Baseline)	0.90	0.99	0.99995
Interest Rate (r)	0.173	0.172	0.167	0.144	0.136
Labor Hours (n)	0.056	0.055	0.051	0.034	0.028
Wage Rate (w)	0.031	0.032	0.033	0.039	0.041
Labor Income ($w * n$)	0.087	0.087	0.084	0.073	0.069
Private Investment (i)	1.048	1.030	0.962	0.658	0.556
Private Consumption (c)	0.015	0.019	0.031	0.086	0.105
GDP (y)	2.078	2.062	2.002	1.731	1.640

Table 5: ϕ is the persistence parameter for the shock variable, government investment (g_i). The top half of the table shows the percentage deviations from the steady state due to a one percent increase in g_t^c under various levels of persistence. The bottom half shows the deviations in USD from the steady state in response to a one USD increase in g_t^i.

3 Data

This section provides an overview of the data used in this study to test the model's predictions on government consumption and investment multipliers. I collect seasonally adjusted Private consumption (C), Private investment (I), Export (Ex), Import (IM), GDP, Government consumption (GC), Government investment (GI), Federal Defense Spending (FDS), Federal Non-Defense Spending (FNDS), State and Local Spending (SLS) and Tax revenue (TR) data for the period 1966: Q1 to 2020: Q4.[11] I deflated these variables using the price indices.[12] The Bureau of Economic Analysis (BEA) publishes "Advance", "Preliminary", and "Final" estimates of the most recent quarter at the end of the first, second, and third month of each quarter, respectively. A sizeable portion of these estimates is trend-based extrapolations. The BEA performs significant revisions to their estimates annually and in their five-year benchmark program when more accurate data from Census Bureau, Internal Service Revenue, and other sources are available (Landefeld, Seskin, and Fraumeni 2008). I compare the "Advance" and "Final" estimates of government spending growth rates with a recent estimate from the BEA. (See Appendix A.2). The "Final" report had no significant corrections, but later versions reflect major adjustments to the original estimates. To avoid potential measurement errors, I use recent estimates by BEA for all macro aggregates.

I use mean Forecasted Government Spending (FGS) data from Survey of Professional Forecasters (SPF) for 1981: Q4 to 2020: Q1.[13] I collect the Greenbook forecasts for government

[11] Based on BEA estimates, GDP includes personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government consumption expenditures and gross investment. Personal consumption expenditures include the durable and non-durable goods and services purchased by consumers in the US. The gross private domestic investment consists of residential and non-residential investments in structures, equipment, and non-residential intellectual property products. Gross private domestic investment also includes changing the physical volume of inventories belonging to private enterprises. Exports and imports capture goods and services sold, given away, or otherwise transferred by US residents to foreign residents and foreign residents to US residents. General government consumption expenditures comprise compensation of general government employees, consumption of general government fixed capital, and intermediate goods and services (durable and non-durable) the government purchases. Government consumption expenditures at other levels, i.e., federal defense, non-defense, and state and local expenditures, are recorded similarly. Government gross investment incorporates investments made at all levels (federal defense, non-defense, and state and local) into structures, equipment, and intellectual property products. I separated gross government investment into government infrastructure and government intellectual property investments, where government infrastructure investment contains investments in structures and equipment. Government intellectual property includes software and research and development. Federal defense spending takes in federal consumption expenditures and federal investment. Similarly, federal non-defense and state and local spending incorporate consumption expenditures and investments at each level. Tax revenue is the current tax receipts, which are personal current taxes, taxes on production and imports, corporate income, and taxes from the rest of the world.

[12] These macro aggregates are available for the period 1947: Q1 to 2021: Q1 on table 1.5.5 and table 3.2 at the BEA website. All variables are converted in real terms using the price index from Table 1.5.4 for Private consumption (C), Private investment (I), Export (Ex), Import (IM), GDP, Government consumption (GC), Government investment (GI) where the base index for the year 2012 price is considered 100. I use the GDP price index to convert Tax revenue (TR) into real terms.

[13] Forecasted government spending is the responses of surveyors based on the advance report of the NIPA and released to the public in the middle month each quarter before the BEA's second report is published. https://www.philadelphiafed.org/surveys-and-data/rslgov

spending for 1966: Q1 to 1981: Q3 prepared for Federal Open Market Committee (FOMC) meetings. Following Auerbach and Gorodnichenko (2012), I choose the forecasts prepared in the middle month of each quarter so that FOMC forecasts are comparable with SPF forecasts. These forecasts are estimated based on "Advance" estimates of NIPA aggregates for the most recent quarter. Due to significant data revisions by the BEA in the subsequent years, government spending forecasts in levels do not explain the actual government spending well.[14]

On the other hand, the growth rate of median government spending forecasts has some predictive power in explaining the actual government spending. In addition, the growth rates of government spending forecasts at the federal and state (and local) levels are also significant in explaining actual government spending. However, the size of those effects is small. For instance, a one percent increase in the growth rate of median government spending forecasts causes 0.000357 and 0.002439 percent increases in government consumption and investment spending, respectively.[15] Though both coefficients are small, the effect is more substantial for actual government investment than government consumption.

I use the market value of public debt (D) instead of par value. The market value of debt captures the actual debt burden to the US government since it updates the interest rates based on observed periods. In contrast, the par value of debt considers the initial interest rate when the debt was issued.[16] I use the interest rate (i) from the effective federal funds rate before 2009 and the shadow interest rate for the period after 2009 to control the zero-lower bound (ZLB) environment. The Shadow interest rate estimate by Wu and Xia (2016) matches with the effective federal funds rate for the non-ZLB period (before).[17] Consumer Price Index (CPI) data are available for the entire sample period.[18]

Private consumption (C), Private investment (I), Export (Ex), Import (IM), GDP, Government consumption (GC), Government investment (GI), Federal Defense Spending (FDS), Federal Non-Defense Spending (FNDS), State and Local Spending (SLS), Tax revenue (TR), and Debt (D) are log-linearized. All data are available from 1947: Q1 to 2020: Q4 except the government spending forecasts, which were unavailable before 1966. So, I truncated the dataset to match the forecasted spending data. Forecasts are important because the private sector can anticipate the spending before the actual expenditure takes place (Ramey 2011).

[14] t-statistics for both dependent variables are small. I also use the median government spending forecast, which does not explain the actual government spending.

[15] Perotti (2005) finds that OECD forecasts do not predict government spending shocks. However, Ramey (2011b) pointed out that the military news shock (a simple dummy variable takes 1 and 0) in the US can anticipate the changes in government spending (Defense spending), and controlling for the anticipations increases the size of the multiplier. Ramey also finds a similar result using the forecasts prepared by the SPF. Auerbach and Gorodnichenko (2012) used the growth rate of government spending forecasts because of significant data revisions done by the BEA. They found that it is correlated with the historical and the most recent estimates of actual government spending growth rates. Also, the multipliers get larger after controlling for the expectations.

[16] This data is available at the website of Federal Reserve Bank of Dallas for the entire study period.https://www.dallasfed.org/research/econdata/govdebt

[17] https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate?panel=2

[18] https://fred.stlouisfed.org/series/CPIAUCSL

I removed the data from the last three quarters of 2020. It's important to note that the COVID-19 pandemic caused a recession that is different from other recessions in the past. The pandemic created a public health emergency that affected the entire world. To slow down the spread of the disease, the US government issued strict shutdowns of businesses and activities. During this period, the US government had to borrow trillions of dollars to provide unprecedented fiscal support to households and businesses. It's worth noting that the aim of this financial support was not to boost the economy but to provide relief during this unprecedented time.

4 Empirical Framework

In this section, I will explain the methods used in this study to estimate the multiplier effects of different types of government spending. The primary objective is to estimate the consumption and investment multipliers based on the available data. Government consumption refers to the salaries of government employees, intermediate goods and services (durable and non-durable), and fixed capital consumption purchased by the government. On the other hand, government investment includes spending on structures, equipment, and intellectual property products. I will also examine whether the impact of additional spending by federal defense, federal non-defense, and state and local categories differs based on the data. I will use two methods, SVAR and LP, to estimate the multipliers.

4.1 Identification

I use the standard identification scheme from Blanchard and Perotti (2002) to be consistent with the literature on government spending multipliers. This strategy assumes that fiscal variables do not respond to macro variables in the same quarter. Therefore, I put fiscal variables at the top of the Cholesky decomposition matrix, followed by other macro aggregates, Private Consumption (C), Private Investment (I), and GDP.[19][20]

4.2 SVAR

Let Y_t denote the vector of endogenous variables. A_0 is the Cholesky decomposition matrix inspired by the identification scheme Blanchard and Perotti (2002). Y_{t-1} denotes one period lag of endogenous variables and A_1 is their coefficient matrix. X_t is the list of exogenous variables where Z is their coefficient matrix. I use one period lag of X_t to avoid simultaneity bias. ξ_t, c, and t are vectors representing error, constant, and trend in the structural model. Φ is the coefficient matrix from VAR(1).

$$A_0 Y_t = A_1 Y_{t-1} + Z X_{t-1} + \xi_t + c + t \tag{15}$$

[19]the SVAR and the LP method require identification order for the Cholesky decomposition matrix. See in the Appendix A.2)

[20]I use the Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) to choose the number of lags. I use the lag of exogenous variables to avoid simultaneity bias.

$$Y_t = \Phi(L)Y_t + Z^* X_{t-1} + U_t + \alpha + \gamma \tag{16}$$

$$\Phi = A_0^{-1} A_1 \tag{17}$$

$$Z^* = A_0^{-1} Z \tag{18}$$

$$U_t = A_0^{-1}\xi_t; \alpha = A_0^{-1}c; \gamma = A_0^{-1}t \tag{19}$$

The impulse response functions (IRFs) over the horizons follow,

$$IR_h = \Phi(L)^h A_0^{-1}; h = 0, 1, 2, 3, 4, ... \tag{20}$$

Scaled responses of all variables are reported in percentage terms for a one percent increase in the shock variable. I converted the GDP responses from percentage terms to the USD to estimate the effect of a dollar increase in spending.

4.3 Local Projections (LP)

Though the LP method has several advantages over the traditional SVAR approach, it also has challenges.[21] Jordà (2005) introduced a novel method that updates the coefficients at every point of the forecasting horizon. This is different from the SVAR approach, which uses the same coefficients to extrapolate impulse responses into distant horizons. As a result, while VAR impulse responses provide an accurate estimate for one period ahead, potential model misspecification errors can be amplified as we move through the horizons (Jordà 2005). However, a recent study by Moller and Wolf (2021) has shown that LP and SVAR methods provide similar IRFs in the short run until the forecasting horizon matches the length of unrestricted lag structures. In other words, given sufficient lag choices, the IRFs from the LP and SVAR approaches are similar. In the appendix, I have provided details on how to estimate impulse responses using the LP method (A.6).

[21]the LP method is vulnerable to serial correlation problems, and Jordà (2005) suggests using robust standard errors following Newey and West (1987) to subside the problem.

5 Empirical Evidence

Figure 4 presents the IRFs from the SVAR. Each panel shows responses of the private sector and GDP in real dollar terms for a dollar increase in government spending. Figure 4a shows the responses of GDP for a dollar increase in government consumption spending from VAR(4).

An increase in public consumption spending has some significant positive effects on GDP, but it is clear that the consumption multiplier in the short run is small.[22] It is because a one-dollar increase in government consumption spending immediately crowds out approximately 70 cents from investment (Figure 4e). The net effect on GDP is closer to zero on impact. Away from the impact, private consumption starts to rise (Figure 4c). Similar results were observed in the sub-sample analysis, excluding the Pre-1980, Great Recession, and post-2008 periods.

The rise of private consumption after a public consumption shock has been commonly cited in the literature for a rise in total government purchases (Gali et al. 2007). Nonetheless, it is not fully consistent with the representative agent DSGE framework that predicts a fall in both consumption and investment. Gali et al. (2007) explained this behavior from a two-agent model by assuming non-Ricardian behavior for a fraction of households.

The Government investment multiplier exceeds two on impact and is larger than one in the short run.[23] One dollar increase in government investment (GI) spending adds approximately 70 cents in consumption and 40 cents in investment (Figure 4d 4f). Hence, the total effect on GDP exceeds two on impact, but it dies out quickly.

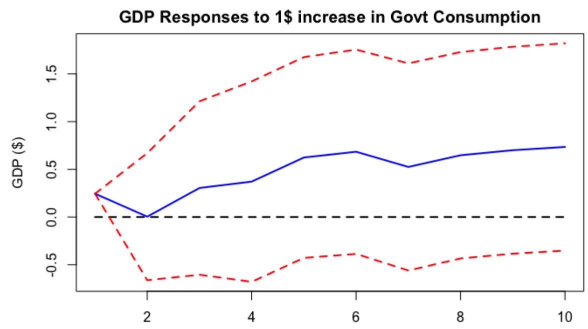
Boehm (2020) concludes that the investment multiplier is smaller because private investment gets crowded out after an investment shock but not after a consumption shock. However, this paper finds evidence on the contrary. Figure 4e shows that a public consumption shock dramatically crowds out private investment. Still, a public investment shock does not crowd out private investment (Figure 4f).

I omitted the IRFs from a linear LP method in the main paper since the results are similar (See in the Appendix-A.11).[24] One disadvantage of the LP method is its high variance, making it increasingly difficult to compare the IRFs into distant horizons.

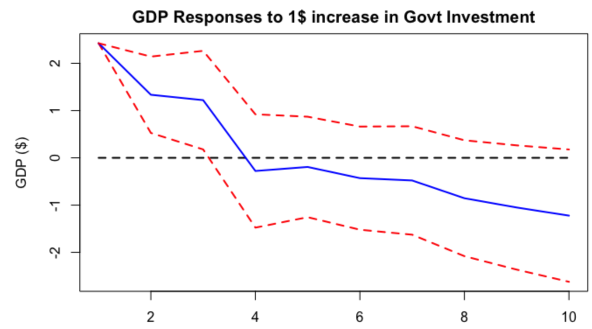
[22]Multiplier effect is not significantly different from zero after the impact.

[23]Multiplier effect is not significantly different from zero after three quarters.

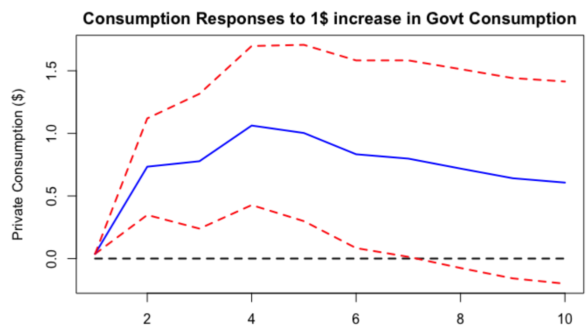
[24]I use the AIC criterion for lag choice.



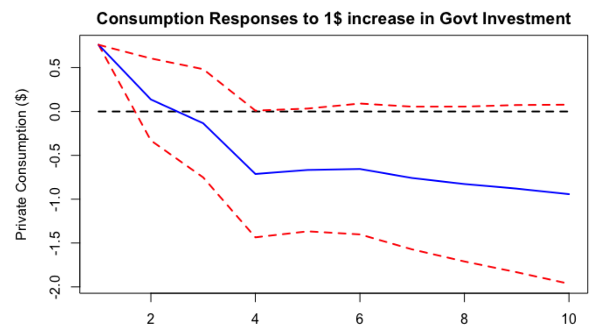
(a) VAR(4)



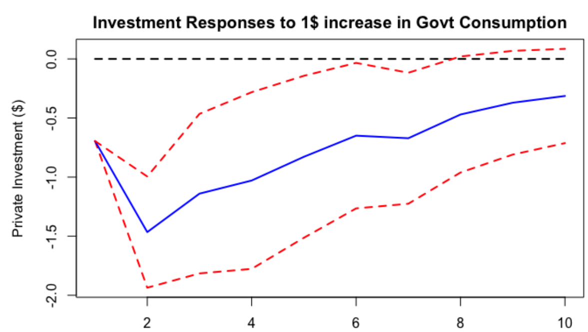
(b) VAR(4)



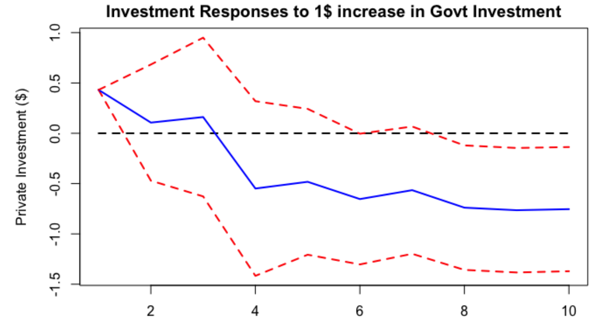
(c) VAR(4)



(d) VAR(4)



(e) VAR(4)



(f) VAR(4)

Figure 4: Responses are estimated in real terms from SVAR IRFs for one USD increase in Government Consumption (GC) and Government Investment (GI). Confidence intervals are estimated from Monte Carlo simulations after 10000 iterations. I report the Response $\pm$ 1.65 S.E.s that is equivalent to a 90 percent Confidence Interval.

5.1 Consumption Multiplier

There are a few possible explanations for why the consumption multiplier is very small for a transitory increase in spending. One reason is that a temporary increase in government consumption spending raises the real interest rate in the economy and crowds out private activity. Since private consumption has a low inter-temporal elasticity of substitution, it reduces less in response to a rise in the real interest rate, and private investment reduces more to smooth consumption over time (Aiyagari, Christiano, and Eichenbaum 1992; Boehm 2020). See the Appendix for details A.3. Other explanations lie with the non-linear and asymmetric effects of government consumption shocks. Using a linear symmetric framework to estimate non-linear and asymmetric effects can underestimate the government consumption multiplier. Larger increases in public consumption generate bigger multiplier effects. Since most increases are small, the average multiplier effect gets reduced. In addition, larger reductions in public consumption have smaller multiplier effects, further diminishing the consumption multiplier estimate.

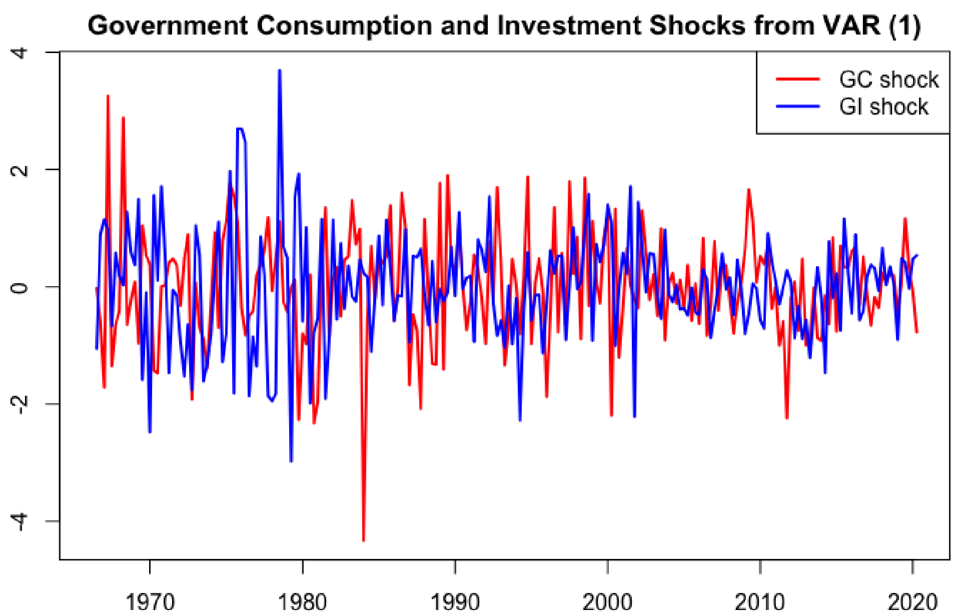


Figure 5: Standardized VAR shocks for government consumption and investment [VAR (1)]

To be consistent with recent literature, a shock denotes only the unanticipated change in public spending. Since the unanticipated changes in public spending can be different over time, shocks can differ in size (Figure 5). Figure 5 shows the structural VAR shocks for government consumption and investment.[25] First, I took the standardized VAR shocks and compared their effects on real economic interest rates after controlling for other relevant variables.[26] I collect the US commercial bank data on 3-month commercial paper rates, Bank prime loan rates for short-term business loans, 30-year fixed mortgage rates, 24-month

[25] After teasing out the anticipated component following Ramey (2011).

[26] One advantage of isolating standardized VAR shocks is that they can be used in the reduced form VAR equations as exogenous shocks. See the Appendix for details A.5.1. Also, shocks that are different in size and sign can be categorized to investigate non-linear and asymmetric effects.

	Commercial paper	Prime loan	Personal loan	Auto loan	Mortgage
GC Shock(UM)	0.09*	0.07*	0.10**	0.08*	0.07*
	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
GC Shock(CV)	0.08**	0.04	0.10***	0.07**	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
GC Shock(SPF)	0.08**	0.04	0.10***	0.07**	0.05**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
GC Shock(CPI-U)	0.15***	0.14**	0.20***	0.16***	0.16***
	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
GI Shock(UM)	−0.05	−0.08	−0.03	−0.03	−0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
GI Shock(CV)	−0.03	−0.03	0.06	0.07	0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
GI Shock(SPF)	−0.03	−0.03	0.06	0.07	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
GI Shock(CPI-U)	−0.11*	−0.11**	−0.08	−0.10*	−0.08
	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; *$p < 0.1$;

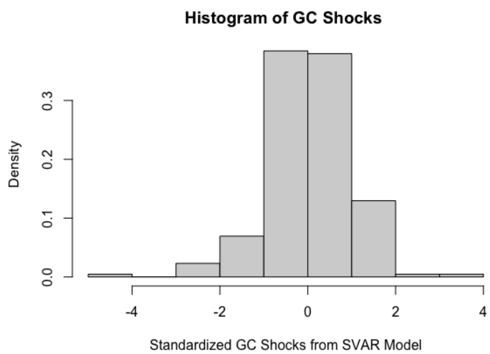
Table 6: Regression results using VAR(1) Shocks to explain the private sector real interest rates. The models control for two lags of the dependent variable, Yield on a 3-month T-Bill, Yield on a 10-year Treasury, the growth rate of bank deposits, personal savings rate, Fed Funds incl. shadow rate, NBER Recession, Cash Transfer, Healthcare Subsidy, Other Transfers

Personal loan rates, and 48-month Auto loan rates.

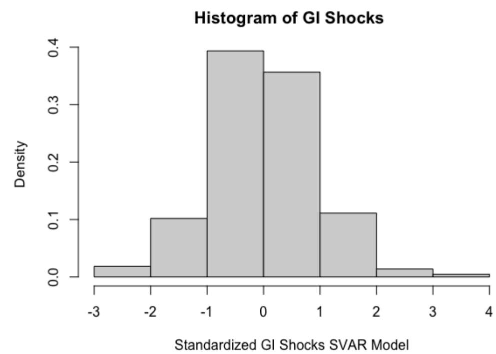
Following Boehm (2018), I use the Fisher equation to construct the real interest rates. One can use various measures for inflation expectations, i.e., a Consumer survey by the University of Michigan (too much inflation after 2010), Asset Price inflation by Cleveland Fed (too much noise probably due to liquidity shocks), the Survey of Professional Forecasters (stable and closer to realized inflation), current CPI-U. CPI-U over the past 12 months can predict expected inflation via perceived inflation. See the Appendix for details A.5.2. The models include the growth rate of bank deposits and personal savings rate to control liquidity shocks.

Table 6 reports the results from the regression models using real rates in the private sector as dependent variables. Real interest rates from various inflation measures rise after a government consumption shock. For example, a one-standard-deviation government consumption shock can raise the 3-month commercial paper rate by 0.09 percent, bank prime loan rate by 0.07 percent, personal loan rate by 0.10 percent, auto loan rate by 0.08 percent, and 30-year fixed mortgage rate by 0.07 percent (using inflation expectations measure by the University of Michigan).

Since the public spending shocks vary in size, a one standard deviation shock can have a different multiplier effect than a three standard deviation shock. For this reason, I divided the GC shocks of different sizes using the dummy variable approach. The dummy variable takes one if the shock is less than one standard deviation, two if the shock is between one and two standard deviations, and three if the shock is greater than three. For convenience, I will refer to them as small, medium, and large shocks.



(a) VAR(1) σ=0.006141915



(b) VAR(1) σ=0.020195051

Figure 6: Histogram of standardized GC and GI shocks from VAR (1)

$$GDP_t = \beta_0 + \beta_1 Trend + \beta_2 X_t + \beta_3 X_{t-1} + \beta_4 GC(Dummy) + \beta_5 GIShocks + \epsilon_t$$

Dependent Variable:	Real GDP	Real GDP
GC Shock Pos ($GC < 1S.D.$)	0.001	(0.78)
	(0.0004)	
GC Shock Pos ($1S.D. < GC < 2S.D.$)	0.003***	(1.27)
	(0.0006)	
GC Shock Pos ($GC > 2S.D.$)	0.007***	(1.67)
	(0.002)	
GC Shock Neg ($GC < 1S.D.$)		−0.001***
		(0.0004)
GC Shock Neg ($1S.D. < GC < 2S.D.$)		−0.003***
		(0.0009)
GC Shock Neg ($GC > 2S.D.$)		−0.001
		(0.001)

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table 7: Regression results using dummy variables for all positive and negative VAR GC Shocks to explain seasonally adjusted real GDP in the US. The model controls for GDP (Up to Lag 2), Private Consumption, Private Investment (Up to Lag 2), Tax revenue (Lag 1), Fed Funds Rate (Up to Lag 2), NBER recession, constant, Trend, Export (Lag1), Import (Lag1), GI shocks, Transfer Payment

Table 7 shows that the small GC shocks have no significant effect on GDP, and the multiplier effect is less than one. As the shock size increases, the impact on GDP becomes significant, and the multiplier effect gets larger than one. An average medium shock can increase the GDP by 0.003 percent, and an average large shock can raise the output by 0.007 percent. The multiplier effects for medium and large GC shocks are 1.27 and 1.67, respectively. Since most of the positive (and negative) GC shocks are small, the average positive multiplier effect for positive GC shocks (and the average negative multiplier effect for negative GC shocks) gets reduced (Figure A.11a).

5.1.1 Why Multipliers are Bigger for Larger Shocks?

It is puzzling to see larger and positive GC shocks have multiplier effects greater than one for transitory changes in spending. The key to generating a large multiplier in a neoclassical model is the persistence parameter since a more persistent shock generates a stronger labor supply response, as explained by Romer (1996, 172-174), Aiyagari, Christiano, and Eichenbaum (1992) and Section 2.8.4 in this study. The output response is closely tied to the employment generation, which depends on the persistence parameter. In a perfect foresight model, agents can anticipate the future path of aggregate variables after an exogenous shock hits the economy. More persistent shock implies greater total shock for any given horizon and a higher tax burden on the household. However, the relationship between the shock size (or persistence parameter) and the employment level is not linear.

$$Ratio^{\phi=0.75}_{\phi=0.50} = \frac{n_t^{\phi=0.75} - n_t^{\phi=0.50}}{\sum_0^{10}(\phi = 0.75)^t - \sum_0^{10}(\phi = 0.50)^t} \times 100 = \frac{0.0337613}{1.78} \times 100 = 1.9 \tag{21}$$

$$Ratio^{\phi=0.90}_{\phi=0.75} = \frac{n_t^{\phi=0.90} - n_t^{\phi=0.75}}{\sum_0^{10}(\phi = 0.90)^t - \sum_0^{10}(\phi = 0.75)^t} \times 100 = \frac{0.0679502}{2.74} \times 100 = 2.5 \tag{22}$$

$$Ratio^{\phi=0.99}_{\phi=0.90} = \frac{n_t^{\phi=0.99} - n_t^{\phi=0.90}}{\sum_0^{10}(\phi = 0.99)^t - \sum_0^{10}(\phi = 0.90)^t} \times 100 = \frac{0.1475524}{3.05} \times 100 = 4.8 \tag{23}$$

$$Ratio^{\phi=0.99995}_{\phi=0.99} = \frac{n_t^{\phi=0.99995} - n_t^{\phi=0.99}}{\sum_0^{10}(\phi = 0.99995)^t - \sum_0^{10}(\phi = 0.99)^t} \times 100 = \frac{0.0334}{0.44} \times 100 = 7.6 \tag{24}$$

As the persistence parameter rises, the total amount of shocks in the next ten periods also increases. From Table 4, the ratio of changes in the employment generation and the changes in the 10-period total shocks when the persistence parameter updates from $\phi = 0.75$ to $\phi = 0.50$ is 1.9. When the total shock size is smaller, households react to the smaller tax burden, and employment increases by 1.9 percent for every shock unit. However, employment response per unit of shock increases as the total 10-period shock rises with the persistence parameter (Table 4). Therefore, employment (and output) response is an increasing function of the shock size. As the shock size increases, the tax burden increases, and output rises at an increasing rate. If that is true, a 2-unit shock should have a larger multiplier effect than a 1-unit shock, given they have the same persistence parameter.

For instance, a unit shock with a persistence parameter $\phi = 0.75$ decays over time.[27] A 3-unit shock with the same persistence parameter also decays. Still, it represents a bigger total shock and tax burden than a unit shock for any given horizon (See Appendix A.4.1). Since a larger shock implies a higher tax burden, households respond with a stronger labor supply. A stronger labor response also denotes higher returns to the capital and labor income (Table 4). Therefore, capital investment will rise, followed by capital stock (Table 4). Like a highly persistent shock, a large transitory shock can generate a strong multiplier effect via increased labor response and capital stock.

5.1.2 Asymmetric Effect

In addition to non-linear effects, asymmetric effects are also observed. In the case of negative GC shocks, small and medium shocks have significant negative effects on GDP. In contrast, large negative shocks do not significantly negatively affect GDP (Table 7). It will suppress the average multiplier effect for negative GC shocks. If the negative multiplier effect gets subdued due to the insignificance of large negative GC shocks, it will further reduce the average multiplier effect. The average multiplier effect is estimated by taking the average effects of positive and negative shocks.

5.2 Investment Multiplier

The baseline model predicts the size of the investment multiplier gets reduced with the increase in the persistence parameter. A more persistent investment shock implies greater worker productivity and wage rate. As explained in Section 2.8.4, households spend more on consumption and leisure and less on investment when the persistence parameter increases. Given the small shock size, employment falls less (-0.057 percent) for every shock unit. However, employment decline per unit of the shock increases with the rise of the 10-period total shock. Therefore, employment (and output) falls at an increasing rate as the shock size grows. Consequently, the larger shock's multiplier effect is reduced (Table 5).

$$Ratio^{\phi=0.75}_{\phi=0.50} = \frac{n_t^{\phi=0.75} - n_t^{\phi=0.50}}{\sum_0^{10}(0.75)^t - \sum_0^{10}(0.50)^t} \times 100 = \frac{-0.0010186}{1.78} \times 100 = -0.057 \quad (25)$$

$$Ratio^{\phi=0.90}_{\phi=0.75} = \frac{n_t^{\phi=0.90} - n_t^{\phi=0.75}}{\sum_0^{10}(0.90)^t - \sum_0^{10}(0.75)^t} \times 100 = \frac{-0.00384044}{2.74} \times 100 = -0.14 \quad (26)$$

$$Ratio^{\phi=0.99}_{\phi=0.90} = \frac{n_t^{\phi=0.99} - n_t^{\phi=0.90}}{\sum_0^{10}(0.99)^t - \sum_0^{10}(0.90)^t} \times 100 = \frac{-0.0170942}{3.05} \times 100 = -0.56 \quad (27)$$

$$Ratio^{\phi=0.99995}_{\phi=0.99} = \frac{n_t^{\phi=0.99995} - n_t^{\phi=0.99}}{\sum_0^{10}(0.99995)^t - \sum_0^{10}(0.99)^t} \times 100 = \frac{-0.0057172}{0.44} \times 100 = -1.29 \quad (28)$$

[27] It decays much faster than a unit shock that has a higher persistence parameter $\phi = 0.99995$.

Non-linear effects of GI shocks are observed in the empirical evidence, but the relationship between the shock size and multiplier is unclear. For instance, Table 8 shows that an average large shock has a smaller multiplier effect than an average medium shock. Still, an average medium shock has a multiplier effect greater than an average small shock. Theoretical prediction says a small shock should have a larger multiplier effect than medium and large shocks. Though non-linear effects exist, it does not empirically diminish the average multiplier size for investment. It is because of two reasons. First, small GI shocks have a significant positive effect on output. Second, their multiplier effects are larger than one. Therefore, the average multiplier effect for all positive GI shocks remains greater than one.

Asymmetric effects of positive and negative GI shocks are observed, but it does not suppress the negative multiplier effect, unlike GC shocks. For instance, large negative shocks have no significant negative effect on GDP, but small negative shocks have a stronger effect than their positive counterpart. It means that the stronger negative effect of small shocks offsets the weaker effect of large shocks. Hence, the average negative multiplier effect for negative GI shocks is less subdued. Moreover, the finding that large negative shocks do not significantly affect GDP is not robust when VAR(1) shocks are replaced with VAR (4) shocks.

$$GDP_t = \beta_0 + \beta_1 Trend + \beta_2 X_t + \beta_3 X_{t-1} + \beta_4 GI(Dummy) + \beta_5 GCShocks + \epsilon_t$$

Dependent Variable:	Real GDP	Real GDP
GI Shock Pos ($GI < 1S.D.$)	0.001^{***}	(1.04)
	(0.0004)	
GI Shock Pos ($1S.D. < GI < 2S.D.$)	0.003^{***}	(1.74)
	(0.0006)	
GI Shock Pos ($GI > 2S.D.$)	0.005^{***}	(1.66)
	(0.003)	
GI Shock Neg ($GI < 1S.D.$)		-0.002^{***}
		(0.0004)
GI Shock Neg ($1S.D. < GI < 2S.D.$)		-0.003^{***}
		(0.0007)
GI Shock Neg ($GI > 2S.D.$)		-0.002
		(0.002)

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table 8: Regression results using dummy variables for all positive and negative VAR GI Shocks to explain seasonally adjusted real GDP in the US. The model controls for GDP (Up to Lag 2), Private Consumption, Private Investment (Up to Lag 2), Tax revenue (Lag 1), Fed Funds Rate (Up to Lag 2), NBER recession, constant, Trend, Export (Lag1), Import (Lag1), GI shocks

5.3 Federal Defense, Non-defense, and State and Local Spending

I break down aggregate government spending into Federal Defense (FDS), Non-Defense (FNDS), and State and Local Spending (SLS); each component includes consumption and investment spending. Figure 8 shows the responses of real GDP in dollar terms for a dollar increase in Federal Defense, Non-Defense, and State and Local Spending.[28] In the short run (4 quarters), the FDS multiplier is smaller than one, the FNDS multiplier is negative, and the SLS multiplier is greater than one. Differences between SLS and FS multipliers are also observed in the sub-sample analysis, excluding the pre-1980, Great Recession, and post-2008 periods.[29]

One possible explanation for such difference is that the consumption component in an average SLS shock is larger than in the FDS and FNDS shocks. Since larger consumption shocks generate greater multiplier effects, the SLS multiplier is larger than the FS multipliers. Consumption-to-investment ratios for all three spending categories hint that consumption should dominate the investment component in average FDS, FNDS, and SLS shocks. However, it dominates the most in SLS shocks (Figure A.1e). Also, SLS spending is the largest category in absolute terms, followed by FDS and FNDS (Figure A.1f). The scaled GC components of all shocks from VAR(1) show that the consumption component in an average SLS shock is indeed the largest, followed by FDS and FNDS (Figure 7).

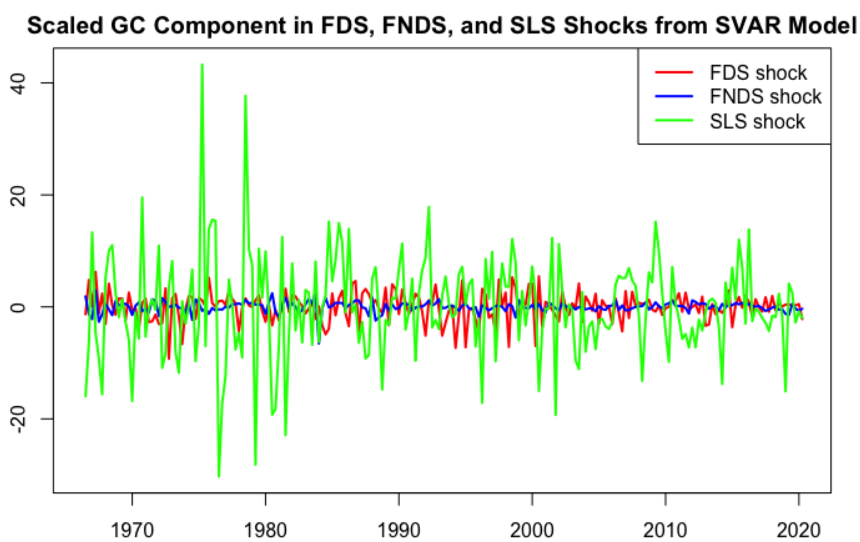
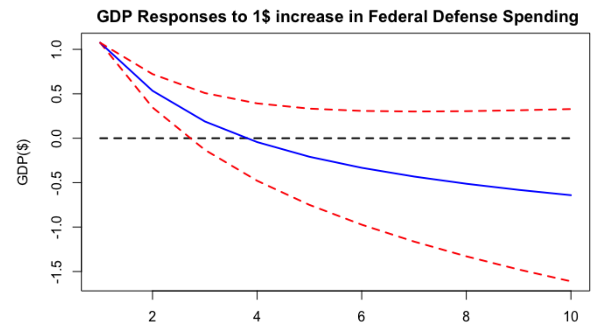


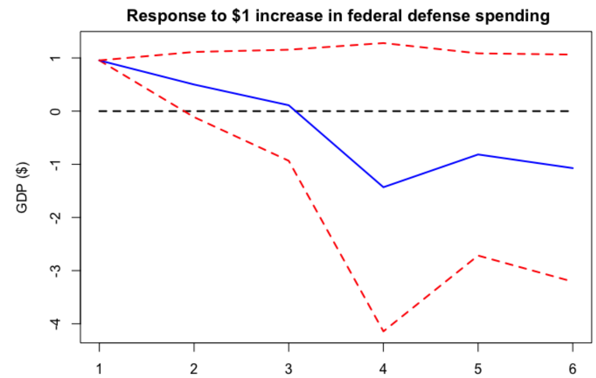
Figure 7: Scaled consumption component in FDS, FNDS, and SLS shocks from VAR (1)

[28]Following the BIC criterion, I report the IRFs from the VAR (1) model in the main section of the paper. The IRFs from VAR (2) following the AIC criterion produce similar results.

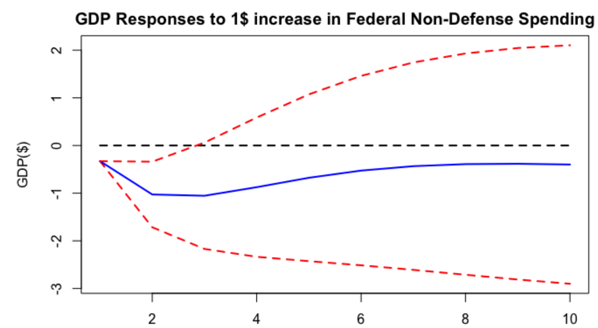
[29]I verified the results using the Local Projection (LP) method. Most results are similar, but one visible difference is that the LP method estimates a stronger negative multiplier for FNDS than the VAR method, mainly because of the massive decline in private consumption spending.



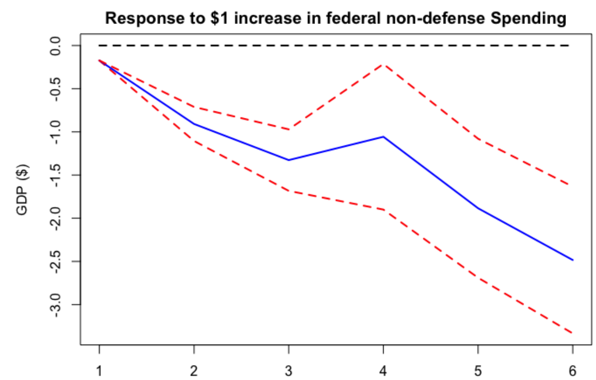
(a) VAR(1)



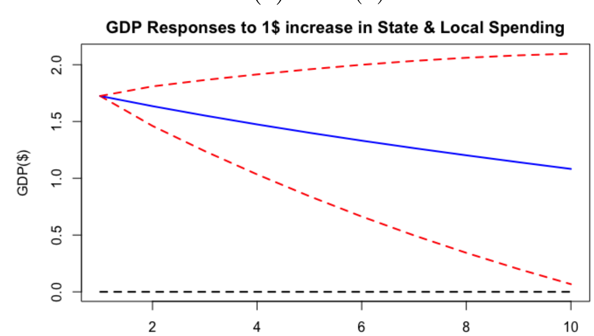
(b) LP(AIC)



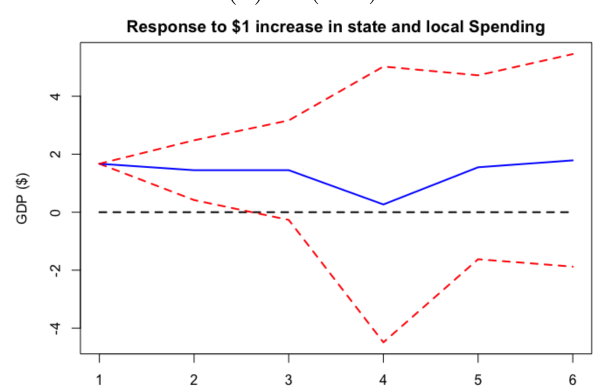
(c) VAR(1)



(d) LP(AIC)



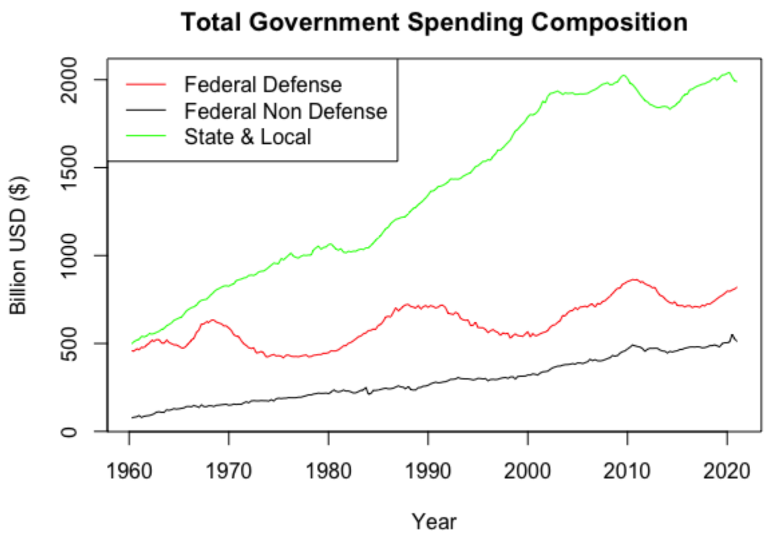
(e) VAR(1)



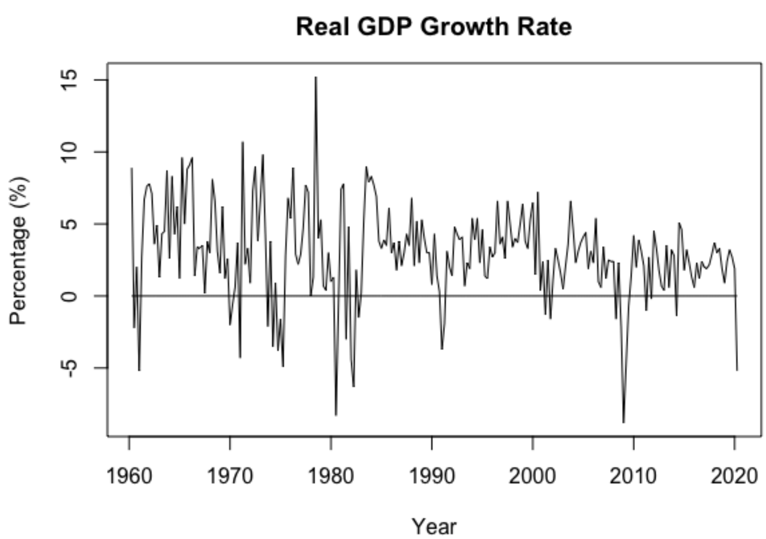
(f) LP(AIC)

Figure 8: Real GDP Responses for 1 USD increase in Federal Defense (FDS), Non-Defense (FNDS), and State and Local Spending (SLS) from SVAR and Local Projection Method. I report the Response ± 1.65 S.E.s that is equivalent to a 90 percent Confidence Interval.

SLS and FS represent approximately 13 percent and 9 percent of US GDP, respectively. Figure 9b shows that state and local government purchases have not increased much since 2000, whereas federal government purchases have been trending. Therefore, stagnation of state and local spending combined with growing federal expenditures may have contributed to the slow GDP growth rate in the recent decades (Figure 9a).



(a)



(b)

Figure 9: a) Composition of government purchase b) Real GDP growth rate

5.4 Robustness

The forecasts prepared by the FOMC meeting and the SPF are based on the "Advance" report of NIPA aggregates for the most recent quarter. When the "Preliminary" and "Final" estimates of the most recent quarter become available in the middle and last month of each quarter, the private sector may revise its expectations, but SPF forecasts are not available for the later part of each quarter. Revised estimates of the previous quarter's government spending from "Preliminary" or "Final" reports may work as a potential proxy for updated expectations (Figure A.2a). However, results do not change after controlling for the revised estimates of government spending (as a proxy for the updated expectations) and the recession dates announced by the NBER. Also, findings remain similar when per capita estimates are used for macro variables. I use the median government spending forecasts prepared by the SPF and FOMC instead of the mean estimates. They are statistically insignificant in explaining actual government spending, similar to the mean government spending forecasts. However, the growth rate of median government spending forecasts is found to have some predictive power on actual government spending. Still, the effect is too small to change the main result. A fraction of actual defense, non-defense, and state and local spending is predicted by the growth rate of median federal, and state and local spending forecasts. Nonetheless, the effects are minimal and do not change the multiplier estimates for federal defense, non-defense, and state and local spending. I have also included the yield on a 10-year treasury in the model. The results remain largely unaffected, except the investment multiplier stays positive for a slightly longer horizon.

6 Conclusion

A standard non-linear DSGE model predicts that government consumption and investment multipliers are much smaller than one in the short run. Based on the US data from 1966 to 2020, I use SVAR and Local Projections methods to estimate the multipliers. The evidence from US data supports the model's prediction for the consumption multiplier, but not for the investment multiplier. In the short run, I find that the investment multiplier is larger than one, and the consumption multiplier is near zero. This paper contributes to the research on government spending multipliers by offering a new explanation that clarifies the difference between consumption and investment multipliers. It also explains how the size of consumption shocks affects the state and local spending multiplier.

There are a few reasons why the consumption multiplier is much smaller than the investment multiplier. First, Private investment gets crowded out substantially after a government consumption shock but not after a government investment shock. This finding is consistent with the scale by which private investment is crowded out after an aggregate government spending shock (e.g., Ramey and Shapiro 1998; Blanchard and Perotti 2002; Mountford and Uhlig 2009; Ramey 2011b). Second, linear and symmetric regression methods fail to capture the non-linear and asymmetric effects of consumption shocks, leading to an underestimation of the consumption multiplier. Consumption shocks are not linearly scale-able; larger ones produce stronger multiplier effects. The SVAR or other linear regression methods estimate linear and symmetric IRFs that may overestimate or underestimate the multiplier effect.

A positive investment shock can directly boost the production function via increased public capital stock. It can also indirectly affect GDP by raising private investment, though evidence for such an effect is weak. Regardless, I do not find evidence of a crowding-out effect on private investment after a government investment shock. My findings align more with the results Auerbach and Gorodnichenko (2012) reported but oppose Boehm's (2020). One reason the results of this study differ in several respects from Boehm (2020) is likely the use of a different dataset. Boehm used OECD data from 38 member countries, including the US, while this study used only US data.

I find evidence that additional spending by state and local governments is more effective in raising output than that by the federal government. The short-run multipliers for federal non-defense, defense, and state and local spending are negative, less than one, and greater than one, respectively. The non-linear effects of consumption shocks help explain this result. While small consumption shocks do not affect output, larger ones can produce a multiplier effect that exceeds one. Since state and local spending shocks have a much larger consumption component on average, they produce a stronger multiplier effect than federal spending shocks. Despite having a stronger multiplier effect, state and local spending in real terms has not grown since 2000, while federal spending has increased following its pre-2000 trends. A shift in the composition of government spending after 2000 may have contributed to the slowdown of the US economy. However, further research is required to confirm this hypothesis.

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A Appendix

A.1 Data

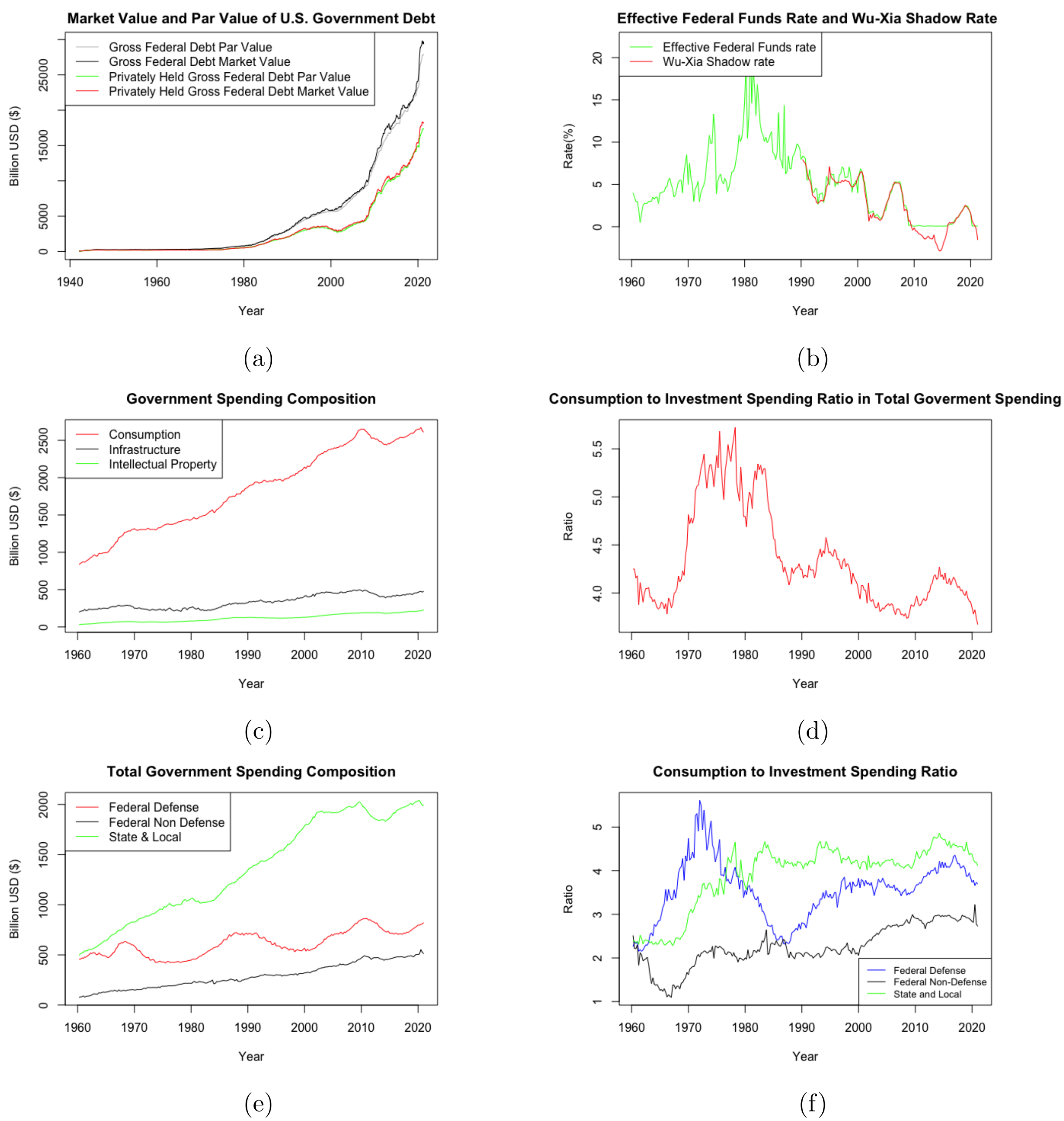
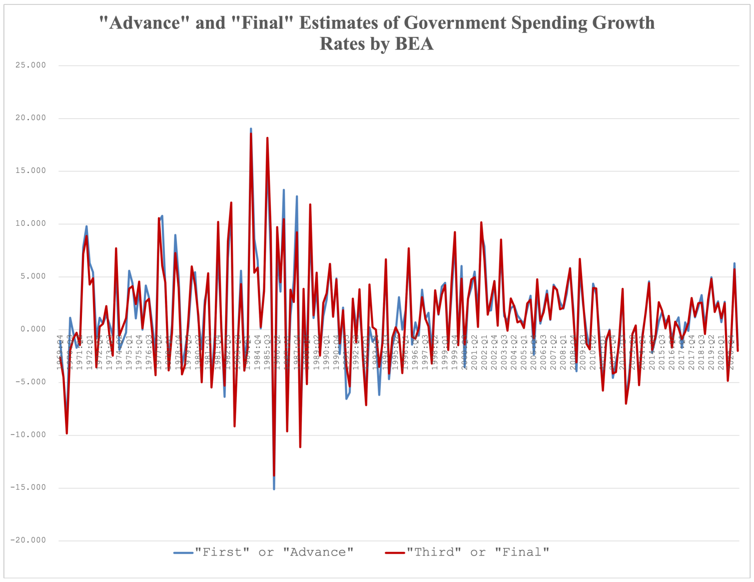
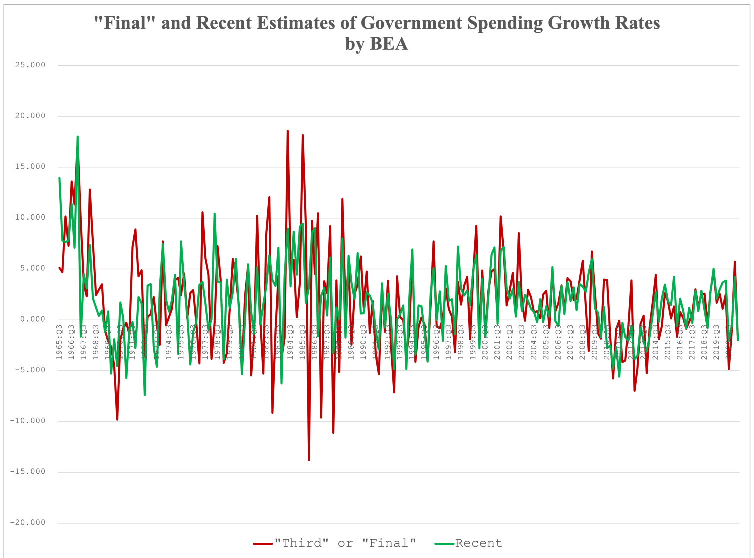


Figure A.1: (a)Market value of the US public debt (b) Shadow interest rate by Wu and Xia (2016) (c) Composition of total government spending (d) Consumption and investment spending ratio in total government spending (e) Composition of total government spending (f) Consumption to investment spending ratios in federal defense, non-defense, and state & local spending



(a)



(b)

Figure A.2: "Advanced", "Final", and Most Recent Estimates of Government Spending by BEA(1966-2020) (a) "Advanced" vs. "Final" estimates of government spending growth rates (b)"Final" vs. Most Recent estimates of government spending growth rates

A.2 Identification

A.2.1 Government Consumption vs. Government Investment

First, I divide the aggregate government spending into government consumption and investment spending. Let Y_t denote the vector of endogenous variables containing Government Consumption (GC), Government Investment (GI), Tax Revenue (TR), Private Consumption (C), Private Investment (I), and GDP. X_t is the list of exogenous variables, including the Growth rate of Median Federal spending Forecast (GMF), the Growth rate of Median State and Local spending Forecast (GMS), Export (EX), Import (IM), Debt (D), Consumer Price Index (CPI), and Interest Rate (i).

$$Y_t = \begin{pmatrix} GC_t \\ GI_t \\ TR_t \\ C_t \\ I_t \\ GDP_t \end{pmatrix}; \; A_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix};$$

$$X_t = \begin{pmatrix} GMF_t & GMS_t & EX_t & IM_t & D_t & CPI_t & i_t \end{pmatrix}$$

A.2.2 Federal Defense vs. Federal Non-Defense vs. State and Local Spending

Then, I divide aggregate government spending into Federal Defense Spending (FDS), Federal Non-Defense Spending (FNDS), and State and Local Spending (SLS). Let Y_t denote the vector of endogenous variables containing Federal Defense Spending (FDS), Federal Non-Defense Spending (FNDS), State and Local Spending (SLS), Tax Revenue (TR), Private Consumption (C), Private Investment (I), and GDP.

$$Y_t = \begin{pmatrix} FDS_t \\ FNDS_t \\ SLS_t \\ TR_t \\ C_t \\ I_t \\ GDP_t \end{pmatrix}; \; A_0 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{pmatrix}$$

$$X_t = \begin{pmatrix} GMF_t & GMS_t & EX_t & IM_t & D_t & CPI_t & i_t \end{pmatrix}$$

A.3 A Two-period Model

Following a two-period textbook model (Wickens 2008, 59), an increase in the interest rate from r_0 to r_1 will reduce the maximum consumption or investment possible in the current period from $C^m_{t+1,0}$ to $C^m_{t+1,1}$ as shown by the green arrow. This is because the amount that can be borrowed against future income falls. Hence, consumption in the current period

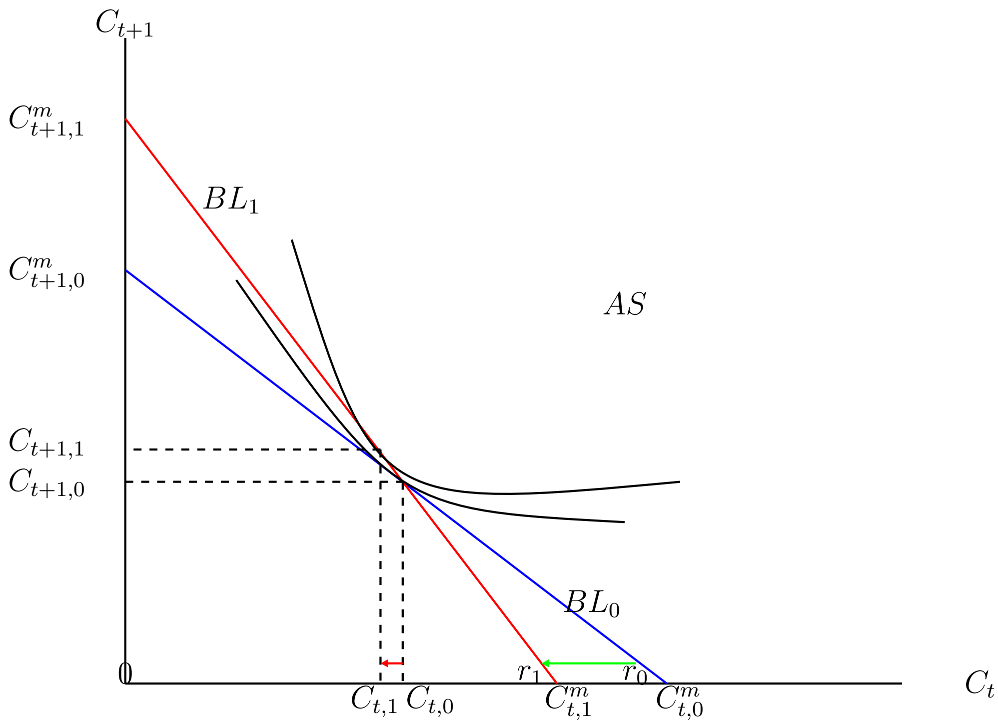


Figure A.3: A two-period model for consumer choice.

falls, but the reduction in consumption is small (shown by the red arrow) compared to the reduction in the net present value of income because,

$$\frac{\Delta C_{t+1}}{C_t} \simeq \frac{r_1 - \theta}{\sigma(1 + r_1)} \tag{29}$$

$$\frac{\Delta C_{t+1}}{\Delta C_t} = -(1 + r_1) \tag{30}$$

$$\frac{\Delta C_t}{C_t} \simeq -\frac{r_1 - \theta}{\sigma(1 + r_1)^2} \tag{31}$$

σ is the consumption smoothing parameter. If σ=4, the agent has a strong desire to smooth consumption over time or low inter-temporal elasticity of substitution for consumption. Hence, consumption $\Delta C_t = (C_{t,0} - C_{t,1})$ falls less, and investment, $\Delta I_t = (C^m_{t,0} - C_{t,0}) - (C^m_{t,1} - C_{t,1})$ falls more.

If σ=1, as in log utility, consumption will reduce substantially because the agent does not have a strong desire to smooth consumption over time. As a result, the investment will not fall dramatically.

A.4 DSGE Model

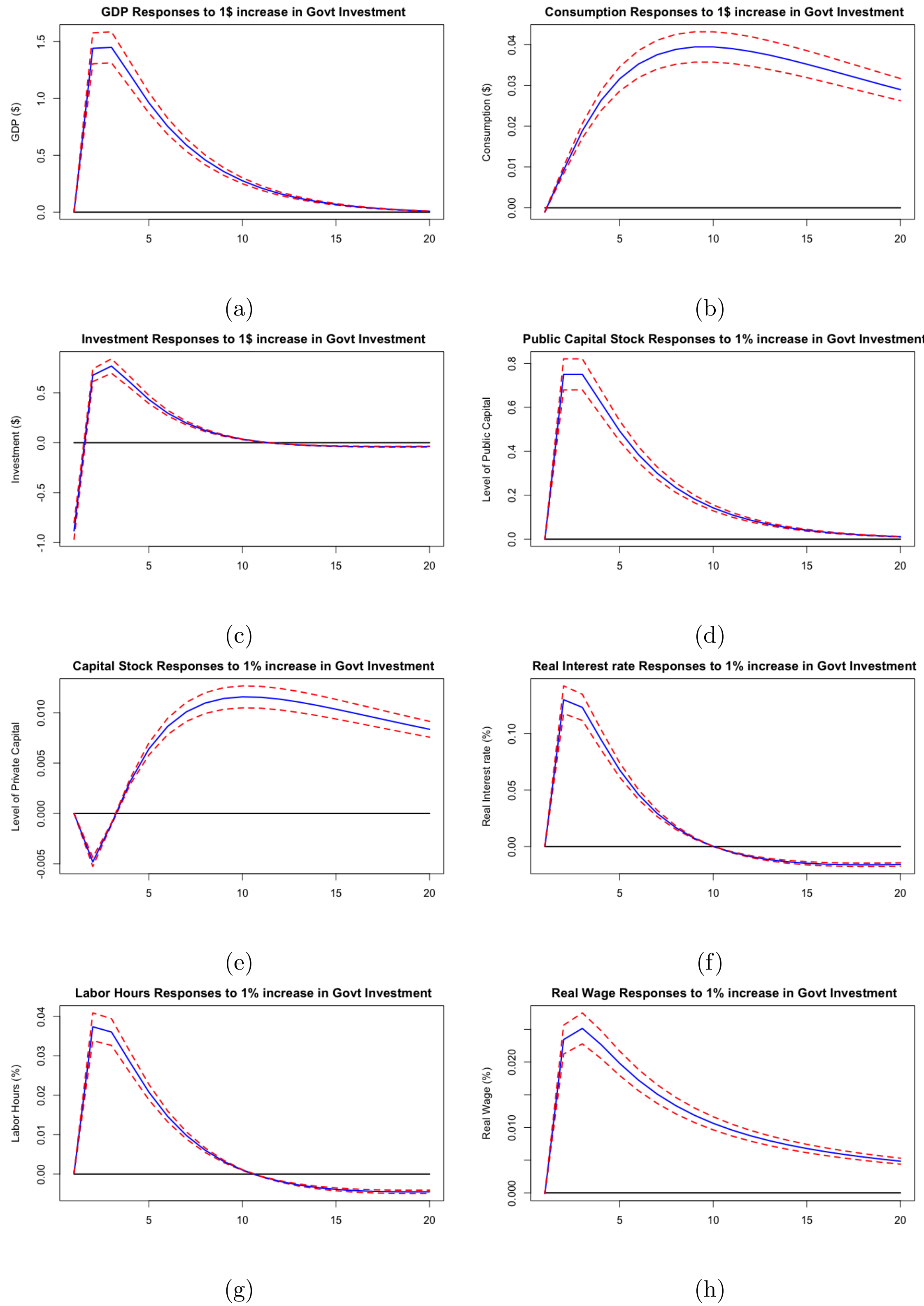
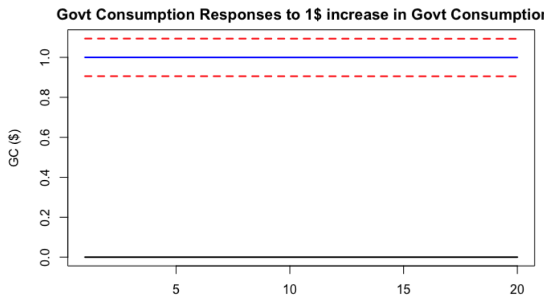
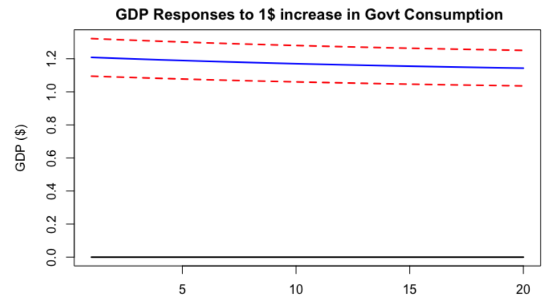


Figure A.4: IRFs from a traditional model ($\delta_g = 0.75, \phi = 0.75$). Figure a-d responses are in USD, and Figure e-h responses are in percentage terms.





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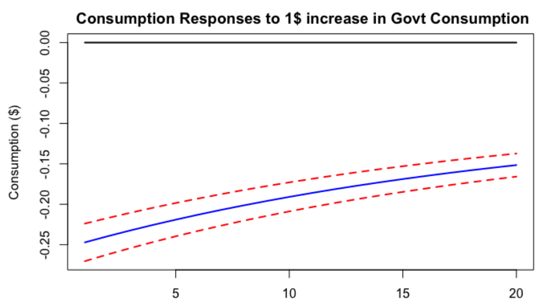

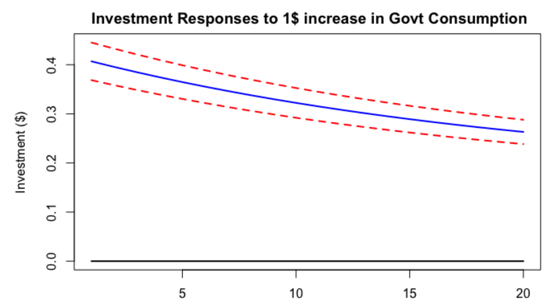

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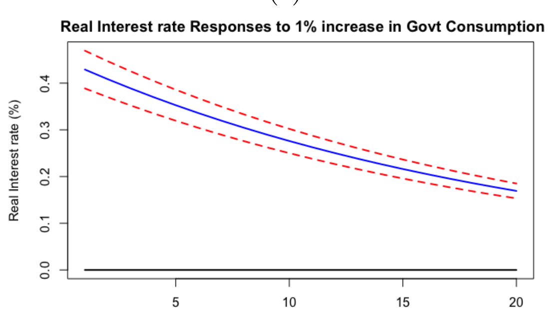

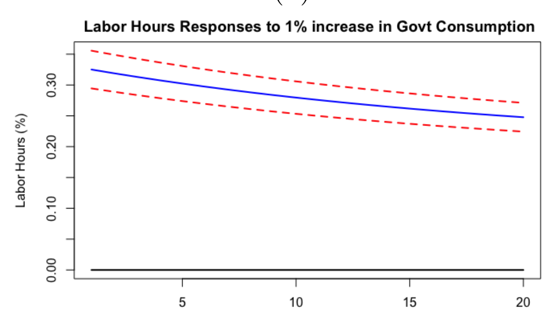

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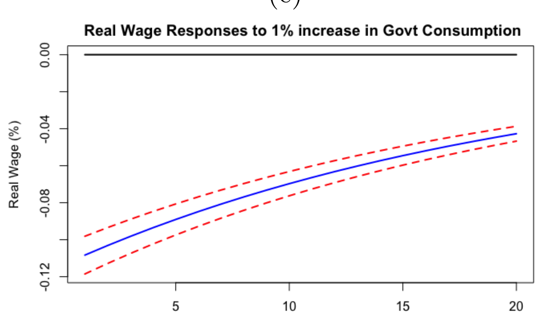
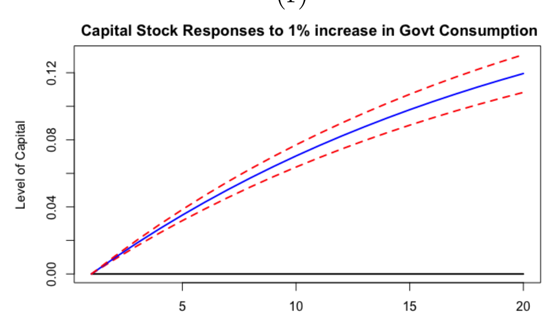
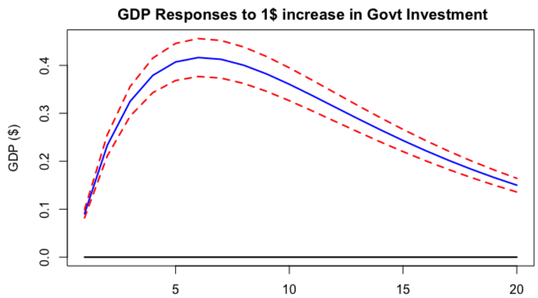


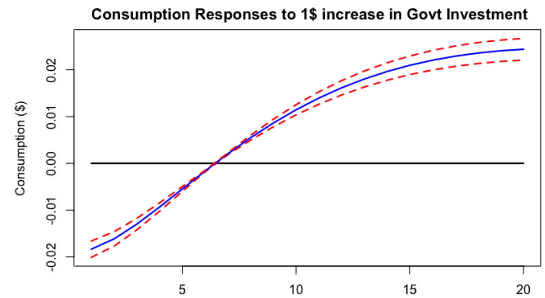


(g) (h)

Figure A.5: IRFs from the baseline model (Persistence parameter $\phi = 0.99995$). Figure a-d responses are in USD, and Figure e-h responses are in percentage terms.



(a)



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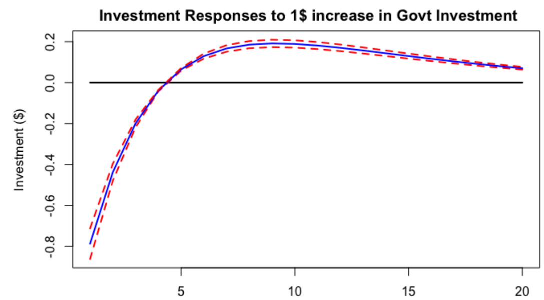

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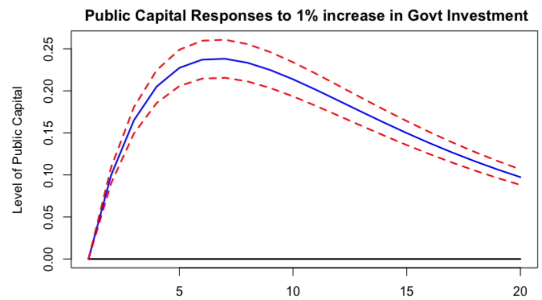

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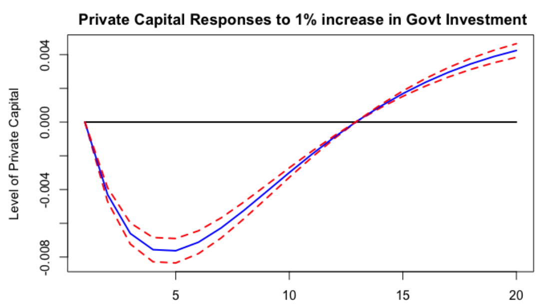
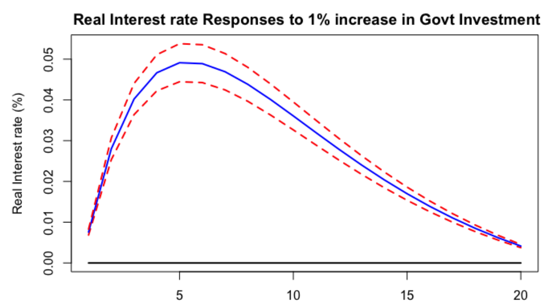


(e)



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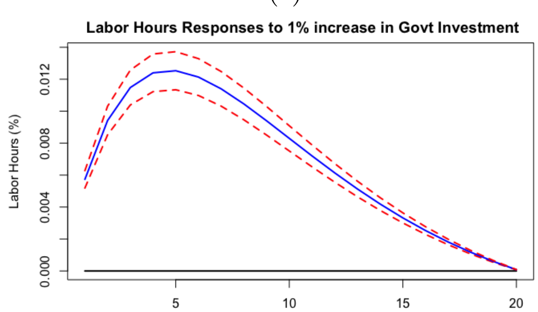
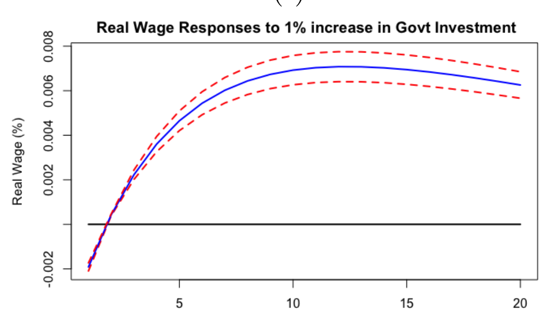
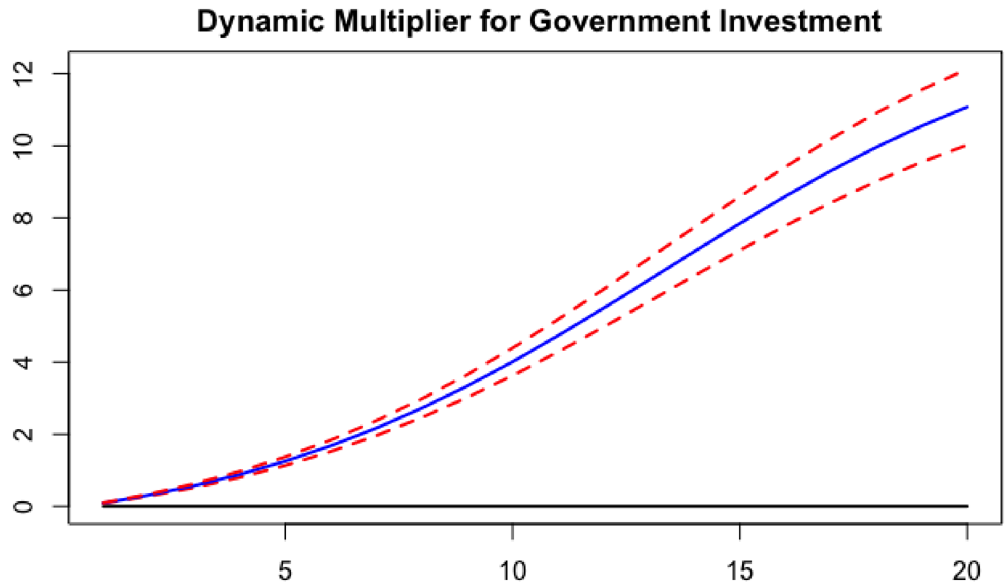


(g)

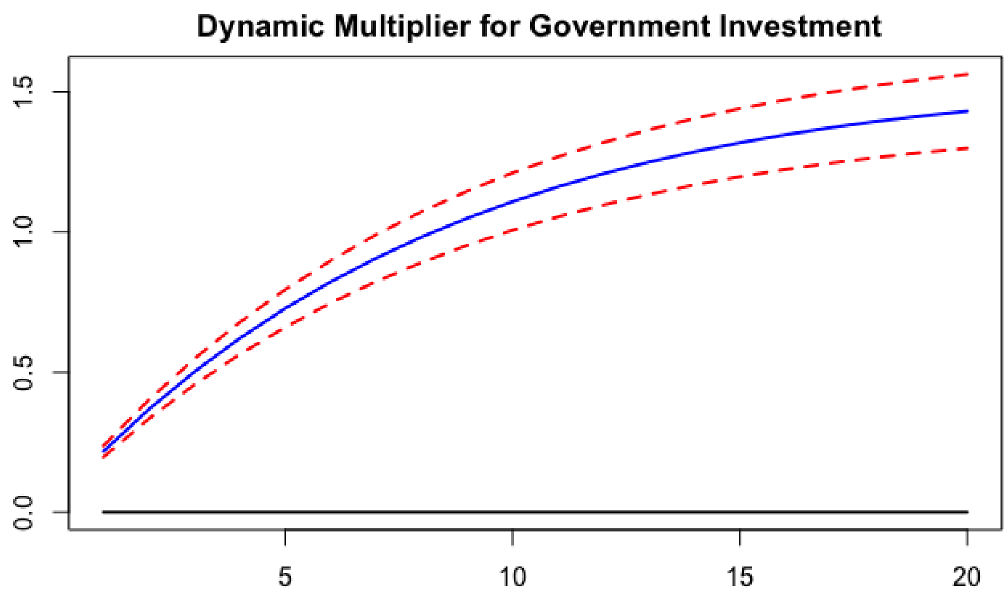


(h)

Figure A.6: IRFs from a traditional model ($\delta_g = 0.1, \phi = 0.75$). Figure a-d responses are in USD, and Figure e-h responses are in percentage terms.



(a) Dynamic Multiplier from a traditional model ($\delta_g = 0.1, \phi = 0.75$)



(b) Dynamic Multiplier from a traditional model ($\delta_g = 0.1, \phi = 0.99995$)

Figure A.7: Dynamic Multiplier for an investment shock

A.4.1 Persistence

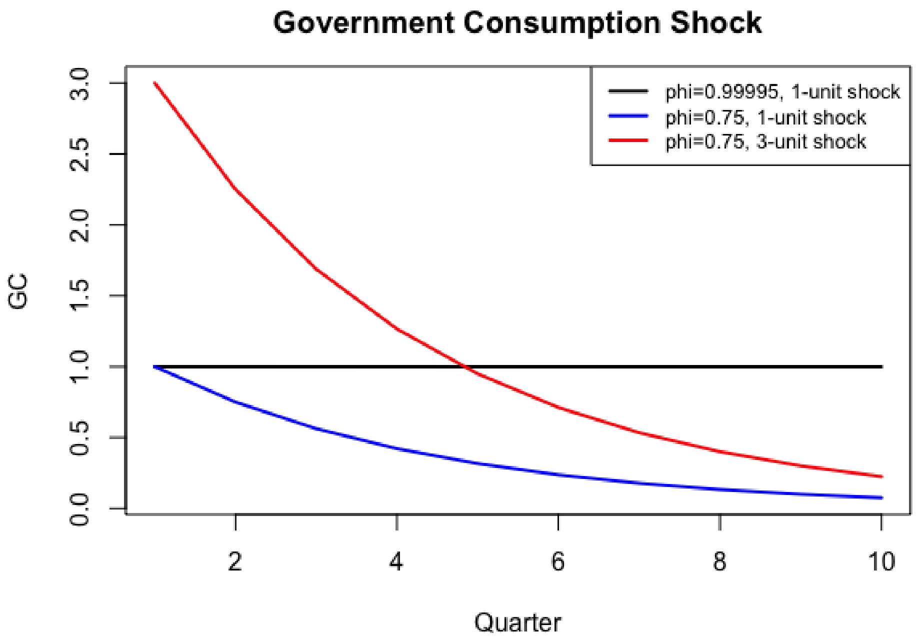


Figure A.8: Heterogeneous GC shocks with various persistence

Aiyagari, Christiano, and Eichenbaum (1992) used an AR(1) process for shock and concluded that the contemporary multiplier effect on output for an increase in government consumption is an increasing function of ϕ. If ϕ takes 0.99999, 0.97, and 0.90, the corresponding multipliers are 1.15, 0.78, and 0.44. In contrast, a purely transitory movement of government consumption or a shock identically and independently distributed over time generates a multiplier effect equal to 0.07. Based on the empirical estimates of this study, government consumption shocks are moderately persistent, where ϕ is around 0.75

$$G_t = \phi G_{t-1} + \epsilon_t \tag{32}$$

$\phi = 0.75$; if the shock is moderately persistent and
$\phi = 0.99995$; if the shock is highly persistent

A.5 SVAR

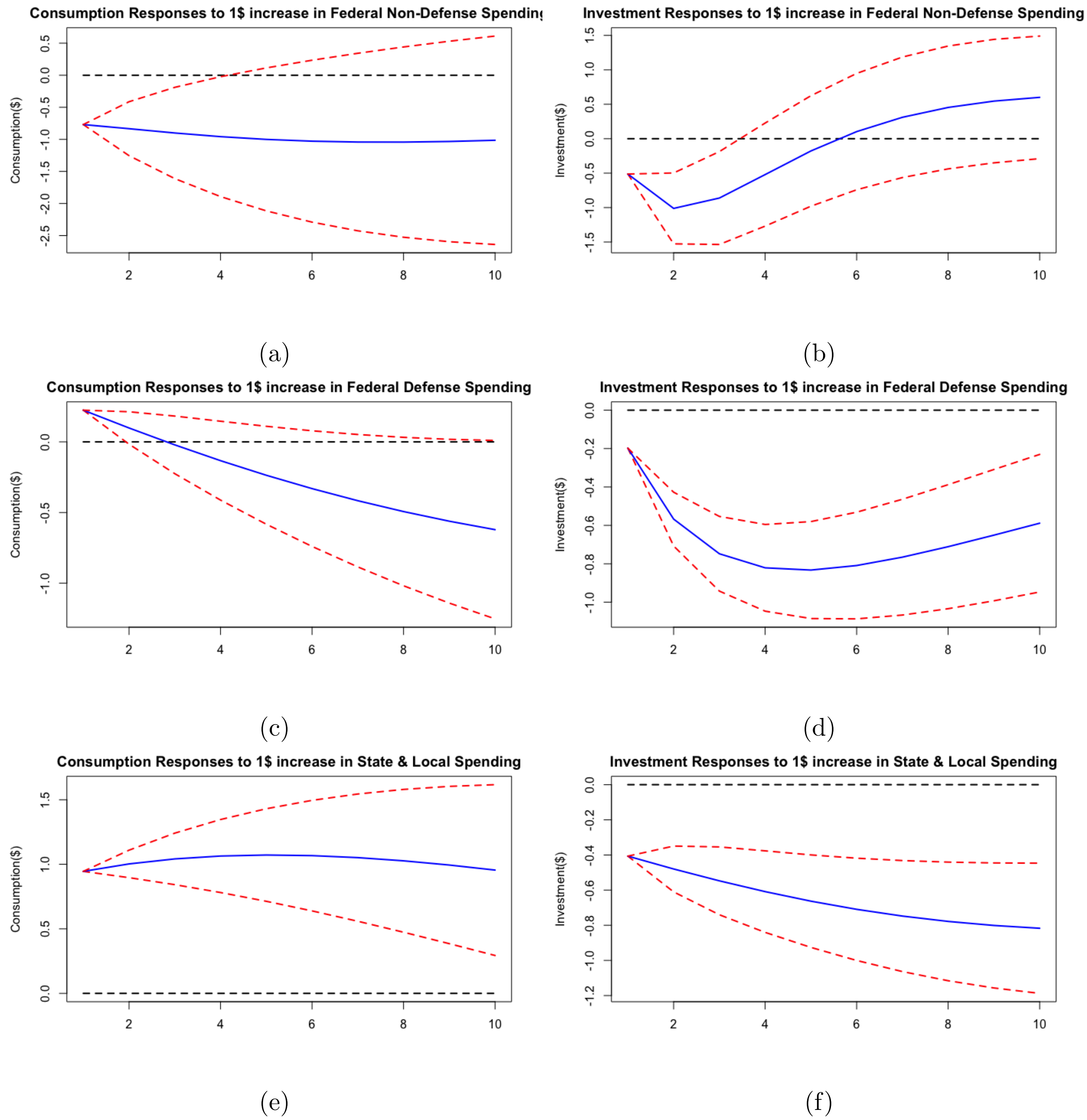


Figure A.9: Private sector responses to Federal Defense (FDS), Non-Defense (FNDS), and State and Local Spending (SLS) shocks VAR (1)

A.5.1 SVAR shocks

A 2-variable Structural VAR equation,

$$AY_t = BY_{t-1} + CX_{t-1} + U_t \tag{33}$$

$$\begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} G_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} c_{11} & 0 \\ 0 & c_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix};$$

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix}^{-1} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} G_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix}^{-1} \begin{bmatrix} c_{11} & 0 \\ 0 & c_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ a_{21} & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix};$$

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} G_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} c_{11} & 0 \\ 0 & c_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix};$$

$$\begin{bmatrix} G_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} G_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} c_{11} & 0 \\ -a_{21} & c_{22} \end{bmatrix} \begin{bmatrix} X_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ -a_{21} & 1 \end{bmatrix} \begin{bmatrix} u_t^G \\ u_t^Y \end{bmatrix};$$

Reduced form VAR equations,

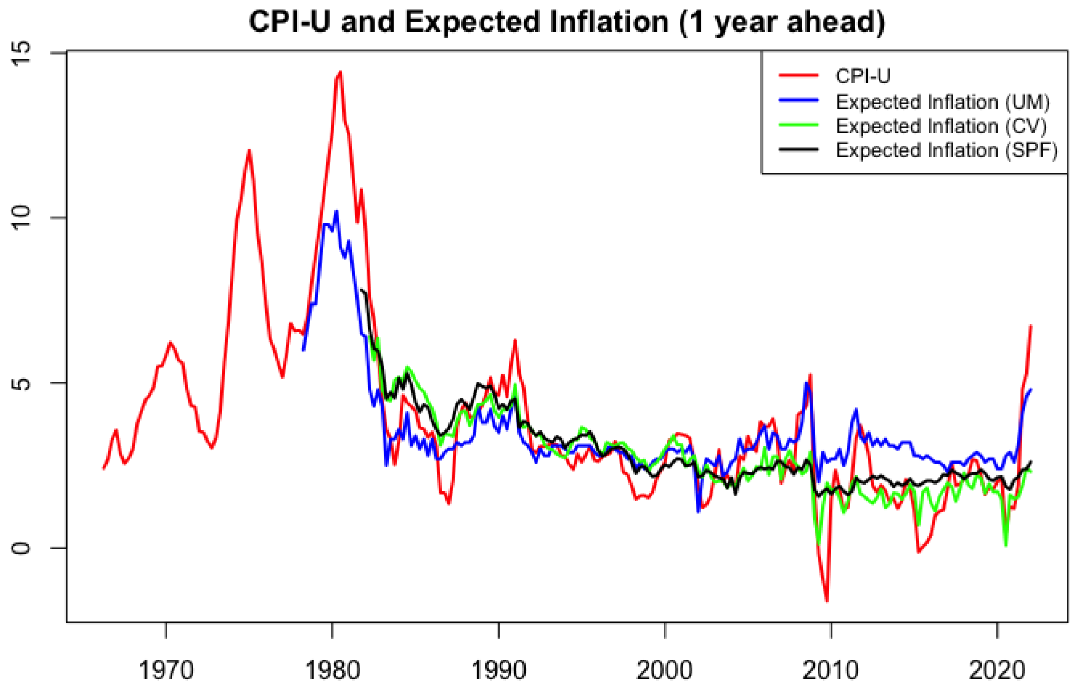
$$G_t = \phi_{11} G_{t-1} + \phi_{12} Y_{t-1} + c_{11} X_{t-1} + u_t^G \tag{34}$$

$$Y_t = \phi_{21} G_{t-1} + \phi_{22} Y_{t-1} - (a_{21} - c_{22}) X_{t-1} - a_{21} u_t^G + u_t^Y \tag{35}$$

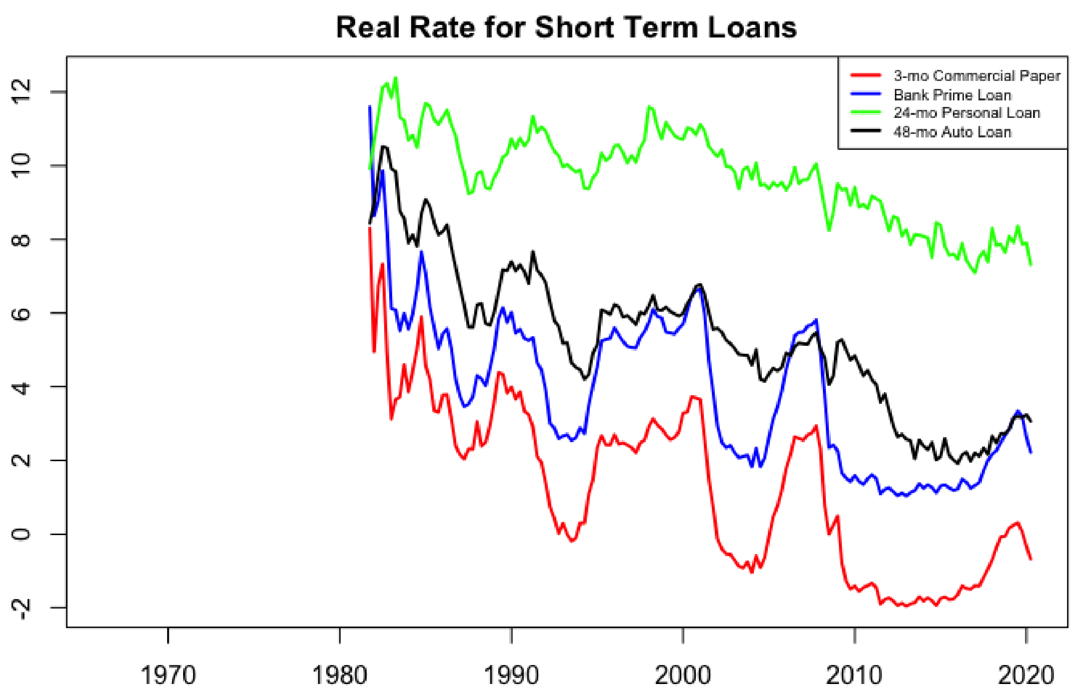
Now, estimate $(\hat{u_t^G})$ from eq(7) and plug it in eq(8),

$$Y_t = \phi_{21} G_{t-1} + \phi_{22} Y_{t-1} - (a_{21} - c_{22}) X_{t-1} - a_{21} \hat{u_t^G} + u_t^Y \tag{36}$$

A.5.2 Expected Inflation and Real Rates



(a) One year ahead inflation expectations



(b) Real interest rates based on Fisher equation

Figure A.10: Expected inflation and real interest rates

A.6 Local Projection (LP) Method

Let Y_t denote the vector of endogenous variables. A_0 is the Cholesky decomposition matrix inspired by Blanchard and Perotti's (2002) identification scheme. $Y_{t-1}, Y_{t-2}, ..., Y_{t-p}$ denotes the lags of endogenous variables and $A_1^h, A_2^h, ..., A_p^h$ are their coefficient matrices for forecast horizon h. X_t is the list of exogenous variables, including the Growth rate of Median Federal spending Forecast (GMF), the Growth rate of Median State and Local spending Forecast (GMS), Export (EX), Import (IM), Debt (D), Consumer Price Index (CPI), NBER Recession, and Interest Rate (i) where B_1^h is their coefficient matrix. I use one period lag of X_t to avoid simultaneity bias. $u_{t+h}^h, \alpha^h, T_{t+h}$ represent a vector of errors, constants, and trends in the structural model. Following Jordà (2005),

$$A_0 Y_{t+h}^h = \alpha^h + A_1^{h+1} Y_{t-1} + A_2^{h+1} Y_{t-2} + ... + A_p^{h+1} Y_{t-p} + B_1^h X_{t-1} + u_{t+h}^h + T_{t+h}^h \tag{37}$$

Jordà (2005) shows $\hat{A}_1^h$ is a consistent estimator of impulse response coefficients and satisfies distributional properties. Hence, structural Impulse Responses(IR) over the horizon are estimated as follows,

$$I\hat{R}_h = A_0^{-1} A_1^h; h = 0, 1, 2, 3, 4, ... \tag{38}$$

For $h = 0$, LP estimates are similar to the estimates from SVAR. As forecasting horizon h increases, the LP method updates the coefficients and re-estimates the IRFs, while the SVAR approach extrapolates from the same set of coefficients. This is why VAR IRFs are more vulnerable to the potential misspecification error in the model, and later impulse responses may not be comparable to the earlier responses. On the other hand, each estimate of IRFs from the LP method is comparable by design over the horizon. Scaled responses of all variables are estimated for structural innovation of a one percent increase in the shock variable. I convert the responses from percentage terms to USD equivalent to estimate the effects of a dollar increase in the shock variable.

A.6.1 IRFs

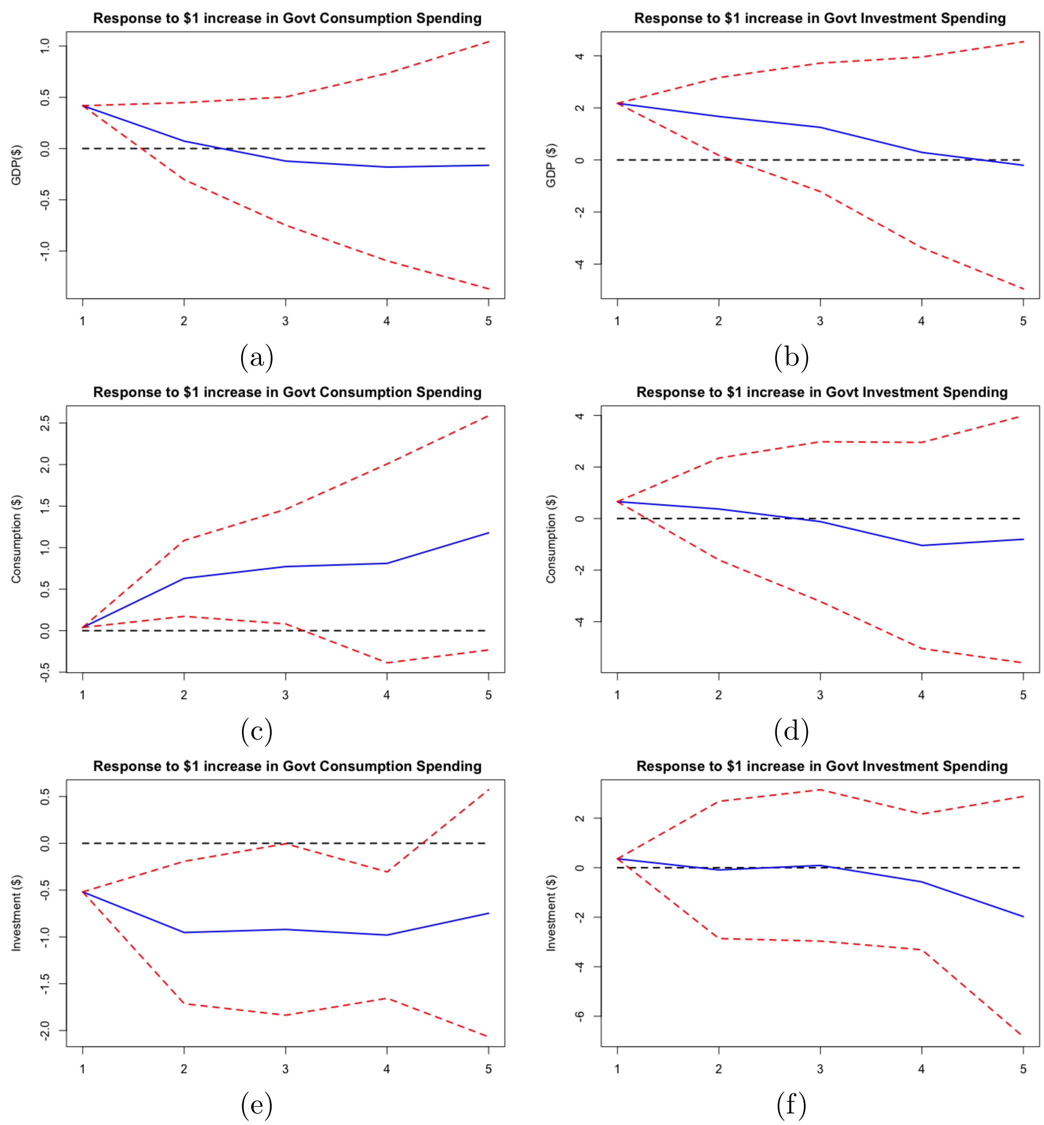


Figure A.11: Responses are estimated in real terms from LP IRFs for one USD increase in Government Consumption (GC) and Government Investment (GI). Confidence Intervals are reported at a 90 percent level, and impulse responses are estimated from the Local projection method using the AIC criterion