A disaggregated approach to the government spending shocks: an theoretical analysis

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13 March 2013

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ABSTRACT

We examine different types of government spending while literature usually treats government spending as a homogenous compound. We disaggregate the government spending into three parts; namely, government investment, government wage component consumption (i.e. wage expenditure) expenditure, and non-wage component consumption (i.e. purchases of goods and services). Next, we estimate a dynamic stochastic general equilibrium model that features a transmission mechanism with different types of government spending. In this regard, we manage to distinguish between different types of government spending where each type of spending has varied role in the economy. Such set up enables them produce different effects on macroeconomic variables.

Keywords: Disaggregated government spending, Government investment, Government wage consumption, Government non-wage component consumption, DSGE model.

JEL Codes: E62; H50

1. Introduction

The main contribution of this paper is that it features a transmission mechanism with different types of government spending: namely government investment, wage component government consumption and non-wage component government consumption. The mechanism works through government production which has a complementary relation with private consumption. Hence, government spending types that are used in the formation of government production have influence on households' preferences and should not be considered as wasteful due to their additional easing effects on the economy.

In the model, government production which plays a crucial role in attaining positive effects of private consumption is a function of government capital and government employment. Government capital is the accumulation of government investment and government employment is measured by government wage expenditure. These two types of spending are channeled into useful dispositions unlike government non-wage component consumption. Moreover, effects of government investment and government wage expenditure also differ from each other as government investment needs to be accumulated as government capital rather than used directly in the government production. Within this context, we claim that the composition of government spending is critical in the determination of spending multipliers and different types of government spending have varied effects on economic variables.

Nevertheless, government spending has been treated uniformly in most of the studies and as Leeper et al (2010) discusses, estimates of multipliers from these studies are all over the map, providing empirical support for virtually any policy conclusion. For instance, in the current economic crisis, United States passed a $787 billion fiscal stimulus plan in February 2009 with the hope of boosting demand, limiting job losses and preventing deep recessions. Yet, there was a lack of consensus among economists indicating where each dollar should be spent in order to minimize the adverse effects of the crisis.

In fact, the diversity of findings highlights the difficulties in obtaining reliable estimates of fiscal effects. This is mainly because responses of economic variables to government spending shocks depend on many factors; type of spending, how the spending is financed and how monetary policy acts in response. Thus, there is a need for systematic analysis that confronts all these fiscal policy complexities. In line with this, the objective of this paper is to shed light on the single effects of these factors in the context of a dynamic stochastic general equilibrium (DSGE) model.

The rest of the paper is organized as follows: Section 2 reviews the literature; Section 3 describes the model and provides the first order conditions whereas its linearized counterparts are given in Section 4. Section 5 explains the calibration. Section 6 presents the results and finally Section 7 concludes.

2.Literature Review

Most of the recent theoretical literature on fiscal policy in DSGE models has been motivated by the empirical evidence. From an empirical point of view, identification of government spending shocks is problematic and has been the subject of a lively debate in recent years.[1] However, theoretical models mainly attempt to capture the results of the VAR approach as this approach is considered as a means to account for the effects of government spending shocks in "normal" times, as opposed to extraordinary episodes like war or military build-up eras. Studies employing VAR approach typically find that a rise in total government spending (a positive spending shock) raises not only GDP, but also (private) consumption (e.g. Blanchard and Perotti (2002), Fatás and Mihov (2001), Gali et al (2007), Monacelli and Perotti (2008)). Regarding the response of private investment, it is found to be either insignificant as in Fatás and Mihov (2001) and Gali et al (2007) or negative (and significant) in Blanchard and Perotti (2002).

[1] See Perotti (2007) and Ramey (2009) for a summary of the issues.

The theoretical literature, driven by DSGE models, begins with studies that employ a standard neoclassical framework such as Aiyagari, Christiano and Eichenbaum (1992) and Baxter and King (1993).[2] These studies suggest that an increase in government spending creates a negative wealth effect for the households as they anticipate an increase in taxes to finance the increase of government spending.[3] Households optimally respond to this by decreasing their consumption and increasing their labor supply. The increased labor supply lowers the real wage but raises output. In the new steady-state, working hours are higher and consumption is lower which contradicts the empirical findings.[4]

Following Neoclassical models, New Keynesian models featuring a sticky price and monopolistically competitive environment were commonly used. The idea of introducing imperfect competition and sticky prices embedded in the New Keynesian models was promising for at least two reasons. First, imperfect competition generates an aggregate demand externality according to which an increase in output leads to a rise in profits and income. Higher profits and income in turn may help to offset the negative wealth effect. Secondly, sticky prices raise the possibility that labor demand reacts stronger than labor supply, with real wages increasing alongside labor supply[5]. Hence, in New Keynesian models, the wealth

[2] Infinitely-lived forward-looking agents, flexible prices, complete asset markets, and lump-sum taxation.
[3]Assuming they are financed by non-distortionary taxes.
[4] Response of investment depends on the persistence. If the shock is sufficiently persistent, the rise in the marginal product of capital leads to more investment and capital accumulation.
[5] To meet increasing demand stemming from increasing government expenditure, some firms will increase production as only a fraction of them can adjust their prices.

effect is accompanied by a demand effect due to price stickiness, whereby both effects increase output. Yet, the wealth effect has a negative impact on consumption while the demand effect has a positive impact. Accordingly, the net response of consumption depends on the relative strength of the two effects where wealth effect still dominates under plausible parameters.

As the standard New Keynesian model cannot replicate the response of increasing consumption under plausible parameters, it has been modified in order to attain increasing consumption. This was achieved by limiting the ability of the private sector to smooth consumption via asset markets, as in the model by Gali et al (2007). These authors have extended the standard New-Keynesian sticky-price model by allowing for the co-existence of “non-Ricardian” and “Ricardian” households, with the former simply consuming their after-tax disposable income each period and the latter optimizing in a forward-looking manner and thereby smoothing consumption over time. Accordingly, Ricardian agents are more sophisticated in the model because they can hold bonds and receive profits deriving from firms’ ownership. On the other hand, non-Ricardian households, also referred to as rule of thumb households, only consume their current disposable income each period and do not have the ability to borrow or save. As a result, they cannot smooth their consumption path in the face of fluctuations. Since this is a simple means of breaking Ricardian equivalence, presence of rule of thumb households contributes to the New Keynesian models in producing positive co-movement between government spending and consumption. Nevertheless, this analysis has been criticized as relying on a large percentage of rule of thumb households. For example, Coenen and Straub (2005) conclude that the estimated share of the non-Ricardian households in the euro area is not sufficiently large to deliver a positive response of consumption. Similarly, Iwata (2009) showed that the estimated mean value of non-Ricardian share is one fourth for Japan, which is half of what Gali et al (2007) are relying upon.

An alternative modification to the standard New Keynesian models is to allow consumer preferences to depend on government spending. Under such a modification, government spending gains an additional role in the economy. First studies assume that government expenditures and private consumption directly enter the utility function of the representative agent linearly such as Barro (1981), Aschauer (1985), Christiano and Eichenbaum (1992) and Finn (1998). Some of the recent studies exploit government spending through the concept of effective consumption, which is a constant elasticity of substitution (CES) aggregate of private consumption and government spending. Linnemann and Schabert (2006) and Bouakez and Rebei (2007) are examples of this kind. This work has similar a set up to these studies in the sense that household preferences depend on government spending in association with private consumption. However, such a structure is not applicable directly to all types of government spending.[6] Instead, it

[6] Even we include all types of government spending to the effective consumption, results do not change.

works indirectly through government production. In other words, we believe placing total government spending in the effective consumption is misleading as government spending itself may have no direct effect in this regard unless this spending is made use of in way that is beneficial for the public. For instance government can recruit workers and purchase all the machinery necessary for road construction. However, such employment and material purchase can contribute to a household's car consumption only if all these spending are put together in producing a highway, which is complementary to car consumption.

Hence, our model differs from other studies in two dimensions. First, government spending is disaggregated into three parts: government investment, government wage component consumption (government wage bill) and government non-wage component consumption (government purchases of intermediate goods and services).

Second, government has a productive role in the economy even though this production differs from the production of private sector in some aspects. In the next subsections, the objectives (together with the constraints) of the agents are presented and transmission mechanism of shocks is explained.

3 The Model

This section describes a dynamic general equilibrium model that consists of a representative household, a continuum of firms (indexed by *j*) producing differentiated intermediate goods, a perfectly competitive firm producing a final good, a central bank in charge of monetary policy, and government as a fiscal authority. All of the agents are infinitely lived and time is divided into periods and each period is indexed by the subscript *t*. The baseline model such as nominal rigidities in the form of price stickiness and real rigidities in the form of investment adjustment cost are standard to the literature. This framework serves as a starting point since it has been shown to fit the US data.

3.1 Households

The economy is populated by a single, infinitely lived, representative household. Households derive utility from leisure $(1-N)$ and effective consumption ($\tilde{C}_t$). In this representation, N_t, is the sum of hours worked for government (public employment; N^G) and hours worked for private sector (private employment; N^P): $N_t = N^G{}_t + N^P{}_t$. Likewise, effective consumption is defined as a CES index of private consumption (C) and government production (Y^G) similar to Bouakez and Rebei (2007):[7]

[7] The CES specification captures the idea of diminishing marginal returns to public spending in order to achieve a given level of effective consumption, ceteris paribus.

$$\tilde{C}_t = \left[aC_t^{\nu-1/\nu} + (1-a)(Y_t^G)^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}$$

In the above representation, a is the weight of private consumption in the effective consumption index and $\nu \succ 0$ is the elasticity of substitution between private consumption and government production. As $\nu \to \infty$, private consumption and government production become perfect substitutes. This is the case when government competes with private sector by producing rival goods. Providing free lunches is an example of government producing rival goods. In contrast, C_t and Y^G_t become perfect complements when $\nu = 0$ and government produces non-rival public goods. In this case, government production increases the marginal utility of consumption, providing an additional motive for households to work more. This, in turn, mitigates the negative wealth effect. Education services, knowledge generated by R&D, legislative services are examples of government production. A critical question at this point is whether private consumption and public spending are complements or substitutes. This has been examined by several studies such as those by Aschauer (1985), Karras (1994), Ni (1995), Amano and Wirjanto (1998), and Okubo (2003). The empirical results, however, are mixed and inconclusive.

In the model, households have preferences described by the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(\tilde{C}_t, N_t)$$

where

$$U(\tilde{C}_t, N_t) = \left[\frac{(\tilde{C}_t)^{1-\sigma}}{1-\sigma} - \kappa \frac{N_t^{1+\psi}}{1+\psi} \right]$$

In the above representation; $\beta \in (0,1)$ is the discount factor, E_t is the time t conditional expectation operator and $N_t = N^G{}_t + N^P{}_t$ as previously defined.

The budget constraint faced by the household is as below:

$$P_t(C_t + I_t) + \frac{B_{t+1}}{R_t} = P_t W^G{}_t N^G{}_t + P_t W^P{}_t N^P{}_t + P_t R^k{}_t K_t + B_t - P_t T_t$$

In this representation, P_t is the price level, $W^P{}_t$ is the private sector real wage, and $W^G{}_t$ is the public sector real wage. As indicated by the budget constraint, households receive labor income of $P_t W_t^P N_t^P$ from private sector and $P_t W_t^G N_t^G$ from public sector as compensation to working.

Capital accumulation (K_t) evolves according to the law of motion (as in Christiano et al. 2005);

$K_{t+1} = (1-\delta)K_t + I_t - I_t\phi_t$ where $\phi_t = \frac{\xi}{2}[\frac{I_t}{I_{t-1}} - 1]^2$ and function ϕ_t satisfies $\phi = \phi' = 0$ and $\phi'' > 0$ in steady-state. With such specification, adjustment costs are proportional to the rate of change in investment and it is costly to change the flow of investment. Thus, investment is inertial; it is unresponsive in the short run, but starts to build up its response gradually over time.

Following Cordoba, Perez and Torres (2009), an important assumption is that there is a positive wage premium received by public sector employees relative to private sector employees. This is the case for countries having a small share of public employment in the labor market. The existence of such a positive premium is a well-documented empirical fact of developed economies, as shown in the surveys of Ehrenberg and Schwarz (1986), Bender (1998), and Gregory and Borland (1999). While there is little research on the determinants of the public wage premium, the literature on public sector labor markets reveals that the influence of public sector labor unions and the ”vote producing” activities by civil servants are the potential reasons for the existence of the earnings differential. In the US, for instance, the most prominent unions are among public sector employees such as teachers and police.

In conjunction with this assumption, the public wage in the model is deemed as the upper limit of the private wage. Such a setup is consistent with the varying public wage premium shown in Figure 1. This figure illustrates how the private and public sector are associated in the labor market by exploiting OECD Economic Outlook Database. The upper panel of the figure shows how this premium has changed over time in the US and in Euro Area. The ratio of public wages over private wages has fluctuated between 1 and 1.2 in the US whereas this ratio has risen as high as 1.4 in Euro Area. Lower panel of the same figure displays the ratio of public employees over private employees during the same period. Accordingly, the public/private wage premium has had a somewhat parallel reflection in the evolution of the ratio of government sector employees to private sector employees. For instance, the ratio of public to private employees in the Euro Area reached a maximum in the second half of the 1980s. This corresponds to the period in which the wage premium reached its minimum.

According to the budget constraint presented above, households receive income from renting their capital holdings (K_t) to intermediate firms and purchasing nominally riskless one-period bonds (B_t). The (real) rental cost of capital is R^k_t and the gross nominal return on bonds is R_t. Lastly, I_t and D_t respectively denote investment expenditures and dividends from ownership of firms while T_t is lump-sum taxes (or transfers, if negative) paid by these consumers.

The first order conditions (with respect to C_t, N_t^P, K_{t+1}, Bt_{+1} and I_t) for the household maximization problem are given below. Note that the household maximizes only with respect to private labor as government employment is exogenously given to the households and the representative household initially meets the government labor demand as she earns a higher wage for working the government (This is due to the positive public wage premium). After meeting government labor demand which is a small portion of her total employment, she optimally chooses her labor supply for private sector.

$$\tilde{C}_t^{-\sigma+\frac{1}{v}} a C_t^{\frac{-1}{v}} = \lambda_t \quad \textbf{(1)}$$

$$N_t^{\psi} = \lambda_t W^P{}_t \quad \textbf{(2)}$$

$$\beta\left[\lambda_{t+1} R_{t+1}{}^k + \lambda_{t+1} Q_{t+1}(1-\delta)\right] = \lambda_t Q_t \quad \textbf{(3)}$$

$$\beta\left[\lambda_{t+1} R_t\right] = \lambda_t (1+\pi_{t+1}) \quad \textbf{(4)}$$

$$\lambda_t Q_t + 2\xi \frac{I_t}{I_{t-1}} \lambda_t Q_t + \beta\lambda_{t+1} Q_{t+1} \xi \frac{I^3{}_{t+1}}{I^3{}_t} = \lambda_t + \lambda_t Q_t \xi \frac{3I^2{}_t}{2I^2{}_{t-1}} + \lambda_t Q_t \frac{\xi}{2} + \beta\lambda_{t+1} Q_{t+1} \xi \frac{I^2{}_{t+1}}{I^2{}_t} \quad \textbf{(5)}$$

In these equations, Q_t represents the shadow price of additional unit of capital and is equal to one at its steady state. Similarly, λ_t represents the Lagrange multiplier of the budget constraint. Again note that the above expressions imply that the households choose the supply of private labor, given that public labor is determined inelastically by the government.

3.2 Firms

I assume that a continuum of monopolistically competitive firms produce differentiated intermediate goods that are used as inputs by a (perfectly competitive) firm producing a single final good.

Final Goods Firm

The final good is produced by a representative, perfectly competitive firm with a constant returns technology: $Y^P{}_t = (\int_0^1 X_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj)^{\frac{\varepsilon}{\varepsilon-1}}$ where $X_t(j)$ is the quantity of intermediate good used as an input and ε>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:

$X_t(j) = (\frac{P_t(j)}{P_t})^{-\varepsilon} Y^P{}_t$. Hence, the zero profit condition: $P_t = (\int_0^1 P_t(j)^{1-\varepsilon} dj)^{\frac{1}{1-\varepsilon}}$

Intermediate Goods Firm

The production function for an intermediate goods firm is given by: $Y^P{}_t(j) = K_t(j)^{\alpha_1} N_t{}^P(j)^{(1-\alpha_1)}$ where $K_t(j)$ and $N_t(j)$ represent the capital and labor services hired by firm.

Cost minimization, taking the wage and the rental cost of capital as given, implies the optimality condition: $\frac{W^P{}_t}{R^k{}_t} = \frac{(1-\alpha_1)}{\alpha_1}\frac{K_t(j)}{N^P{}_t(j)}$ **(6)**

Real marginal cost is common to all firms:

$$MC_t = \frac{(1-\alpha_1)^{\alpha_1-1}}{\alpha_1^{\alpha_1}}\frac{(W_t{}^P)^{1-\alpha_1}}{(R_t{}^k)^{-\alpha_1}} \quad \textbf{(7)}$$

Price Setting

Intermediate firms are assumed to set nominal prices in a staggered fashion, according to the rule proposed by Calvo (1983). Each firm resets its price with probability 1-θ of each period, independent of the time elapsed since the last adjustment. Thus, each period a measure 1-θ of producers reset their prices, while a fraction θ keep their prices unchanged. A firm resetting its price in period *t* will seek to solve:

$$\text{Max}_{(P^*)} \sum_{k=0}^{\infty} \theta^k E_t\{\frac{C_t}{C_{t+k}} \beta^k Y^P{}_{t+k}(j)[(P^*{}_t / P_{t+k}) - MC_{t+k}]\}$$

subject to the sequence of demand constraints: $Y^P{}_{t+k}(j) = X_{t+k}(j) = (P^*{}_t / P_{t+k})^{-\varepsilon} Y^P{}_{t+k}$

First order conditions can be obtained from the maximization as;

$$E_t \sum_{k=0}^{\infty} \theta^k E_t \{ \frac{C_t}{C_{t+k}} \beta^k Y^P{}_{t+k}(j)((P^*{}_t / P_{t+k}) - \mu MC_{t+k})\} = 0 \quad \textbf{(8)}$$

where $\mu \equiv \varepsilon / (\varepsilon - 1)$ is the gross "frictionless" price markup at zero inflation steady state. Hence, at steady state: $MC \equiv 1 / \mu \equiv (\varepsilon - 1) / \varepsilon$

Finally, the equation describing the dynamics for the aggregate price level is given by:

$$P_t = \left[\theta P_{t-1}{}^{1-\varepsilon} + (1-\theta)(P_t^*)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \quad \textbf{(9)}$$

3.3. Monetary Policy

The stance of monetary authority is important in determining the movements of the real interest rate, which plays a role in how macroeconomic variables react to spending shocks. For instance, recent work by Cogan, Cwik, Taylor, and Wieland (2009) and Christiano, Eichenbaum, and Rebelo (2009) have pointed out that when the monetary policy is completely unresponsive or the nominal interest is at the zero bound, the monetary-fiscal interactions have significant effects on the size of fiscal multipliers.

On the other hand, we consider the case of active monetary policy where the central bank is assumed to set the nominal interest rate $r_t \equiv R_t - 1$ every period according to a standard Taylor type rule:

$$r_t = r + \varphi_{\Pi} \pi_t + \varphi_y \hat{y}_t + \varepsilon_t \quad \textbf{(10)}$$

where r is the steady state nominal interest rate and both parameters are positive. In this equation, and henceforth, lower-case letters with hats denote log-deviations with respect to the corresponding steady state values. Thus, this rule implies that the nominal interest rate should respond to divergences of actual inflation rates from *target* inflation rates and of actual Gross Domestic Product (GDP) from *potential* GDP. Such representation is sufficient to reflect the variations in the Federal Funds rate over the Greenspan era which corresponds to the second half of our sample period.

3.4. Fiscal Policy

The government's budget is constraint is defined as below:

$$P_t T_t + \frac{B_{t+1}}{R_t} = B_t + P_t (GI)_t + P_t (GW)_t + P_t (GNW)_t$$

where *(GI)*, *(GW)* and *(GNW)* respectively represent government investment, government wage consumption and government non-wage consumption. According to the budget equation, government can finance its spending either by borrowing (debt, B_t) or taxing households (T_t).

Regarding the government's fiscal rule, unlike monetary policy, there isn't any widely accepted specification. Leeper (1991) initially mentions a fiscal rule with taxes responding to the level of real outstanding government debt. Then, McGrattan (1994) introduces reduced form fiscal rules with a VAR representation of exogenous state variables, government spending and tax rates and Schmitt-Grohe and Uribe (2007) show that such rules can approximate optimal policy rules. Following these studies, we assume below fiscal rule for the government:

$$\hat{t}_t = \varphi_b \hat{b}_t + \varphi_g \hat{g}_t \qquad \textbf{(12)}$$

where parameters are again positive constants.[8]

On the spending side, all types of government spending (in deviations from steady state, and normalized by steady state values) are assumed to evolve exogenously according to some autoregressive process of AR(1):

$$(g\hat{w})_t = \rho_{gw}(g\hat{w})_{t-1} + e_t \qquad (gn\hat{w})_t = \rho_{gnw}(gn\hat{w})_{t-1} + e_t \qquad (g\hat{i})_t = \rho_{gi}(g\hat{i})_{t-1} + e_t$$

where $0 < \rho < 1$, and e_t represents an i.i.d. government spending shock with constant variance.

For government wage expenditure, which is the multiplication of government employment and public wage, the shock stems from the government employment according to the model. This is because we have already assumed public wage is constant and defined as the maximum amount that private wage can reach.

In addition to its standard tasks, we assign a production role to the government. Thus, the government is assumed not only to spend and collect lump-sum taxes (T_t) from households but also to produce. From this aspect, this study is similar to Cavallo (2005) in which government produces output by using a fraction of its purchases of goods in combination with the labor hired from households. On the

[8] As parameters of fiscal rule (φ_b, φ_g) can differ from each other, we keep debt (B_t) in the budget equation even though taxes are lump-sum.

other hand, unlike Cavallo (2005), an important feature of government production in this study is that government production is not sold in the market; hence it is not a component of total output.

The government produces government output, Y^G, from government capital, *(GK),* and public employment, (N^G), according to the following production function:

$$Y^G{}_t = (GK_t)^{\gamma_1} (N^G{}_t)^{1-\gamma_1} \qquad \textbf{(11)}$$

According to (11), we assume that the government combines hours and its capital to assemble what we refer to as government output. This is consistent with the NIPA tables as shown in Table 2.1. According to this table, added value of government corresponds to the sum of compensation of government employees and government consumption of fixed capital. BEA categorizes both items as government consumption expenditures. For purposes of the model, however, we classify government consumption of fixed capital in the context of government investment, as it is merely a measure of the services of general government fixed assets and represents depreciation of capital goods.

As before government's capital accumulation of government evolves as below;

$$(GK)_{t+1} = (1-\delta)(GK)_t + (GI)_t - (GI)_t \phi_t \qquad \text{where } \phi_t = \frac{\xi}{2}[\frac{I_t}{I_{t-1}} - 1]^2$$

As described in Section 3.1, government production has a role in the formation of effective consumption together with private consumption. Hence, depending on the data, government production might possess either complementary or substitute characteristics to private consumption. For instance, while government spending used for building a highway is complementary to car consumption, it becomes a substitute if the government gives the same car itself as subvention.

3.5. Market Clearing:

The clearing of factor and good markets requires that the following conditions are satisfied:

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

$$Y_t = Y^P{}_t = X_t(j)$$

$$G_t = (GI)_t + (GW)_t + (GNW)_t \quad Y_t = C_t + I_t + G_t$$

$$N_t = N^P{}_t + N^G{}_t = \int_0^1 N_t(j)dj + N^G{}_t$$

4. Linearized Equilibrium Conditions

In the present section, we derive log-linear versions of the key optimality and market-clearing conditions that will be used in the analysis of the model's equilibrium dynamics. Some of these conditions hold exactly, whereas others represent first order approximations around a zero-inflation steady state. As a reminder, lower-case letters with hats denote log-deviations with respect to the corresponding steady state values.

4.1. Households

Next we list the log-linearized versions of the defined households' optimality conditions, expressed in terms of the aggregate variables. Log linearizations of the first order equations from **(1)** to **(5)** are respectively presented below:

$$\hat{\lambda}_t = (-\sigma + \frac{1}{v})(\hat{\hat{c}})_t - \frac{1}{\hat{v}}\hat{c}_t \quad \textbf{(13)}$$

$$\hat{\lambda}_t + \hat{w}^p{}_t = \psi\hat{n}_t \quad \textbf{(14)}$$

$$\beta\overline{R}^k(\hat{\lambda}_{t+1} + r^k{}_{t+1}) + \beta(1-\delta)(\hat{\lambda}_{t+1} + \hat{q}_{t+1}) = \hat{\lambda}_t + \hat{q}_t \quad \textbf{(15)}$$

$$\hat{\lambda}_{t+1} + r_t = \hat{\lambda}_t + \pi_{t+1} \quad \textbf{(16)}$$

$$\hat{q}_t + \xi(\hat{i}_{t-1} - \hat{i}_t) + \beta\xi(\hat{i}_{t+1} - \hat{i}_t) = 0 \quad \textbf{(17)}$$

Lastly, the log-linearized capital accumulation equations are as follows:

$\hat{k}_{t+1} = (1-\delta)\hat{k}_t + \delta\hat{i}_t$ and

$$(g\hat{k})_{t+1} = (1-\delta)(g\hat{k})_t + \delta(g\hat{i})_t$$

Also, note that private wage can be obtained from **(13)** and **(14)** as:

$$\hat{w}^p{}_t = \psi\hat{n}_t - \left[(-\sigma + \frac{1}{v})(\hat{\hat{c}})_t - \frac{1}{v}\hat{c}_t\right]$$

4.2. Firms

Starting with the firms' production function (which is also equal to total production in the economy as government production is not sold), the log-linearized of it is presented below:

$$\hat{y}^p{}_t = \alpha_1\hat{k}_t + (1-\alpha_1)\hat{n}^p{}_t \quad \textbf{(18)}$$

Moreover, log-linearization of **(8)** and **(9)** around the zero inflation steady state yields the familiar equation describing the dynamics of inflation as a function of the log deviations of the real marginal cost from its steady-state level:

$$\pi_t = \beta\pi_{t+1} + \zeta(m\hat{c})_t \qquad \text{where } \zeta = \frac{(1-\theta)(1-\beta\theta)}{\theta} \tag{19}$$

Ignoring constant terms; $\hat{w}^p{}_t = \hat{y}^p{}_t - \hat{n}^p{}_t + (m\hat{c})_t$ and $r^k{}_t = \hat{y}^p{}_t - \hat{k}_t + (m\hat{c})_t$**.** Equivalently, defining the average mark up in the economy as $\hat{\mu}_t = -(m\hat{c})_t$,

equations given above can be written as a function of average mark up.

4.3 Fiscal Policy

Linearization of the government production function is given by:

$$\hat{y}^g{}_t = \gamma_1(g\hat{k})_t + (1-\gamma_1)\hat{n}^g{}_t \tag{20}$$

And $(g\hat{k})_{t+1} = (1-\delta)(g\hat{k})_t + \delta(g\hat{i})_t$

Furthermore, linearization of the government budget constraint around a steady state with zero debt and a balanced primary budget yields

$$\frac{\overline{T}}{\overline{B}}\hat{t}_t + \frac{(\hat{b}_{t+1} - r_t + \hat{\pi}_{t+1})}{\overline{R}} = \hat{b}_t + \frac{\overline{G}}{\overline{B}}\hat{g}_t \tag{21}$$

4.4. Market Clearing

$$\hat{y}_t = \hat{y}^p{}_t$$

$$\hat{y}_t = \frac{\overline{C}}{\overline{Y}}\hat{c}_t + \frac{\overline{I}}{\overline{Y}}\hat{i}_t + \frac{\overline{G}}{\overline{Y}}\hat{g}_t$$

$$\hat{g}_t = (g\hat{i})_t \frac{(\overline{G}\,\overline{I})}{\overline{G}} + (g\hat{w})_t \frac{(\overline{G}\,\overline{W})}{\overline{G}} + (gn\hat{w})_t \frac{(\overline{G}\,\overline{N}\,\overline{W})}{\overline{G}}$$

$$\hat{n}_t = \frac{\overline{N}^P}{\overline{N}}\hat{n}^p{}_t + \frac{\overline{N}^G}{\overline{N}}\hat{n}^g{}_t$$

5. Calibration

In the present section we analyze the effects of shocks to each government spending type in the model economy described above. To do so, we calibrate our parameters in line with the literature. This includes setting the subjective discount factor β to 0.99 (so that the annual steady state real return on financial assets is 4%), the depreciation rate δ to 0.025 (implying a 10% annual depreciation rate of capital), the production function parameters of firms (α_1) to 0.33 and of government (γ_1) to 0.85 (which makes the steady state labor share in income approximately equal to 67% and 15% respectively). We take weight of disutility from working (κ) in the utility function as 1. These values are roughly consistent with the data as discussed by Gali et al (2007). Furthermore, the capital adjustment cost parameter of ξ is assigned a value equal to 3 as estimated by Christiano et al. (2005) and Schmitt-Grohé and Uribe (2008).

Regarding the ratios employed in the paper, US data is examined. Some of the steady state variables are also calibrated based on averages over the sample period considered in the paper. In this perspective, steady-state ratios of debt to GDP and total government spending to GDP are set as 0.33 and 20 percent respectively. Shares of government wage expenditure, non-wage consumption and government investment are calibrated as 50, 25 and 25 percent of total government spending respectively reflecting their average shares for the US over the sample. The share of government working hours in total working hours is set as 1/6. Figure 2 and 3 illustrate the data associated with the stated ratios. Additionally, a steady state price markup (μ-1) of 0.2 is chosen by setting ε equal to 6. The fraction of firms that keep their prices unchanged (θ) is given a baseline value of 0.75 implying to average price duration of one year.

Parameters obtained from the US data are shown below in line with Gali et al (2011) and Bouakez and Rebei (2007):

	Description	**Values**
ψ	Elasticity of wages with respect to hours	0.20
σ	Inverse of elasticity of intertemporal substitution	1.00
a	Weight of private consumption	0.80
ρ	Autoregressive parameter of government spending shocks	0.90
γ_y	Response of nominal interest rate to output	0.50
γ_π	Response of nominal interest rate to inflation	1.50
ϕ_b	Response of tax to debt	0.33
ϕ_g	Response of tax to government spending	0.10

For the elasticity of substitution parameter between C and Y^G (ν), we use several values given that this is a crucial parameter representing the degree of substitution between government production and (private) consumption in our model. Yet, our inferences are based on the results obtained from employing this parameter as 0.25 or 0.5. This is mainly because Bouakez and Rebei (2007) attain this parameter as 0.33 in their work in a similar set up.

6 Results

6.1 Responses of the Model

Figures 4, 5 and 6 display the response functions of output, (private) consumption and (private) investment given one percentage point shock to each type of government spending. The x-axis shows quarters after the shock hits the economy and the y-axis shows deviations from the steady state in response to a unit shock in government spending.

Figure 6 shows the output responses to an increase in each type of government spending. Output rises on impact in all graphs which is a common finding in the empirical literature. Apart from this, these graphs indicate that size of output responses differ among the spending types. Regarding (private) consumption, it increases in response to a shock in government wage expenditure but decreases in response to a government non-wage consumption shock. Lastly, responses of (private) consumption are initially negative in the case of government investment shocks, but become positive over time while government investment accumulates as government capital.

Regarding the positive effects of government spending shocks on output and consumption, government production (which is a function of government wage consumption and government capital) plays a role in offsetting the negative wealth effect in addition to price stickiness and imperfect competition. Typically, given a government spending shock, households foresee to be taxed later. In order to compensate this negative effect, they optimally choose to increase their labor supply which in turn lowers their real wage. As a result, output rises with increasing labor but consumption shrinks due to the negative wealth effect. However, adding government production into the mechanism mitigates the negative wealth effect as government production serves as a complement to private consumption in the formation of effective consumption. Hence, a government wage consumption shock (and a government investment shock after a certain period of time) increases the marginal utility of consumption providing an additional motive for households to consume (as shown in Figure 5).

Lastly, the responses of (private) investment, all types of spending shocks have negative effects (shown in Figure 4). This result is in line with Blanchard and

Perotti (2002) which obtain negative responses of (private) investment given a spending shock.

6.2 Impact Multipliers

Following Blanchard and Perotti (2002), studies generally summarize the effects of government spending by the impact multiplier, which is the increase in the level of output *k* periods ahead in response to a change in the fiscal variable of interest given by ΔG_t at time *t*.[9]

Impact multiplier *k* periods ahead = $\frac{\Delta Y_{t+k}}{\Delta G_t}$

Figure 7 shows how output multipliers vary over time with respect to the parameter representing the degree of substitution between government production and (private) consumption. For our benchmark cases (for which ν is 0.25 or 0.5 implying that government production and private consumption are complements), government wage expenditure shock has the largest output multipliers indicating that a fiscal stimulus plan should primarily include government wage expenditure. On the other hand, government wage expenditure shock produces the smallest multipliers if the government output of a particular country acts as a substitute with private consumption.

[9] For instance the government spending multiplier is computed as follows, $\frac{\Delta Y_{t+k}}{\Delta G_t} = \frac{\%\Delta Y_{t+k}}{\%\Delta G_t}\frac{Y}{G}$, where Y and G are the steady state values of output and government spending respectively.

Output multipliers of government investment and government non-wage consumption are mostly parallel to each other. Yet, smaller the degree of substitution between government production and (private) consumption, the bigger the multiplier of government investment becomes on average.

7 Conclusion

In the paper, total government spending has been disaggregated in the context of a theoretical model which assigns different roles to each type of government spending. The model incorporates a transmission mechanism regarding the effects of various types of government spending on economic variables. The government wage component of consumption has the largest effect on economic variables affecting the economy through the public sector employees necessary for government production. Government investment has a similar transmission mechanism but its effects are limited as it needs to accumulate as government capital. Additionally, all types of spending shocks influence the output directly as they are components of the total government spending.

Figures 4-6 demonstrate the contemporaneous responses in output, private consumption and private investment to each type of government spending shocks. Accordingly a government wage expenditure shock has positive effects both on private consumption and output. As this spending type constitutes half of the total spending, total government spending usually reflects the responses to government wage expenditure shocks. Other two government spending types have also positive effects on output whereas their responses on (private) consumption and (private) investment are mostly negative. Yet, negative effect of government investment shock on (private) consumption turns to positive over time as the government capital reaches a certain level.

Consequently, these results provide an explanation for the wide range of multipliers existing in the literature. An equal amount of total government spending might have different multipliers depending on its composition as different types of government spending have different effects on output and private consumption. With this set up, we bring an alternative explanation to the empirical puzzle of increasing consumption given a government spending shock in addition to Gali et al (2007). These authors decompose the standard representative household into two types by introducing rule of thumb household and emphasizing their consumption behavior difference. We also feature a disaggregating approach but in total government spending (rather than the representative household) and assign different roles to each type.

References

Aiyagari R., L. Christiano and M. Eichenbaum (1992). “Output, Employment and Interest Rate Effects of Government Consumption”, *Journal of Monetary Economics*, 30, 73–86.

Baxter, Marianne, and Robert King (1993). “Fiscal Policy in General Equilibrium”, *American Economic Review*, 83, 315–334.

Bender, K. (1998). “The central government-private sector wage differential”, *Journal of Economic Surveys*, 12, 177-220.

Blanchard, Olivier, and Roberto Perotti (2002). “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output.” *Quarterly Journal of Economics*, 117, 1329–1368.

Bouakez, H. and N. Rebei (2007). “Why does Private Consumption Rise After a Government Spending Shock?” *Canadian Journal of Economics*, 40 (3), 954-979.

Calvo, Guillermo (1983). “Staggered Prices in a Utility Maximizing Framework”, *Journal of Monetary Economics*, 12, 383–398.

Cavallo, M. (2005). “Government employment expenditure and the effects of fiscal policy Shocks”, Working Paper 16, Federal Reserve Bank of San Francisco.

Christiano L.J., Eichenbaum, M., Evans, C., (2005). “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”. Journal of Political Economy 113(1), 1-45.

Christiano L.J., Eichenbaum, M., Evans, C., (2009) “When is the Government Spending Multiplier Large”, NBER Working Paper 15394

Cogan, J. F., T. Cwik, J. B. Taylor, and V. Wieland (2009) New Keynesian versus Old Keynesian Government Spending Multipliers," NBER Working Papers 14782, National Bureau of Economic Research, Inc.

Coenen, G. and R. Straub (2005). “Does Government Spending Crowd in Private Consumption? Theory and Empirical Evidence for the Euro Area.” *International Finance*, 8, 436-470.

Cordoba G.D., Perez J.J. And Torres J.L. (2009), “Public and Private Sector Wages Interactions in a General Equilibrium Model”, ECB Working Paper Series, 1099.

Ehrenberg, R.D. and Schwarz, J.L. (1986). Public-sector labor markets, in Ashenfelter, O. and Leyard, R. (eds.), *Handbook of Labor Economics*, Vol. 2, North-Holland.

Fatás, Antonio, and Ilian Mihov (2001). “The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence”, Working paper, INSEAD.

Galí, J., López-Salido, J.D., Vallés, J., (2007). “Understanding the effects of government spending on consumption”, *Journal of the European Economic Association*, 5(1), 227-270.

Gregory, R, and Borland, J. (1999). Recent developments in public sector labor markets, in O. Ashenfelter & D. Card (ed.), *Handbook of Labor Economics*, edition 1, volume 3, chapter 53, p. 3573-3630 Elsevier.

Iwata Y. (2009). “Fiscal Policy in an Estimated DSGE Model of the Japanese Economy: Do Non-Ricardian Households Explain All?”, 15th International Conference on Computing in Economics and Finance.

Linnemann, L., Schabert A. (2006). “Productive Government Expenditure in Monetary Business Cycles” *Scottish Journal of Political Economy*, vol. 53(1), p. 28-46, 02

Monacelli, T., Perotti, R., (2008). “Fiscal Policy, Wealth Effects, and Markups”, NBER Working Paper No. 14584, National Bureau of Economic Research, December.

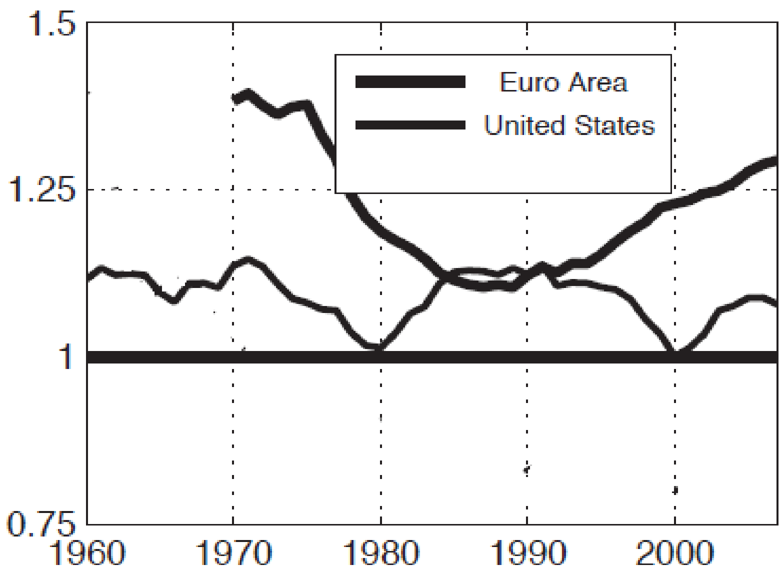
Perotti, Roberto (2007). "In Search of the Transmission Mechanism of Fiscal Policy", NBER Macroeconomics Annual.

Ramey, Valerie, and Matthew Shapiro (1998). “Costly Capital Reallocation and the Effect of Government Spending.” *Carnegie-Rochester Conference Series on Public Policy*, 48, 145–194.

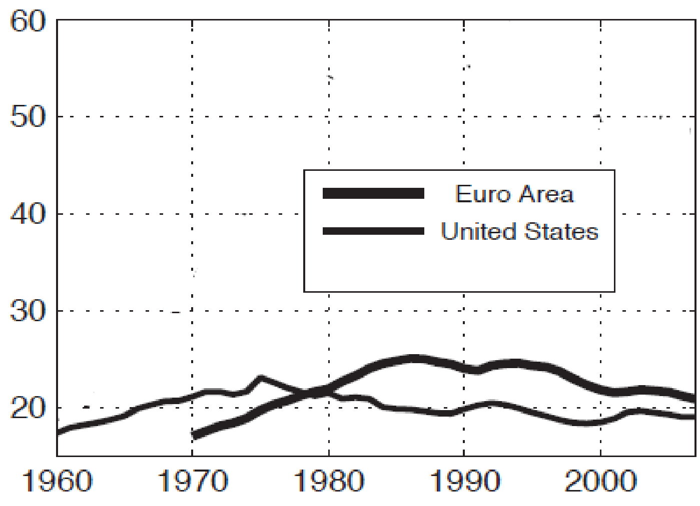
Schmitt-Grohé, Stephanie and Martín Uribe (2008): "What’s News in Business Cycle", NBER Working Paper No. 14215

Figure 1 Public/Private Sector Interaction

Ratio of Public/Private Sector Wages Per Employee



Ratio of Public/Private Sector Employee



Source: Labor force surveys (OECD).

Figure 2 Share of Total Government Spending in GDP (%)

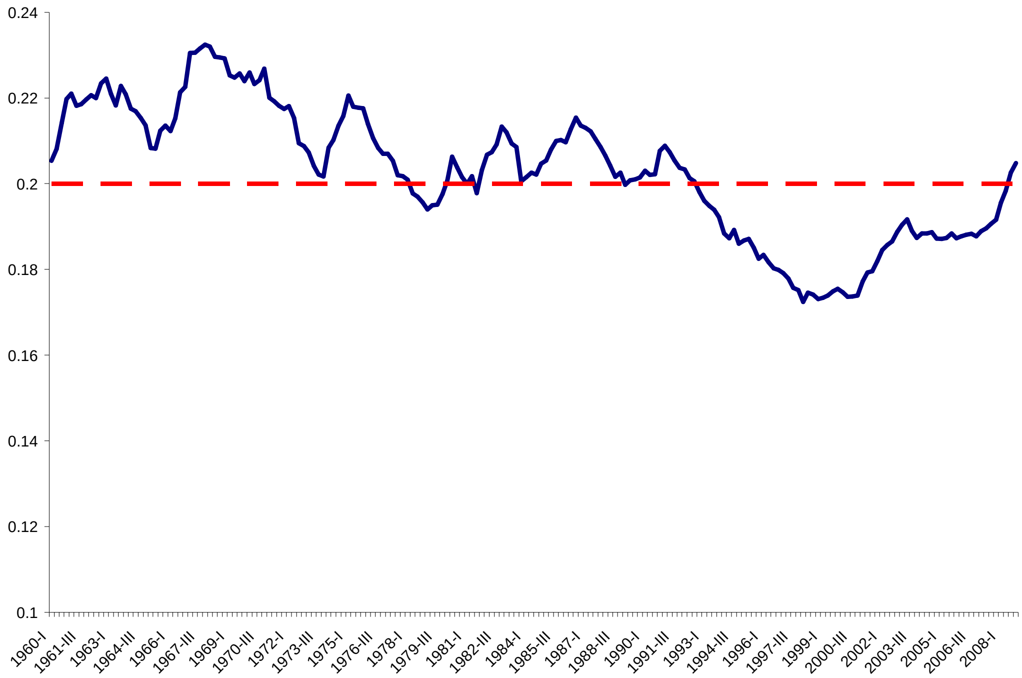


Figure 3 Ratio of Net Federal Debt to Output

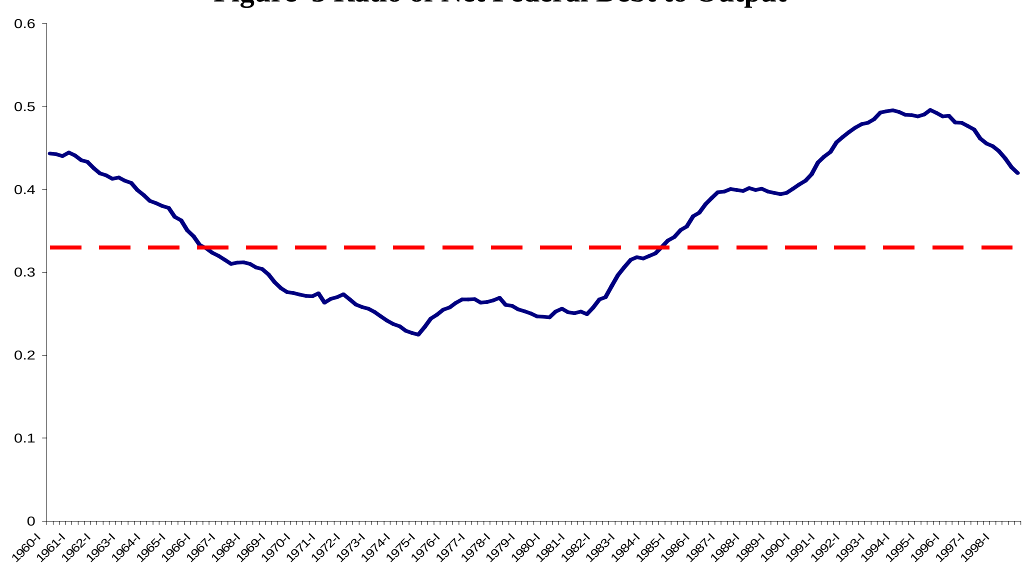
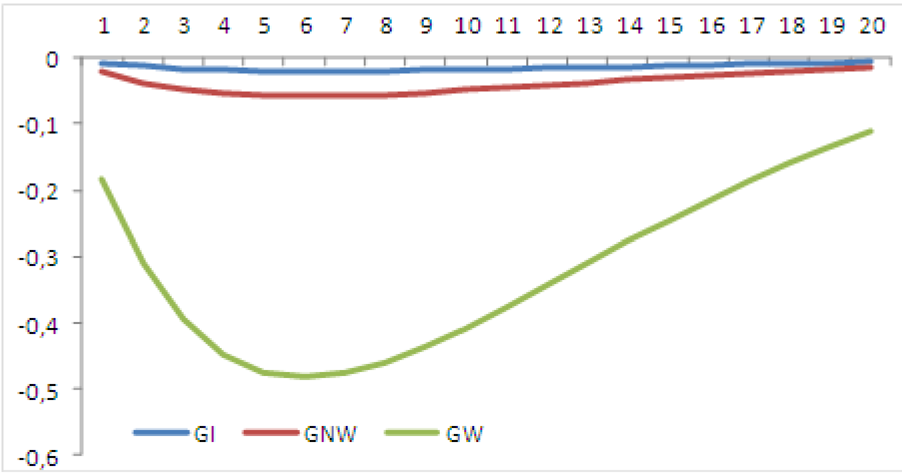


Figure 4 Model Responses of (Private) Investment

For ν =**0.25;**



For ν =**0.5;**

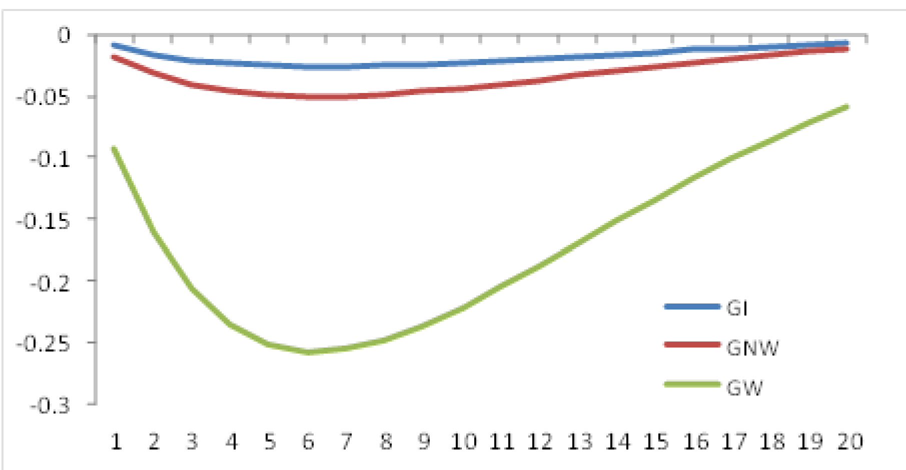
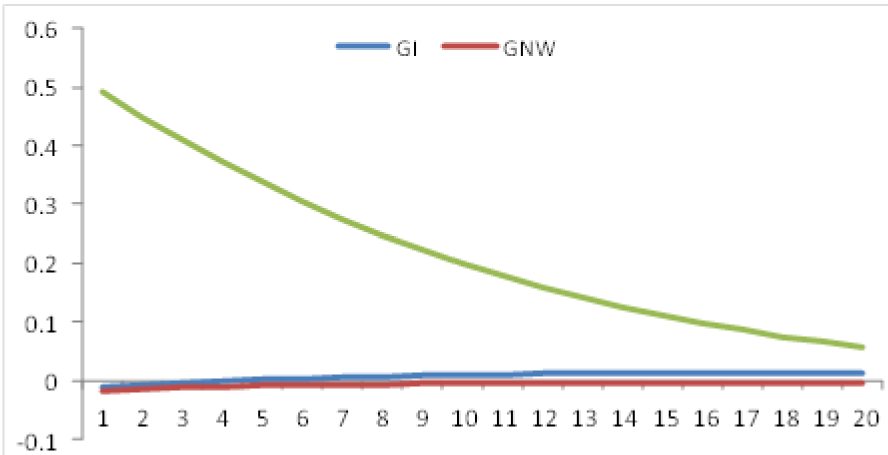


Figure 5 Model Responses of (Private) Consumption

For v =**0.25;**



For v =**0.5;**

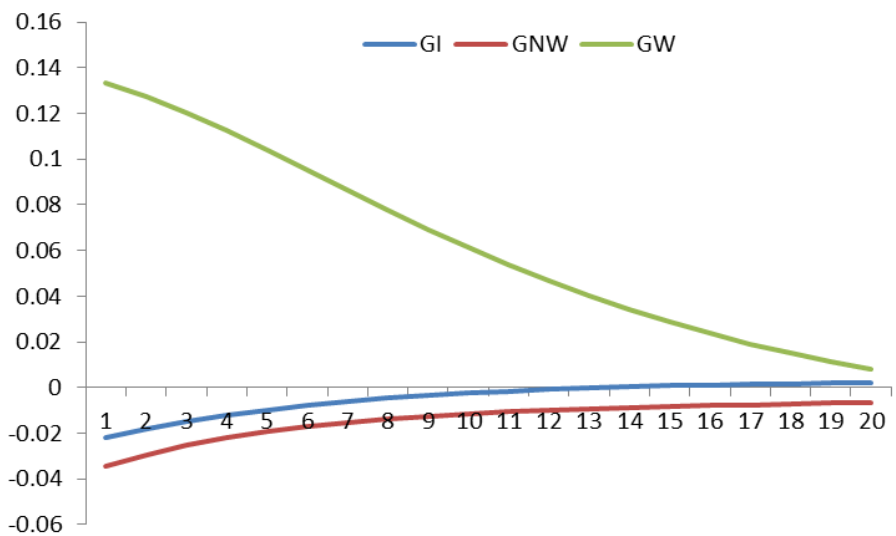
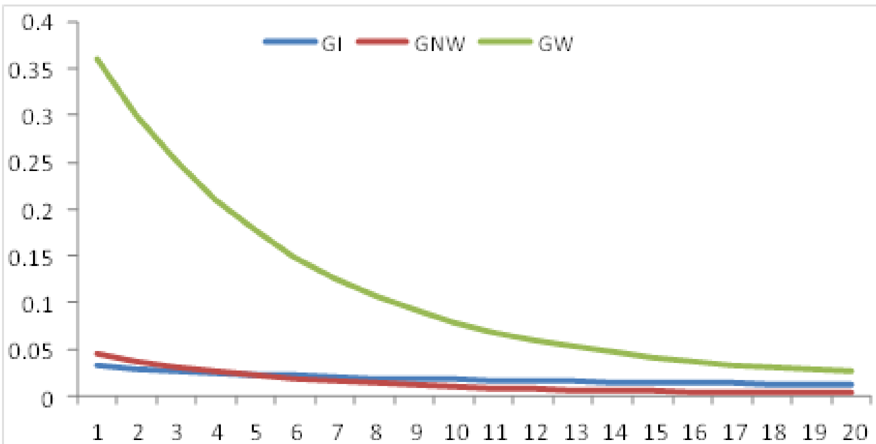


Figure 6 Model Responses of Output

For ν **=0.25;**



For ν **=0.5;**

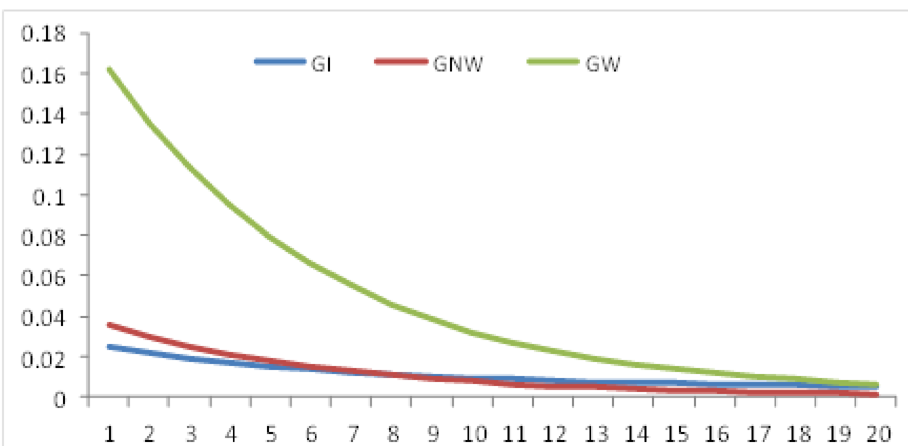
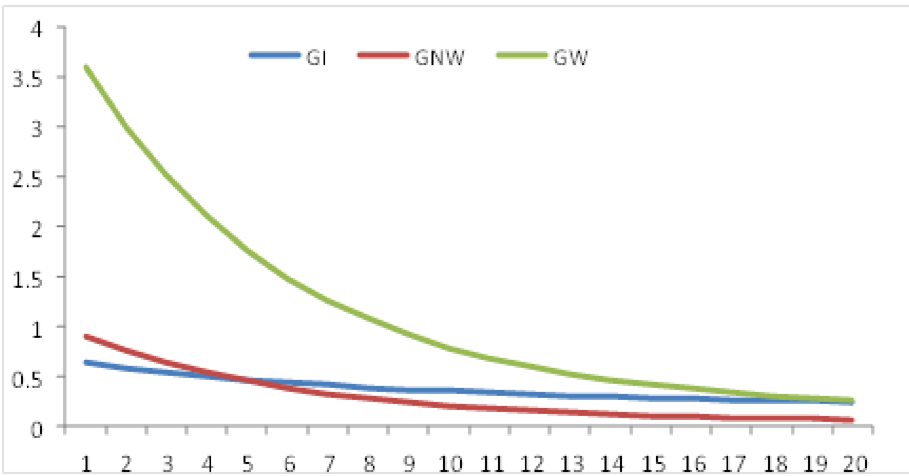


Figure 7 Output Multipliers

For v =**0.25;**



For v =**0.5;**