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Essays on Fiscal Policy

by

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Summary

This thesis contributes to three important issues relating to fiscal policy and its short-run effects on the real economy.

The first chapter investigates how housing wealth dynamics and collateral constraints jointly matter for the non-linear transmission of fiscal policy shocks. A dynamic stochastic general equilibrium (DSGE) model with housing investment and occasionally binding collateral constraints reveals a non-linear pattern of responses to fiscal shocks: positive government consumption shocks are more expansionary during times that housing wealth is relatively high and the collateral constraint is slack, while tax cuts are more expansionary during times that housing wealth is low and the collateral constraint binds. The key mechanism is a collateral channel that is in effect when the collateral constraint binds, while it is absent when the constraint is slack. Moreover, this collateral channel buffers government spending stimuli while boosts tax cut stimuli. Empirical evidence, using a threshold VAR model, confirms theoretical predictions.

The second chapter is a joint work with Evi Pappa and Eugenia Vella. We compare output, unemployment and deficit effects of fiscal adjustments in different types of government outlays in the US, Canada, Japan, and the UK. Shocks to government consumption, investment, employment and wages are identified in a structural VAR, using sign restrictions from a sticky price DSGE model with matching frictions in the private and public sector, endogenous labor participation and heterogeneous unemployed jobseekers. Government employment cuts induce the highest output losses, the smallest deficit reductions and significant unemployment increases in the US and the UK. On the other hand, wage cuts generate the lowest output and unemployment losses, and typically the highest deficit gains. According to the theoretical model, public wage cuts increase labor supply in the private sector and can undo the negative effects of the tightening, while public vacancy cuts reduce it and result in stronger contractions.

The last part naturally extends the analysis of the second chapter to open economies. In particular, this chapter studies the effects of disaggregated fiscal policy on the trade balance and the real exchange rate. Structural VAR estimations reveal distinct patterns for all shocks: gov-

ernment (non-wage) consumption and investment shocks induce a fall in private consumption, a real depreciation and an improvement of the US trade balance; public employment shocks lead to an increase in private consumption, a real depreciation and an improvement of the US net exports; finally, public wage shocks induce a decline in private consumption, a real appreciation and a deterioration of the trade balance. A two-country DSGE model with frictions in the labor market and complete international financial markets can replicate satisfactorily the empirical responses to government employment and wage shocks. However, a correlation puzzle emerges for public consumption and investment shocks: a fall in private consumption as a response to those shocks is accompanied by a real depreciation in data, while it is accompanied by a real appreciation in theory.

Chapter1

Non-linear effects of fiscal policy: the role of housing wealth and collateral constraints

1 Introduction

The burst of 2008 financial crisis and the subsequent recession have revived a hot debate in policy circles and academic research on whether countercyclical fiscal policy is effective in stimulating private activity during times of financial stress. This debate is partly based on the theoretical intuition that, during periods of adverse financial conditions, private agents are more likely to become liquidity constrained thus finding it hard to optimally smoothen their consumption along time. In turn, fiscal shocks will have relatively more pronounced effects on private demand during bad times. The seminal work of Perotti (1999) is one of the first attempts to document state-dependent effects of fiscal policy related to financial conditions, such as the number of liquidity constrained consumers in an economy and the level of public debt. Similarly, Tagkalakis (2008) directly controls for financial conditions. Both papers support the view that fiscal policy is more effective in stimulating private activity during times characterized by adverse financial conditions. They base their analysis on the assumption that during bad times the fraction of liquidity constrained (hand-to-mouth) households increases, thus raising the marginal propensity to consume in the economy. As a result, fiscal expansions raise disposable income and strongly trigger private consumption during bad times. In the same spirit, Gali et al. (2007) propose a model with *rule-of-thumb consumers* that are excluded from financial markets in order to replicate the positive response of private consumption after fiscal expansions. On the other hand, Canzoneri et al. (2012) provide a theory of state-dependent fiscal multipliers by postulating an ad-hoc positive relationship between the output gap and the interest rate spreads' elasticity to output. This mechanism plays the role of a financial accelerator for fiscal shocks; it speeds up reductions in spreads and economic recovery during recessions, while it implies only modest effects on spreads and output during normal times.

However, the theoretical literature discussed above has so far neglected a critical aspect: the increasing role of *collateralized credit*. Last decades financial markets have been developed rapidly and a greater fraction of people have gained access to credit. Commercial banks have provided massive credit to households which is collateralized by their existing housing property. What is more, figure 1 shows that house prices and real estate wealth in the US have experienced at least four boom-bust cycles in the last decades. Such sharp house price and wealth deviations from trend could seriously affect collateral capacity and the tightness of collateral constraints. A serious implication is that the transmission of fiscal policy shocks might be different between times that collateral constraints are tight and times that constraints become laxer or slack[1]. What is more, collateral constraints may not only matter as an initial condition for the transmission of fiscal shocks, but the endogenous reaction of the collateral to the shocks could also play a role. In particular, fiscal shocks may affect house prices, collateral capacity and borrowing limits. In turn, tighter or laxer borrowing limits could affect the volume of credit provided to households, and thus impact on their demand for consumption and investment. As models with collateral constraints become more and more appealing for policy analysis today, we should know what they imply for the transmission of fiscal policy[2].

The present paper attempts to fill the gap in the literature discussed above. In particular, we investigate how housing wealth dynamics and collateral constraints jointly matter for the non-linear transmission of fiscal policy shocks. A DSGE model with housing investment and *occasionally binding collateral constraints* reveals a non-linear pattern of responses to fiscal shocks. Most importantly, the implications are distinct from what existing non-linear models predict: fiscal policy may be relatively less effective in stimulating the economy during bad times (times of low housing wealth and tight credit). In the second part, we test the model's predictions in the data, providing empirical evidence of state-dependent effects of fiscal policy.

More analytically, in the first part we consider a *New Keynesian model* with heterogeneous households (savers and borrowers) and a two-sector production (non-durable goods and housing) similar to the models of Iacoviello and Neri (2010) and Guerrieri and Iacoviello (2013). The non-durable production sector features monopolistic competition and Calvo-type price rigidities. Borrowers are collateral-constrained, and the debt limit is determined by the their expected housing wealth. Incorporating housing investment and an occasionally binding collateral constraint into an otherwise standard DSGE model offers a critical link between housing wealth fluctuations and the tightness of collateral constraints, thus defining two distinct regimes/states of the economy: when housing wealth is low collateral capacity is also low

[1]This idea has been first introduced by Guerrieri and Iacoviello (2013) for the non-linear effects of house price shocks.

[2]Roeger and in't Veld (2009) and Andrés et al. (2012) analyze fiscal policy in models with collateral constraints but they restrict to linear analysis.

and the collateral constraint binds, while when housing wealth and the collateral capacity rise substantially the collateral constraint may become slack. The theoretical exercise consists of simulating the two distinct environments/regimes and calculating the model's responses to a government consumption and an income tax rate shock within each regime. The purpose is to document any non-linearities that arise across regimes.

The predictions of the theoretical model with respect to the fiscal shocks are the following; positive government consumption shocks have more pronounced and expansionary effects on output and private consumption in times characterized by high housing wealth and a slack collateral constraint rather than times of low wealth and a binding constraint. On the contrary, tax shocks are more effective in stimulating the economy when housing wealth is relatively low and the collateral constraint binds. The key mechanism is that when the constraint binds there is an extra transmission channel that comes from the valuation effects on the collateral (*collateral channel*). In particular, if the collateral constraint binds, then variations in the credit supplied to households are proportional to variations in the collateral capacity (borrowing limit). At the same time, positive government consumption shocks lead to lower real house prices, thus lower collateral value. As a result, government consumption shocks cause both collateral capacity and credit supplied to households to fall. The latter has a contractionary impact on households' consumption and investment. However, this negative effect of the collateral channel on private demand is absent when the collateral constraint is slack. For tax shocks the opposite holds; tax cuts induce an increase in real house prices and collateral capacity. When the constraint is slack, variations in collateral capacity are irrelevant for households' responses. However, when the constraint binds, then the credit supplied to households becomes proportional to their collateral capacity. Therefore, a tax cut will raise both collateral capacity and credit, thus inducing further expansionary effects on private demand for consumption and investment. Overall, an environment of low housing wealth and a binding collateral constraint implies *a collateral channel for the transmission of fiscal shocks that buffers government spending stimuli and boosts tax cut stimuli*.

In the next step, the paper attempts to reconcile theory with empirics. We estimate a *threshold VAR model*, and we identify government consumption and personal income tax shocks in order to track the effects of those shocks on several macrovariables. The VAR estimates are conditioned to a threshold variable that approximates housing wealth, and this is a house price index.

The main findings of the VAR estimation confirm theory; positive government consumption shocks have more pronounced and expansionary effects on output and private consumption during times that housing wealth is relatively high (above the threshold), while tax cuts are more expansionary during times that housing wealth is relatively low (below the threshold). Furthermore, positive spending shocks cause real house prices to fall, while tax cuts drive house prices up.

The results of this paper have significant policy implications. Given that the effectiveness of fiscal policy is not independent of the prevailing credit conditions, then nonlinear empirical studies should become the guidance for policy impact assessments. According to the results of this paper, linear estimates of fiscal multipliers may overestimate the effectiveness of government spending shocks and underestimate the effectiveness of tax shocks during times of financial stress.

The rest of the paper is organized as follows. Section 2 elaborates on the theoretical model while section 3 discusses the theoretical results. Section 4 consists of the empirical analysis. Section 5 provides some more discussion and sensitivity analysis that attempts to reconcile theory with empirics. In section 6 we make a direct comparison of the effectiveness of the two fiscal instruments (spending versus tax shocks). Finally, section 7 concludes.

2 The Model

The model follows Iacoviello and Neri (2010) and Guerrieri and Iacoviello (2013). We build a New Keynesian two-sector model with heterogeneous households and collateral constraints. Specifically, there are two types of households in the economy, the patient households of population size $1-\omega$ and the impatient households of size ω. The two types of households only differ in their time preference rate; impatient households have a lower time preference rate, thus discounting the future more heavily than the patient households. This heterogeneity leads to a positive amount of debt held by the impatient households in equilibrium. The maximum debt that they can hold is restricted by a collateral constraint similar to the setup in Kiyotaki and Moore (1997) and Iacoviello (2005). In the production side, there are perfectly competitive firms that either produce an intermediate good as input for the production of non-durable retail goods, or they produce houses. The non-durable retail goods are produced by monopolistic competitive firms that face sticky prices *á la* Calvo. In addition, there is a monetary policy authority that sets interest rates according to a Taylor rule and, finallly, a government that manages public expenses and tax revenue.

2.1 Patient Households (Savers)

The problem of patient households is quite standard. They maximize their lifetime utility subject to their budget constraint. In particular, they maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t, n_{c,t}, n_{h,t}) \tag{1}$$

with respect to their non-durable consumption c_t, housing stock h_t and hours worked in the non-residential and residential sector $n_{j,t}$ with $j \in \{c, h\}$, subject to the budget constraint (expressed in terms of the non-durable retail good prices):

$$c_t + q_t h_t + b_t \leq (1 - \tau_t^n) \left[w_{c,t} n_{c,t} + w_{h,t} n_{h,t} \right] + q_t (1 - \delta) h_{t-1} + \frac{R_{t-1} b_{t-1}}{\pi_t} + \Xi_t - T_t \tag{2}$$

where $c_t, q_t, h_t, b_t, R_t, \pi_t, \Xi_t$ and T_t are respectively the non-durable consumption, real house prices, the housing stock, total savings in form of non-contingent bonds, the interest rate, the gross inflation rate, the profits from the monopolistic competitive firms that households own and the lump-sum taxes. Finally, τ_t^n is the labor income tax rate and $w_{j,t}$ is the real wage rate paid in the sector $j \in \{c, h\}$.

We use the following functional form for the utility, first proposed by Greenwood et al. (1988) and subsequently used by Monacelli and Perotti (2008) for fiscal policy analysis[3]:

$$U(c_t, h_t, n_{c,t}, n_{h,t}) = \frac{(X_t - \Phi N_t^{\varphi})^{1-\sigma} - 1}{1 - \sigma} \tag{3}$$

$$\text{where } X_t \equiv \left[(1 - \alpha_t)^{\frac{1}{\eta}} c_t^{\frac{\eta-1}{\eta}} + \alpha_t^{\frac{1}{\eta}} h_t^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{4}$$

$$N_t \equiv \left(n_{c,t}^{1+\nu} + n_{h,t}^{1+\nu} \right)^{\frac{1}{1+\nu}} \tag{5}$$

[3] Monacelli and Perotti (2008) adopt a non-separable utility in consumption and hours in order to replicate a positive response of private consumption after fiscal expansions, which is typically observed in the empirical literature.

where $\Phi > 0$ is a disutility parameter related to labor, φ is the inverse of the Frisch elasticity of labor supply, and α_t is a preference parameter for housing that follows an AR(1) process with a zero-mean, white-noise shock ε_t^{α}.

2.2 Impatient Households (Borrowers)

Impatient households face a similar problem. They maximize their lifetime utility being constrained by the budget constraint and an extra collateral constraint. Specifically, they maximize:

$$E_0 \sum_{t=0}^{\infty} \widetilde{\beta}^t U\left(\widetilde{c}_t, \widetilde{h}_t, \widetilde{n}_{c,t}, \widetilde{n}_{h,t}\right) \tag{6}$$

subject to the budget constraint:

$$\widetilde{c}_t + q_t \widetilde{h}_t + \frac{R_{t-1}\widetilde{b}_{t-1}}{\pi_t} \leq (1-\tau_t^n)\left[w_{c,t}\widetilde{n}_{c,t} + w_{h,t}\widetilde{n}_{h,t}\right] + q_t(1-\delta)\widetilde{h}_{t-1} + \widetilde{b}_t - \widetilde{T}_t \tag{7}$$

and a collateral constraint that limits their debt up to a certain portion of their expected real estate wealth[4]:

$$\widetilde{b}_t \leq \theta E_t \frac{q_{t+1}\widetilde{h}_t \pi_{t+1}}{R_t} \tag{8}$$

2.3 Production

There are two types of perfectly competitive firms: the first belong to the sector "c" and produce intermediate goods as inputs for the production of non-durable retail goods, while the second type belong to the sector "h" and produce houses. Any type of firms $j \in \{c, h\}$ use a linear technology:

$$y_t^j = A_t N_t^j \tag{9}$$

[4] This constraint specification was first proposed by Kiyotaki and Moore (1997). We use a modified version of the collateral constraint introduced by Iacoviello (2005) and subsequently used in Iacoviello and Neri (2010) and Guerrieri and Iacoviello (2013).

where A_t is an aggregate technology parameter that follows an AR(1) process and N_t^j are the total hours supplied by the households to the sector j. Firms maximize profits subject to their technology process:

$$\max_{N_t^j} \left\{ z_t^j A_t N_t^j - P_t^c w_t^j N_t^j \right\} \tag{10}$$

where z_t^j is the price of the goods or houses produced. Note that real wage w_t^j is defined as the nominal wage deflated by non-durable retail goods price P_t^c.

2.4 Retailers

There is a continuum of monopolistically competitive retailers in the sector of non-durable goods, indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms one unit of intermediate good into one unit of retail good. Note that the relative price of intermediate goods, z_t^c/P_t^c, coincides with the real marginal cost faced by the retailers, mc_t. Let y_{it}^c be the quantity of output sold by retailer i. Final non-durable goods can be expressed as:

$$y_t^c = \left[\int_0^1 (y_{it}^c)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{11}$$

where $\varepsilon > 1$ is the constant elasticity of demand for intermediate goods. The retail good is sold at its price, $p_t^c = \left[\int_0^1 (p_{it}^c)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$. The demand for each intermediate good depends on its relative price and aggregate demand:

$$y_{it}^c = \left(\frac{p_{it}^c}{p_t^c} \right)^{-\varepsilon} y_t^c \tag{12}$$

Following Calvo (1983), we assume that in any given period each retailer can reset her price with a fixed probability $1 - \chi$. Hence, the price index is:

$$p_t^c = \left[(1-\chi)(p_t^*)^{1-\varepsilon} + \chi (p_{t-1}^c)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{13}$$

The firms that are able to reset their price, p_{it}^*, choose it so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} (p_{it}^* - mc_{t+s}) y_{it+s}^c$$

The resulting expression for p_{it}^* is:

$$p_{it}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} mc_{t+s} y_{it+s}^c}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{it+s}^c} \tag{14}$$

2.5 Monetary Policy

There is an independent monetary authority that sets the nominal interest rate according to a simple Taylor rule:

$$R_t = R_{t-1}^{\rho_\pi} (\pi_t^c)^{(1-\rho_\pi)\phi_\pi} \tag{15}$$

where π_t^c is the gross inflation rate of the non-durable good's retail price, ρ_π is a coefficient measuring inertia in interest rate setting and ϕ_π measures the "aggressiveness" of monetary policy to fight inflation.

2.6 Government

Government's income consists of tax revenue, while expenditures consist of consumption purchases. The government deficit in real terms is defined as:

$$DF_t = g_t - \tau_t^n (w_t^c N_t^c + w_t^h N_t^h) - T_t \tag{16}$$

where g_t is public consumption, and τ_t^n is the labor income tax rate. The government budget constraint is given by:

$$\frac{R_{t-1}^{-1} b_{t-1}^G}{\pi_t} + DF_t = b_t^G \tag{17}$$

where b_t^G denotes government bonds sold to patient households. For the two fiscal instruments we assume the exogenous processes:

$$\log x_t = (1 - \boldsymbol{\varrho}_x) \log \overline{x} + \boldsymbol{\varrho}_x \log x_{t-1} + \varepsilon_t^x \tag{18}$$

where $x \in \{g, \tau^n\}$, ρ_x determines the persistence of the processes, and ε_t^x is a zero-mean, white-noise disturbance. Finally, to ensure determinacy of equilibrium and a non-explosive solution for debt (see e.g. Leeper (1991)), we assume a debt-targeting rule for the lump-sum taxes of the form:

$$T_t = \overline{T} \exp(\zeta_{ß}(ß_t - \overline{ß})) \tag{19}$$

where $\overline{ß}$ is the steady state level of debt to GDP ratio, $ß_t = \frac{B_t}{y_t}$.

2.7 Market Clearing

In equilibrium all markets clear. The equilibrium in the non-durable goods market implies the aggregate resource constraint:

$$y_t^c = (1-\omega)\, c_t + \omega \widetilde{c}_t + g_t \tag{20}$$

Similarly, the equilibrium in the real estate market requires:

$$y_t^h = (1-\omega)\,(h_t - (1-\delta) h_{t-1}) + \omega \left(\widetilde{h}_t - (1-\delta)\widetilde{h}_{t-1}\right) \tag{21}$$

Also, the labor markets in the non-durable good sector and the residential sector should clear in equilibrium:

$$N_t^c = (1-\omega)\, n_{c,t} + \omega \widetilde{n}_{c,t} \tag{22}$$

$$N_t^h = (1-\omega)\, n_{h,t} + \omega \widetilde{n}_{h,t} \tag{23}$$

If all markets above clear then the bond market also clears by Walras' law. Finally, we define total output produced as the sum of non-residential output and residential investment:

$$y_t = y_t^c + q \cdot y_t^h \tag{24}$$

where q is the price of houses expressed in non-durable retail goods prices.

2.8 Calibration and Solution

The model period is a quarter. We parameterize the model such that we target several statistics for the US economy. Specifically, we set the steady state value of the preference variable α equal to 0.1 in order to target the residential investment-to-GDP ratio which is approximately 5% for the US. The time preference rate of patient households is set to 0.99 which implies an annual interest rate of 4%, close to the average Fed Funds rate. The discount rate for impatient households is set lower at 0.98 in order to ensure positive debt in equilibrium. In addition, the values of several fiscal variables are set according to data. Government consumption amounts for 20% of the US GDP, the deficit/GDP ratio is set to 1% and the debt/GDP ratio 50%.

Following Monacelli and Perotti (2008) we set φ so that it implies a Frisch labor supply elasticity equal to 1.25, while the labor disutility parameter Φ is set such that the hours worked by households correspond to 1/3 of their time. The specific aggregator for hours worked by a household in the utility function permits for a varying level of substitutability or complementarity. When ν is zero the hours of the two sectors are perfect substitutes. However, we set ν to 0.7 which implies an imperfect substitutability as in Iacoviello and Neri (2010). It is assumed that the housing investment depreciates at an annual rate of 4% and as a result δ is set to 0.01. The retail sector of non-durable goods is characterized by sticky prices that cannot change for three quarters and consequently the stickiness parameter χ is set to 0.67. A summary of all parameters are presented in table 1 of appendix B.

In order to solve the model with an occasionally binding collateral constraint we follow Guerrieri and Iacoviello (2015) who present a novel piecewise linear solution. Specifically, there are two regimes characterized by whether the constraint binds or not. In the steady state the constraint always binds. When a shock hits the economy, the constraint may become slack but it is expected to revert and bind again in the future. Within a given regime the solution is linear so that there are two linear policy rules, one for each regime. The policy rules are derived from a first-order approximation of the log-linearized version of the model. The system of equations that describe the model are given in appendix A.

3 Theoretical Results

In order to compute the state-depedent responses to the fiscal shocks we simulate two regime-specific environments: an environment characterized by a binding collateral constraint and an environment characterized by a slack collateral constraint. As first described in Guerrieri and Iacoviello (2013), a model with housing investment and a collateral constraint provides a direct link between housing wealth fluctuations and the tightness of the constraint. Specifically, the model's implication is as follows: when housing wealth is relatively low, the value of housing collateral and borrowing limits are also low, and consequently the collateral constraint binds; however, when housing wealth increases substantially after a series of shocks, then the collateral value and borrowing limits may increase so much that the collateral constraint becomes slack. To this end, we proceed in three steps. First, we hit the economy with a series of house preference shocks that directly affect house prices and housing wealth, and hence dictate a fixed regime (either a binding or a slack collateral constraint) throughout the impulse response horizon. We save the responses of all variables. In the second step, we compute the same set of responses after the same shock process but further adding the fiscal shock under investigation. We save the new set of responses. Finally, we subtract the responses obtained in the first step from the responses obtained in the second step, and the result is the marginal contribution of the fiscal shock to the variables' dynamics.

The benchmark results are presented in figures 3 and 4. All shocks considered are expansionary, and all variables and their corresponding responses are measured in real terms. Figure 3 shows the responses to a 1% of GDP increase in government consumption. The (blue) solid lines represent responses when the economy is simulated to be in an environment of low housing wealth and a binding collateral constraint while the (red) dashed lines stand for an environment of relatively high housing wealth and a slack constraint. The abbreviation "S" in the variables' names denotes savers while "B" denotes borrowers. Let first consider the effects of spending shocks on house prices. The patient households' first order condition with respect to housing (equation A.2) , written in a more concise form where $U_{h,t}$ is the marginal utility of housing and $U_{c,t}$ the marginal utility of consumption, is:

$$U_{h,t} - U_{c,t}q_t + E_t\left[\beta(1-\delta)U_{c,t+1}q_{t+1}\right] = 0 \tag{25}$$

If we iterate it forward, it can be restated as:

$$U_{c,t}q_t = \underbrace{E_t\left[\sum_{j=1}^{\infty}\left[\beta(1-\delta)\right]^j U_{h,t+j}\right]}_{\approx \text{ constant}} \tag{26}$$

The left-hand-side term $U_{c,t}q_t$ represents the shadow value of housing, which optimally should be equal to the discounted present value of marginal utilities of the service flow of housing (right-hand-side term). As it is widely discussed in the literature[5], the right-hand-side term is almost constant because δ is small and $U_{h,t+j}$ is a smooth process. As a result, any variations in the marginal utility of consumption $U_{c,t}$ should be matched by analogous adjustments in the real house price q_t , and vice versa, in order to satisfy the optimal demand decision for housing. A positive shock to government consumption expands demand for labor, hours worked rise and so does the marginal utility of consumption. Therefore, equation 26 requires that the real house price must fall. This effect on house prices should be common in both regimes (i.e. when the collateral constraint is either slack or binding).

According to the benchmark parameterization, the output multiplier reaches 0.2 when the collateral constraint binds, while it reaches around 2 when the constraint becomes slack. This result comes from the response of total private consumption, which is negative when the constraint binds while it is positive when the constraint is slack. The reasoning goes as follows. After a government spending expansion, total working hours increase due to a positive labor supply and a positive labor demand effect. In addition, due to the assumption of a non-separable utility, the increasing hours worked raise the marginal utility of consumption and lead patient and impatient households to increase their consumption. As a result total consumption and output tend to increase. Those effects should be common in both regimes. However, the binding constraint regime implies a further *collateral channel* that alters the transmission of fiscal policy. In particular, the fall in house prices after the shock erodes impatient households' collateral value, and hence they are forced to borrow and spend less according to what their collateral constraint dictates. If this negative effect on consumption caused by the collateral channel is stronger than the positive effect induced by the increase in hours and the marginal utility of consumption, then private consumption of borrowers will fall, as indeed does here. What is more, this collateral channel plays the role of a financial accelerator which reinforces the decline in house prices and private debt. For this reason, when the collateral constraint binds house prices fall by much more than when the constraint is slack. This fact has serious implications for the behavior of patient households as well. Specifically, house prices fall so much that equation 26 would require a substantial increase in the marginal utility of consumption. The latter is achieved through a decline in patient households' consumption. Note that the sharp fall in real house prices also leads to a substitution effect; patient households will de-

[5] See Barsky et al. (2007) for a detailed analysis.

sire to substitute consumption of non-durables with relatively cheaper housing. Overall, when the collateral constraint is binding for borrowers aggregate private consumption falls, while when the constraint is slack aggregate consumption increases. Residential investment typically is crowded out in both cases, but does not contribute that much to the asymmetric behavior of output. As a result, the non-linear behavior of private consumption is the main source of asymmetries. To sum up, *government spending shocks are more effective in stimulating output when housing wealth is relatively high and the collateral constraint is slack* rather than the rest times.

Figure 4 shows the responses after a 1 percentage point cut in the labor income tax rate. As expected, the shock is expansionary in both regimes but the expansion of output is more pronounced in the binding constraint regime. The reasoning goes as follows. Let first consider the regime that the collateral constraint is slack. A cut in the labor income tax rate encourages labor supply, and total hours worked increase. The increase in hours of both patient and impatient households will raise their marginal utility of consumption and, consequently, consumption increases. In addition, residential investment and subsequently house prices increase due to a fall in the interest rate. As a result, total output increases by 0.4% on impact. However, when the collateral constraint is binding the implications are different. The increase in real house prices implies an increase in the value of collateral for borrowers, thus a relaxation of the borrowing limit and a proportional increase in the credit extended to households. This positive effect on borrowers' resources will be reflected on higher demand for consumption and residential investment. The significant increase in house prices will force patient households to substitute non-durable goods for housing, and consequently investment of patient households falls while their consumption increases. Overall, given a binding collateral constraint, total consumption and output rise by 1.1%. As a result, *tax cuts are more effective in stimulating the economy in times of low housing wealth and binding collateral constraints* rather than the rest times.

The next sections are devoted to (i) a non-linear empirical analysis in order to test the model's predictions in the data and (ii) a sensitivity analysis of the model which attempts to reconcile theory and empirics.

4 Empirical Analysis

4.1 The Threshold VAR Model

In this step, we estimate the non-linear effects of fiscal policy on output and its components after government consumption and income tax shocks in order to test whether data reveal a similar pattern of the state-dependent effects of fiscal policy that we received in the theoretical analysis. We consider a threshold VAR (TVAR) model following Koop et al. (1996) and Balke (2000). Such a model has the advantage of capturing non-linear dynamics conditioned to a transition (threshold) variable that is observable and endogenous to the system. Moreover, this threshold variable can be endogenous in the VAR system. Specifically, the threshold VAR model we estimate is:

$$y_t = A_1(L)y_{t-1} + B_1(L)x_t + I\left[z_{t-1} \geq z^*\right] \cdot (A_2(L)y_{t-1} + B_2(L)x_t) + u_t \tag{27}$$

where y_t is the vector of endogenous variables, x_t the vector of exogenous variables, and z is the transition (threshold) variable that determines two distinct regimes. $I[\cdot]$ is an indicator function that equals 1 when variable z_{t-1} is above a threshold value z^* and 0 otherwise. The regression model also contains a deterministic trend and regime-specific constants. The model parameters $A_1(L)$, $B_1(L)$, $A_2(L)$, $B_2(L)$, z^*, the deterministic term coefficients and the error covariance matrix are estimated using the Conditional Ordinary Least Squares estimator proposed by Tsay (1998).

4.2 Data

We use quarterly, seasonally adjusted data of the US for the period 1963q1-2007q4. The series come from the NIPA tables. The benchmark model contains six endogenous variables: the log of real per capita government consumption, the net (of transfers) tax revenue, the gross domestic product, house prices, an interest rate and a sixth variable. To economize in degrees of freedom, the last variable rotates between the private consumption of non-durables and services, and the residential investment. In order to identify exogenous tax shocks, we also consider a measure of average personal income tax shocks as exogenous variable. The exogenous shocks are constructed in Mertens and Ravn (2013) and more details are provided in the next section. The fiscal variables, GDP, consumption and investment are in log per capita terms and deflated by the GDP deflator, while house prices are in logarithms and deflated by the GDP deflator. All variables except for the interest rate are linearly detrended. According to information criteria we set the lag length of the VAR to two.

Concerning the threshold variable z_{t-1} we use real house prices. House prices mainly drive housing wealth. What is more, figure 1 shows that house prices strongly comove with private sector's real estate wealth, having a correlation of 0.95. As a result, house prices could be considered as a reliable proxy for collateral fluctuations and the tightness of collateral constraints. As benchmark house prices we use the median house price index of the US Census Bureau described in appendix A.

4.3 Identifying the Shocks

A key challenge in this framework is the identification of the fiscal shocks. Many identification approaches have been suggested in the past and still there is no conclusive empirical work on determining the best way of identifying fiscal shocks in the data. To recover government spending shocks we use a recursive identification according to the SVAR literature, as in Blanchard and Perotti (2002) and Fatas and Mihov (2001). This identification method assumes that the reduced VAR residuals are a linear combination of structural uncorrelated shocks, and that government spending cannot be contemporaneously affected by any other variable in the system. When using quarterly data it is reasonable to assume that public spending decisions cannot be revised within a quarter and thus cannot react to current economic conditions. Those two assumptions are satisfied if i) the contemporaneous matrix that links the VAR errors with the structural shocks is given by the Cholesky factor of the estimated VAR error covariance matrix, and ii) government consumption is ordered first in the VAR system. Then, given the estimated Cholesky factor and the estimated VAR residuals, one can recover the government spending shocks.

Concerning the identification of the personal income tax shocks one should be more careful because the tax revenue are affected by the economic cycle, prices and other factors, and, as a result, it is much more difficult to isolate the discretionary exogenous component of the changes in tax revenue. The most popular approach so far to overcome this problem has been a narrative identification using official budget records, news press records and other official documents that report exogenous policy decisions and their estimated or actual net effects on tax liabilities. The seminal work of Romer and Romer (2010) introduces this framework for the US and several other papers further contribute to expand this approach in terms of methodology (Favero and Giavazzi (2012), Mertens and Ravn (2013) and Perotti (2012)) or in terms of country sample (Cloyne (2013)). In particular, Mertens and Ravn (2013) construct narrative average personal income tax and corporate income tax shocks, and they consider them as instruments for the observed average income tax series. Using a novel GMM framework the authors estimate the effects of the distinct tax revenue components on the US output. In a similar vein, Favero and Giavazzi (2012) use the narrative tax revenue shocks constructed by Romer and Romer (2010), but the authors treat the shocks as an exogenous variable in a fiscal VAR model. The methodology of Favero and Giavazzi (2012) seems very suitable for our empirical framework, and as a result we use the narrative personal income tax shocks of Mertens and Ravn (2013) as an exogenous variable x_t in the threshold VAR model (equation 27). The average personal income tax shocks are plotted in figure 2 and they are defined as the change in the personal income tax liabilities between two consequtive quarters divided by the personal taxable income of the previous period.

4.4 Empirical Results

4.4.1 Benchmark Results

Figures 11a and 11b present the impulse response functions of output, private consumption, residential investment and real house prices after an 1% of GDP increase in government consumption and 1 percentage point cut in personal income tax rate respectively[6]. The left columns represent the regime where house prices are below the threshold at the time that the shock hits, while the right columns represent a regime where house prices are above the threshold value. The estimated threshold value (trend deviation of house prices) in this specification is approximately 0.004. To make the comparison between the two regimes more clear, tables 2 and 3 presents the 1-year and 3-year annualized cumulative responses of output, consumption and residential investment to the two shocks, and the peak responses. The benchmark results are

[6] At this step, the computed impulse responses ignore any endogenous feedback of the system to the threshold variable. In other words, the benchmark impulse responses assume that the economy can stay in a given regime for a sufficient number of periods and there is no endogenous regime shift. This framework can be equally seen as an analysis of fiscal policy in two boundary scenarios, one referring to a protracted period of high house prices (e.g. financial boom) and the other referring to a protracted period of low house prices (e.g. financial crisis). This type of impulse responses are useful for two reasons. First of all, it is easier to compare the two regimes and assess their distinct implications for the tranmission of the fiscal shocks. Secondly, they can be directly comparable with the theoretical results. However, in the robustness section we also compute impulse responses that allow for endogenous regime shifts.

given in the first block of those tables (under the label "Benchmark model").

According to figure 11a, the effects of government consumption shocks are highly non-linear; when house prices are above the estimated threshold the spending shock has an expansionary and lasting effect on output and private consumption. Specifically, output significantly increases for twelve quarters with a peak at 1.88% in the sixth quarter, while private consumption increases persistently throughout the horizon with a peak at 1.76%. On the other hand, in the low house price regime (left column), responses switch sign after the first quarter. In particular, a fiscal expansion makes output and private consumption fall significantly and persistently. Notably, output responses follow the pattern of private consumption responses in both regimes. Also, real house prices fall persistently in both states. Residential investment significantly falls in the low house price regime, thus being in accordance with what theory predicts, while it does not move significantly in the other regime. The same conclusions can be reached according to table 2. In the regime that house prices lie above the threshold (in table notation: regime II), both the one-year and three-year cumulative responses of output are significant and equal to 1.25% and 4.12% respectively. The cumulative responses of private consumption are also significant and with values very close to those of output. However, when house prices are relatively low (in table notation: regime I) the three-year cumulative response is significant and equal to -3.90%.

Figure 11b similarly reveals non-linear patterns of the responses to tax shocks. In the regime characterized by low house prices, the tax effects are more pronounced comparably to the high price regime. In particular, in an environment of low house prices, a 1 percentage point cut in the average personal income tax rate induces an increase in output by approximately 0.9% on impact. Output peaks in the third quarter at a maximum value of 1.58%, and the increase remains persistent for fourteen quarters. In contrast, in the regime characterized by high house prices, the response of output is weaker and not significantly different from zero. The responses of private consumption and residential investment have almost the same pattern; a 1 percentage point tax cut yields a peak response of private consumption around 1.49% in the third quarter in an environment of low house prices , while responses are buffered and not statistically significant when house prices are above the threshold. Similarly, residential investment significantly increases with a peak response at around 10.54% in the third quarter when house prices are below the threshold, while it does not move significantly in the other regime. Finally, real house prices significantly and persistently increase throughout the horizon in both regimes. Similar conclusions can be reached according to table 3. In the regime that house prices lie below the threshold (regime I), both the one-year and three-year cumulative responses of output are significant and equal to 1.60% and 4.06% respectively. The cumulative responses of private consumption are also significant and equal to 1.04% and 3.47%. Residential investment's cumulative responses over one and three years are also significant. However, when house prices are relatively high (regime II) neither cumulative responses nor the peak responses of all three variables are statistically significant. Notably, the estimates of output in the low house price regime are very close to the ones that Mertens and Ravn (2013) report for income tax rate shocks in a linear model. In particular, the authors report a peak response of GDP by 1.8% at the third quarter.

4.4.2 Robustness Analysis

The threshold variable A first issue is whether the empirical results are sensitive to alternative threshold definitions. As a benchmark case, we considered the median price for new, single-family houses sold (including land) provided by the US Census Bureau. The first exercise here is to use a shorter series of house prices available from the Bank for International Settlements starting in 1970 and referring to residential property prices of existing dwellings. These series are derived from the Corelogic database and are constructed using the weighted-repeat sales methodology proposed by Case and Shiller. A second alternative definition of house prices we are going to consider is the median price for all houses provided by the US Census Bureau. We repeat the benchmark TVAR regression using the two alternative threshold variables in place of the benchmark house prices. The TVAR model remains the same at all other aspects. Exact definitions of the variables are provided in appendix A.

Figures 12a and 13a refer to the responses to spending shocks for the two alternative threshold definitions. The responses convey a message similar to the benchmark result: positive spending shocks are more expansionary with respect to private consumption and output during times of relatively high house prices (figures 12a and 13a, right columns), while responses become weaker or even switch sign during times of relatively low house prices (left columns). Residential investment may fall or not move significantly when house prices are relatively low, while it may increase or not react when house prices exceed the threshold. Similarly, the cumulative and peak responses of output and private consumption are quite high and mostly significant in the regime defined by high house prices (regime II, second and third block of table 2) while the cumulative responses in the low price regime are barely significant and turn negative (regime I, second and third block of table 2).

Figures 12b and 13b refer to the responses to tax shocks for the two alternative threshold definitions. As before, the benchmark result remains robust across threshold definition: tax cuts are more expansionary on output and consumption during times characterized by low house prices rather than in times of high house prices. Table 3 (second and third block) conveys the same message. The cumulative and peak responses of all variables are significant and high in the regime defined by low house prices (regime I), while they are very low and barely significant in the high price regime (regime II).

Controlling for expectations Another important aspect is the timing of fiscal policy and the implications for the proper identification of government spending shocks. In particular, the seminal work of Ramey (2011) highlights that fiscal policy measures are often pre-announced or expected by individuals. In such a case, a shock considered at a certain point in time actually has already affected economic decisions of agents well before, at the point it was announced or simply expected by the public. According to Ramey (2011), failing to distinguish between the expected component and the truly unexpected component of a fiscal policy shock will result to bias in the estimates. Therefore, we re-estimate the TVAR model adding the forecast series of real government expenditure provided by the Survey of Professional Forecasters. The forecast series is ordered first in the TVAR since it is a predetermined variable in the system. All rest variables are ordered as in the benchmark TVAR model. This ordering permits to purge government spending series from their expected component, and to estimate the effects of the truly unexpected spending shocks. The responses of macrovariables to unexpected government spending shocks are shown in figure 14, while cumulative and peak responses are provided in the fourth block of table 2 (under the label "Anticipation effects"). The responses are quite close to the benchmark ones, and hence they confirm our main conclusions.

SVAR-based tax shocks In the benchmark specification we consider tax shocks identified using a narrative approach since this method seems to be the most reliable way of obtaining truly exogenous changes in taxes. This part robustifies benchmark estimations using SVAR-based tax shocks. In particular, we construct average income tax rate series following the approach of Jones (2002). Details on the construction of the tax rate series are provided in the appendix A. The alternative VAR specification contains the following endogenous variables: the log of real per capita government consumption, the constructed average tax rate series, the gross domestic product, house prices, an interest rate and a sixth variable which again rotates between the private consumption and the private residential investment. The tax rate variable is ordered last in the VAR in order to purge it from any endogenous response to other variables like output or interest rates.

The results of the alternative TVAR model are shown in figure 15. The responses of output, consumption and house prices bear striking similarities to the benchmark estimations. If house prices lie below the threshold when a tax rate cut hits, output and consumption significantly increase with a peak at 1.56% and 1.37% respectively. However, if house prices exceed the threshold at the moment a tax shock hits the system, then output and consumption barely respond. House prices significantly increase in both regimes, while residential investment initially increases only in the low price regime. According to table 3 (fourth block) the one- and three-year cumulative responses of output, consumption and investment are significantly high when house prices lie below the threshold (regime I), while they are low and not different from zero when house prices exceed the threshold (regime II). Overall, the benchmark results remain robust under the alternative identification method.

Generalised Impulse Responses The benchmark impulse responses ignore any endogenous feedback of the system to the threshold variable. In other words, the benchmark impulse responses assume that the economy can stay in a given regime for a sufficiently large number of periods and there is no endogenous regime shift. This framework can be equally seen as an analysis of fiscal policy in two boundary scenarios, one referring to a protracted period of high house prices (e.g. financial boom) and the other referring to a protracted period of low house prices (e.g. financial crisis). This type of impulse responses are useful for two reasons. First of all, it is easier to compare the two regimes and assess their distinct implications for the tranmission of the fiscal shocks. Secondly, they can be directly comparable with the theoretical results. However, at this point it would be useful to compute *generalised impulse response functions (GIRFs)* that allow for endogenous regime shifts and test whether our benchmark result remains robust.

Impulse responses to a shock may depend on several factors: initial conditions (values) of one or more variables, the variables' history, the size and the direction of current and future shocks. All those factors together determine how far from the threshold value the transition variable lies and how often it crosses the threshold. In turn, the frequency and the pattern of the regime shifts is what determines the generalised impulse responses. In other words, the GIRFs represent a kind of marginal effects of shocks when history, the size and direction of current and future shocks are all averaged out.

The TVAR is reestimated and GIRFs are computed. The responses with respect to the government consumption shock are presented in figure 16a. When house prices are below the threshold, output, private consumption and residential investment does not significantly react to a government consumption shock. On the other hand, in the regime defined by high house prices, output and private consumption increase with a peak at 0.79% and 0.81% in the fifth quarter respectively. House prices robustly fall in both regimes.

Responses to tax shocks (figure 16b) also remain robust. A one percentage point cut in the personal income tax induces a significant increase in output, private consumption, residential investment and house prices in the regime defined by low house prices. On the contrary, responses of all variables are more buffered in the regime defined by high house prices.

5 Back to the model: Squaring theory and empirics

Both the theoretical model and the empirical analysis are in accordance that housing wealth is a significant factor that dictates two distinct regimes and differentiates the transmission mechanism of fiscal shocks across the regimes. In the theory, fluctuations of house prices and housing wealth make a collateral constraint occasionally binding and thus imply heterogeneous dynamics depending on whether the constraint is binding or slack when the fiscal shock hits the economy. Similarly, in the empirical model house prices directly define two distinct regimes. The aim of this section is to explain which assumptions or parameters in the theoretical model are crucial for matching theoretical responses with empirical ones.

5.1 The role of (non)separable utility

In the theoretical model we have assumed a utility function that is non-separable in consumption and hours. Monacelli and Perotti (2008) first proposed such a specification of the utility in fiscal policy analysis in order to replicate the positive response of private consumption after fiscal expansions that is typically reported by the structural VAR literature. But how much crucial is such an assumption in our framework? Indeed, non-separability seems to play an important role for matching theoretical and empirical responses. To see why, we repeat the theorerical analysis with a model that assumes a separable utility. The responses of both specifications (separable and non-separable) after a government spending shock are presented in figure 5a for the case that the collateral constraint binds and in figure 5b for the case that the constraint is slack. When the collateral constraint binds and the economy is hit by a positive government consumption shock (figure 5a) non-separability implies a relatively more contractionary effect on consumption and hence a less expansionary effect on output than what separability implies for the given shock and regime. This happens because, given a government spending shock and the subsequent expansion of hours worked, non-separability implies an increase in the marginal utility of consumption by more than what would be the case in the separable utility model. Therefore, according to equation 26, a non-separable utility model requires a relatively sharper decline in the real house price, which in turn leads to a stronger negative collateral effect and more contractionary impact on private demand for consumption and housing. What is more, comparing figures 5a and 11a (left column), the responses of the non-separable utility model are closer to the empirical responses where actually both output and consumption contract. On the other hand, when the collateral constraint is slack and the economy is hit by a positive government consumption shock (figure 5b) non-separability implies a relatively more expansionary effect on consumption and output than what separability implies for the given shock and regime. The reason is that with non-separable utility a spending shock induces an increase in the marginal utility of consumption and triggers private consumption, while separability does not imply such an effect on the marginal utility of consumption. Instead, in the case of a separable utility any increase in the marginal utility of consumption that is required in order to satisfy the Euler equations A.4 and A.10 can be only achieved through reductions in private consumption. Most importantly, comparing figures 5b and 11a (right column), the responses of the non-separable case are closer in value to the empirical responses, where both output and consumption expand and, particularly, output multipliers exceed the unity. The separable utility specification cannot generate strong expansions and output multipliers higher than one.

Now we turn our attention to the role of (non)separability for tax shocks. The responses of both specifications (separable and non-separable) after a tax rate cut are presented in figure 6a, for the case that the collateral constraint binds, and in figure 6b, for the case that the constraint is slack. In both states of collateral constraints (both figures 6a and 6b) non-separability implies a relatively more expansionary effect on consumption and output than what separability does. The reasoning goes as before; with non-separable utility a tax cut induces an expansion in hours and a subsequent increase in the marginal utility of consumption which further stimulates private consumption and output. Comparing figures 6a and 11b (left column), the responses of the non-separable utility model are closer in value to the empirical responses where both output and consumption significantly expand. The separable utility specification can generate only weaker expansions.

Above all, we conclude that the non-separable utility model generates responses that better matches the empirical patterns. However, there are still some more discrepancies between the theoretical and empirical results. Next subsections suggest how results could further improve by modifying some other aspects of the model.

5.2 The role of the shock persistence

The theoretical analysis concluded that positive government consumption shocks increase output in both regimes, and that the response is more buffered in the environment characterized by low housing wealth and a binding collateral constraint. However, in the empirical part, output significantly falls in the analogous regime of low housing wealth. The shock persistence, ρ_g and ρ_τ, is a possible explanation for this discrepancy. In particular, an increase in the persistence of a shock to deficit-financed spending implies a stronger negative wealth effect due to much higher taxes in the future. In turn, this negative wealth effect will force households to cut back consumption. If the negative response of private consumption dominates the positive response of public consumption, then it could be the case that output falls. As a result, the higher the persistence of the shock, the more likely for output to fall after a fiscal expansion. To test that, figure 7a show the responses for various values of the shock persistence after a positive government consumption shock in the regime defined by a binding collateral constraint (left column) and a regime defined by a slack collateral constraint (right column). As expected, in the binding constraint regime (left column) higher shock persistence implies more negative responses of private consumption. Especially when the shock persistence is 0.95 then the deep fall in private consumption dominates, and therefore output falls as well. Furthermore, higher shock persistence implies flatter and more persistent responses of all variables in the regime defined by a slack collateral constraint (right column). The flatter and more persistent responses in high values of ρ_g are similar to the empirical responses in the analogous regime. Overall, a higher shock persistence, about 0.95, yields theoretical responses that are closer to the empirical ones for both regimes. Notably, the estimated lag coefficient of an AR(1) process for the government spending is around 0.94. This result further confirms our view that shock persistence may be the factor that make our bencmark output responses be slightly different than the empirical ones. Hence, once applying the estimated shock persistence in the model, theoretical responses improve. What is more, the benchmark result remains robust to alternative values of shock persistence: spending shocks have relatively more expansionary effects on output and private consumption in the slack constraint regime rather than the binding constraint regime.

Similar conclusions can be derived for the responses after tax shocks, shown in figure 7b. A higher tax shock persistence implies stronger responses of house prices, consumption, investment and output in both regimes. This helps to improve the match between the theoretical and empirical responses in the regime characterized by low housing wealth (compare left columns of figures 7b and 11b). Furthermore, the benchmark result remains robust to alternative values of shock persistence: tax cuts are more expansionary in the tight credit regime.

5.3 The role of monetary policy

The response of monetary policy to stabilize prices after fiscal shocks is another important factor that affects the transmission of shocks. In particular, both the sensitivity of the policy rate to inflation (i.e. the Taylor rule coefficient ϕ_π) and the Taylor rule inertia (coefficient ρ_π) determine the extent to which interest rates react to fiscal shocks, thus the extent of crowding-out of private demand. To test for the role of monetary policy, we consider three different monetary policy stance specifications: an accommodative policy ($\phi_\pi = 1.1, \rho_\pi = 0.8$), the benchmark policy ($\phi_\pi = 1.5, \rho_\pi = 0.5$), and an aggressive policy ($\phi_\pi = 2.5$, $\rho_\pi = 0$). Figures 8a and 8b present the responses for spending shocks and tax shocks in the regime defined by a binding collateral constraint (left columns) and a regime defined by a slack collateral constraint (right columns). According to figure 8a, a more aggressive monetary policy (high ϕ_π and low ρ_π) induces more contractionary (or less expansionary) effects of government spending shocks on output and private consumption in both regimes. This is quite intuitive because spending expansions put upward pressure on inflation. If the policy rate is very sensitive to inflation and exhibits no inertia, then it rises substantially and generates a contractionary effect on consumption and output. Most importantly, an aggressive monetary policy improves the match between empirical and theoretical responses, especially in the low housing wealth regime where constraints are more likely to bind: as monetary policy becomes more aggressive with no inertia, fiscal expansions through spending induce a stronger interest rate response and a bigger crowding-out of private demand. The latter dominates and finally output falls.

On the other hand, according to figure 8b, tax cuts induce a decline in inflation and a lower interest rate as a response to the former. The negative response of interest rates after tax cuts is the reason why tax cuts induce stronger expansionary effects when the monetary policy is more aggressive. As before, varying the level of monetary policy aggressiveness does not make much difference for the comparison of the two regimes, and instead confirms our benchmark result: tax cuts are more expansionary in the tight credit regime.

6 A policy instrument comparison

As the previous analysis shows, the effectiveness of fiscal policy will depend on the prevailing credit conditions. In particular, the analysis suggests that spending policies are highly effective in stimulating private demand in times of loose credit, while tax policies are highly effective in doing so in times of tight credit. However, it would be also interesting to know whether, for instance, in times of tight credit a tax policy is still preferable to a spending policy. The present framework permits us to make a direct comparison between the two fiscal instruments. To do so, we rescale the tax rate shock to correspond to a 1% of GDP cut in income tax revenue while the spending shock corresponds to a 1% of GDP increase in the government consumption. Figure 9 makes a direct assessment for the effectiveness of spending shocks against tax shocks for the regime characterized by low housing wealth and a binding collateral constraint. Output multiplier equals 0.2 for the spending shock while it is 1.7 for the tax shock. This discrepancy comes from the fact that tax cuts stimulate private demand for consumption and investment while spending increases crowd-out both. Those effects are further reinforced by the presence of the *collateral channel*. In particular, tax cuts induce an increase in real house prices, an increase in the value of collateral and a proportional positive wealth effect that stimulates consumption and investment of borrowers. In contrast, after positive government spending shocks real house prices fall, the value of collateral declines and the credit supplied to borrowers contracts. This effect worsens the crowding-out of private consumption and investment. Therefore, government spending shocks cannot be so expansionary as tax cuts during times of tight credit.

However, the opposite holds during periods of loose credit. According to figure 10, government spending shocks imply an output multiplier around 2 while a tax cut implies a multiplier around 0.6. The difference in the effectiveness of the two instruments comes from the following reasons. Both positive government consumption shocks and tax cuts will increase hours worked which will subsequently drive the marginal utility of consumption up. To restore equilibrium, households increase consumption, and output expands. However, the increase in hours after tax cuts is not so pronounced as the increase in hours after the positive spending shocks. This is reasonable because positive spending shocks imply (i) a negative wealth effect, thus increasing labor supply and (ii) a direct demand effect that increases labor demand, and overall the hours worked increase substantially. On the other hand, tax cuts directly imply only a labor supply effect. Therefore, total hours worked increase more after spending expansions rather than tax cuts. In turn, the marginal utility of consumption, consumption itself and output increase by more after spending expansions rather than tax cuts. As a result, in times of loose credit, spending-based fiscal stimuli are more effective than tax-based stimuli of equal size.

7 Conclusion

This paper investigates how housing wealth dynamics and collateral constraints jointly matter for the non-linear transmission of fiscal policy shocks. To this end, a DSGE model with housing investment and occassionally binding collateral constraints is proposed and studied. The effects of fiscal shocks are found to be highly non-linear in such a model. In particular, positive government spending shocks have more pronounced and expansionary effects on output and private consumption when housing wealth is relatively high and the collateral constraint is slack rather than in rest times. On the contrary, tax cuts are more expansionary in times of low housing wealth and a binding collateral constraint rather than in rest times. The key mechanism is that when the collateral constraint binds an extra transmission channel emerges that comes from house price movements and the subsequent valuation effects on the housing collateral. This collateral channel buffers government spending stimuli while boosts tax cut stimuli.

A threshold VAR model also reveals significant state-dependent effects of fiscal shocks conditional on housing wealth, and confirms the theoretical model's predictions. Moreover, the data are in favor of a model with non-separable utility in consumption and hours, since, in contrast to a sepable utility model, it generates responses that are closer to the empirical ones. In addition, higher shock persistence and a more aggressive monetary policy stance seem to improve the model's performance comparably to data.

The model also has important implications for the relative efficiency of spending policies versus tax policies. In particular, income tax shocks are more expansionary on output and private demand than government consumption shocks in times of tight credit. On the contrary, spending shocks are more effective in stimulating private demand and output than tax shocks in times of loose credit. This result is highly policy relevant; during times of tight credit and low housing wealth, such as the period that followed the 2008 financial crisis, a tax-based stimulus would be more recommendable than a spending-based stimulus. However, for countries that have implemented fiscal consolidation programs in the aftermath of the financial crisis, spending-based austerities would be less harmful to output and private demand than tax-based austerities.

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APPENDIX A

Data Definitions and Sources

Government consumption: Consumption expenditures, Item 18, Table 3.1. Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Government wage consumption: Compensation of general government employees, Item 4, Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Source: Bureau of Economic Analysis.

Income tax revenue: Personal current taxes, Item 3, Table 3.1. Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Output: Gross domestic product, Item 1, Table 1.1.5. Gross Domestic Product, Source: Bureau of Economic Analysis.

Consumption: Personal consumption expenditures of non-durables and services, Items 5+6, Table 1.1.5. Gross Domestic Product, Source: Bureau of Economic Analysis.

Investment: Residential investment, Item 13, Table 1.1.5. Gross Domestic Product, Source: Bureau of Economic Analysis.

House prices: Median price for new, single-family houses sold (including land). Source: US Census Bureau.

Alternative house prices1: Residential property prices, existing dwellings, per dwelling. Source: National sources, BIS Residential Property Price database. http://www.bis.org/statistics/pp.htm.

Alternative house prices2: Median price for all houses. Source: US Census Bureau.

Interest rate: FED Funds Rate, Item: FEDFUNDS, Source: FRED.

Narrative shocks to the average personal income tax rate, Source: Mertens and Ravn (2013)

Construction of average tax rates

The approach to construct average tax rates on labor income follows Mendoza et al. (1994) and Jones (2002). The source of data are NIPA tables (www.bea.gov).

The average personal income tax rate is calculated as:

$$\tau^p = \frac{IT}{W + PRI/2 + CI}$$

$$\text{where} \;\; CI \equiv PRI/2 + RI + CP + NI$$

and IT denotes total income taxes (table 3.1: line 3), W denotes wages and salaries (table 1.12: line 3), CI denotes the capital income, PRI denotes the proprietor's income (table 1.12: line 9), RI denotes the rental income (table 1.12: line 12), CP denotes corporate profits (table 1.12: line 13) and NI denotes the net interest (table 1.12: line 18).

The labor tax rate is subsequently calculated as:

$$\tau^n = \frac{\tau^p \left(W + PRI/2\right) + CSI}{EC + PRI/2}$$

where CSI denotes contributions to social insurance (table 3.1: line 7) and EC denotes compensation of employees (1.12: line 2).

Equilibrium Conditions of the Model

- Patient Households

$$\lambda_t = (X_t - \Phi N_t^{\varphi})^{-\sigma} \left(\frac{(1-\alpha_t) X_t}{c_t} \right)^{\frac{1}{\eta}} \tag{A.1}$$

$$(X_t - \Phi N_t^{\varphi})^{-\sigma} \left(\frac{\alpha_t X_t}{h_t} \right)^{\frac{1}{\eta}} - \lambda_t q_t + E_t \left[\beta (1-\delta) \lambda_{t+1} q_{t+1} \right] = 0 \tag{A.2}$$

$$(X_t - \Phi N_t^{\varphi})^{-\sigma} \Phi \varphi N_t^{\varphi - \nu - 1} n_{j,t}^{\nu} = \lambda_t (1 - \tau_t^n) w_{j,t} \qquad \text{for any} \;\; j \in \{c, h\} \tag{A.3}$$

$$\lambda_t = \beta E_t \left[\lambda_{t+1} \frac{R_t}{\pi_{t+1}} \right] \tag{A.4}$$

$$\text{where } X_t \equiv \left[(1-\alpha_t)^{\frac{1}{\eta}} c_t^{\frac{\eta-1}{\eta}} + \alpha_t^{\frac{1}{\eta}} h_t^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{A.5}$$

$$\text{and} \quad N_t \equiv \left(n_{c,t}^{1+\nu} + n_{h,t}^{1+\nu} \right)^{\frac{1}{1+\nu}} \tag{A.6}$$

- Impatient Households

$$\widetilde{\lambda}_t = (\widetilde{X}_t - \widetilde{\Phi}\widetilde{N}_t^{\varphi})^{-\sigma}\left(\frac{(1-\alpha_t)\widetilde{X}_t}{\widetilde{c}_t}\right)^{\frac{1}{\eta}} \tag{A.7}$$

$$(\widetilde{X}_t - \widetilde{\Phi}\widetilde{N}_t^{\varphi})^{-\sigma}\left(\frac{\widetilde{\alpha}_t\widetilde{X}_t}{\widetilde{h}_t}\right)^{\frac{1}{\eta}} - \widetilde{\lambda}_t q_t + E_t\left[\widetilde{\beta}(1-\delta)\widetilde{\lambda}_{t+1}q_{t+1}\right] + \mu_t\theta E_t\left[\frac{q_{t+1}\pi_{t+1}}{R_t}\right] = 0 \tag{A.8}$$

$$(\widetilde{X}_t - \widetilde{\Phi}\widetilde{N}_t^{\varphi})^{-\sigma}\widetilde{\Phi}\varphi\widetilde{N}_t^{\varphi-\nu-1}\widetilde{n}_{j,t}^{\nu} = \widetilde{\lambda}_t(1-\tau_t^n)w_{j,t} \qquad \text{for any} \quad j \in \{c,h\} \tag{A.9}$$

$$\widetilde{\lambda}_t = \widetilde{\beta}E_t\left[\widetilde{\lambda}_{t+1}\frac{R_t}{\pi_{t+1}}\right] \tag{A.10}$$

$$\widetilde{c}_t + q_t\widetilde{h}_t + \frac{R_{t-1}\widetilde{b}_{t-1}}{\pi_t} \leq (1-\tau_t^n)\left[w_{c,t}\widetilde{n}_{c,t} + w_{h,t}\widetilde{n}_{h,t}\right] + q_t(1-\delta)\widetilde{h}_{t-1} + \widetilde{b}_t - \widetilde{T}_t \tag{A.11}$$

$$\widetilde{b}_t \leq \theta E_t\frac{q_{t+1}\widetilde{h}_t\pi_{t+1}}{R_t} \tag{A.12}$$

$$\text{where } X_t \equiv \left[(1-\alpha_t)^{\frac{1}{\eta}}c_t^{\frac{\eta-1}{\eta}} + \alpha_t^{\frac{1}{\eta}}h_t^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{A.13}$$

$$\text{and} \quad N_t \equiv \left(n_{c,t}^{1+\nu} + n_{h,t}^{1+\nu}\right)^{\frac{1}{1+\nu}} \tag{A.14}$$

- Intermediate Firms in the Non-durable Goods Sector

$$y_t^c = A_t N_t^c \tag{A.15}$$

$$w_{c,t} = mc_t \tag{A.16}$$

- Firms in the Housing Sector

$$y_t^h = A_t N_t^h \tag{A.17}$$

$$w_{h,t} = q_t \tag{A.18}$$

- Retailers in the Non-durable Goods Sector

  Combining and log-linearizing equations 13 and 14 results to a typical Philipps curve:

$$\pi_t^c = \frac{(1-\chi)(1-\beta\chi)}{\chi}\widehat{mc}_t + \beta E_t\left[\pi_{t+1}^c\right] \tag{A.19}$$

- Taylor Rule

$$R_t = R_{t-1}^{\rho_\pi}(\pi_t^c)^{(1-\rho_\pi)\phi_\pi} \tag{A.20}$$

- Government

$$DF_t = g_t - \tau_t^n(w_{c,t}N_t^c + w_{h,t}N_t^h) - T_t \tag{A.21}$$

$$\frac{R_{t-1}^{-1}b_{t-1}^G}{\pi_t} + DF_t = b_t^G \tag{A.22}$$

$$T_t = \overline{T}\exp(\zeta_{ß}(ß_t - \overline{ß})) \tag{A.23}$$

- Market Clearing Conditions and Aggregation

$$y_t^c = (1-\omega)\,c_t + \omega\widetilde{c}_t + g_t \tag{A.24}$$

$$y_t^h = (1-\omega)\,(h_t - (1-\delta)h_{t-1}) + \omega\left(\widetilde{h}_t - (1-\delta)\widetilde{h}_{t-1}\right) \tag{A.25}$$

$$N_t^c = (1-\omega)\,n_{c,t} + \omega\widetilde{n}_{c,t} \tag{A.26}$$

$$N_t^h = (1-\omega)\,n_{h,t} + \omega\widetilde{n}_{h,t} \tag{A.27}$$

$$y_t = y_t^c + q\cdot y_t^h \tag{A.28}$$

- Shock processes

$$\log x_t = (1 - \boldsymbol{\varrho}_x) \log \overline{x} + \boldsymbol{\varrho}_x \log x_{t-1} + \varepsilon_t^x \quad x \in \{g, \tau^n, a, A\} \tag{A.29}$$

- Given the shock processes A.29, the equilibrium conditions and rest definitions A.1-A.28 define a system that can be solved for all endogenous state and control variables: c, $\widetilde{c}$, h, $\widetilde{h}$, n_c, n_h, $\widetilde{n_c}$, $\widetilde{n_h}$, X, $\widetilde{X}$, N, $\widetilde{N}$, N^c, N^h, λ, $\widetilde{\lambda}$, y^c, $y^h_,$ y, w_c, w_h, q, π^c, R, DF, b^G, $\widetilde{b}$, T_t.

APPENDIX B

Tables

Table 1: Benchmark calibration

Parameters		Values
ω	Size of impatient households	0.4
β	Discount factor of patient households	0.99
$\widetilde{\beta}$	Discount factor of impatient households	0.98
$\overline{\alpha}$	Steady state housing preference	0.1
φ	Parameter relevant to the Frisch elasticity	2
ν	Elasticity of substitution across labor types	0.7
δ	Housing depreciation rate	0.01
θ	Maximum loan to value ratio	0.9
ε	Elasticity of substitution for non-durable goods	6
η	Elasticity of substitution between non durables - housing	1
σ	Inverse of elasticity of substitution in consumption	1
χ	Price stickiness in the non-durable goods sector	0.67
$\zeta_{ß}$	Debt elasticity of lump-sum taxes	0.02
ϕ_π	Taylor rule coefficient	1.5
ϱ_π	Taylor rule inertia	0.5
ϱ	Persistence of shocks	0.85
Steady state target values		
n_c+n_h	Total hours worked by a household	1/3
π	Gross inflation rate	1
	Annual interest rate	0.04
$\frac{y^h}{y}$	Residential investment to GDP ratio	0.06
$\frac{g}{y}$	Public consumption to GDP ratio	0.20
$\overline{ß}$	Public debt to GDP ratio	0.50
$\frac{DF}{y}$	Public deficit to GDP ratio	0.01

	Output		Private Consumption		Residential Investment	
	Regime I	Regime II	Regime I	Regime II	Regime I	Regime II
	Benchmark model					
T=1	-0.62	1.25*	-0.57*	1.42*	-3.02	3.24
T=3	-3.90*	4.12*	-4.13*	4.30*	-12.50	7.94
Peak	0.57	1.88*	0.34	1.76*	-0.98*	6.11
	Alternative threshold variable (BIS prices)					
T=1	-0.22	0.04	-0.47	0.93*	-8.35*	1.26
T=3	-0.65	3.69*	-1.83	5.18*	-20.09*	19.77*
Peak	0.68	1.98*	0.30	2.23*	6.80	11.19*
	Alternative threshold variable (US Census prices)					
T=1	-0.56	0.60*	0.03	0.59	0.83	1.70
T=3	-4.58*	2.80*	-2.65*	2.45*	5.52	7.27
Peak	0.54	1.24*	0.44	1.01	5.20	4.19
	Anticipation effects					
T=1	-0.56	0.95*	-0.39	1.40*	-5.48	2.51
T=3	-1.89	3.51*	-2.28	4.76*	-14.98	-4.08
Peak	0.91	1.63*	0.24	1.85*	-0.74	4.10
	Generalised Impulse Response Functions					
T=1	-0.17	0.76*	-0.24	0.78*	-1.32	2.21
T=3	-1.01	2.01*	-1.35	1.76*	-0.95	7.16
Peak	0.69	0.79*	0.40	0.81*	1.66	6.27

Table 2: Annualized cumulative responses of output (columns 1-2), consumption (columns 3-4) and residential investment (columns 5-6) to a 1% of GDP increase in government consumption.

An asterisk * denotes one standard error statistical significance.

	Output		Private Consumption		Residential Investment	
	Regime I	Regime II	Regime I	Regime II	Regime I	Regime II
	Benchmark model					
T=1	1.60*	0.02	1.04*	0.08	10.92*	-0.50
T=3	4.06*	0.21	3.47*	0.01	25.90*	1.05
Peak	1.58*	0.16	1.49*	0.08	10.54*	1.45
	Alternative threshold variable (BIS prices)					
T=1	2.06*	0.50	1.20*	0.31	-5.72*	4.13
T=3	2.44*	0.43	2.56*	0.00	2.47	2.70
Peak	2.01*	0.48	1.37*	0.29	8.43*	4.15
	Alternative threshold variable (US Census prices)					
T=1	1.10*	0.21	0.88*	0.26	7.21*	-1.35
T=3	3.02*	0.79	2.75*	0.58	11.21*	0.13
Peak	1.21*	0.36	1.28*	0.28	9.14*	0.85
	SVAR-based tax shocks					
T=1	0.75*	0.17	0.65*	0.09	4.32*	0.43
T=3	2.71*	0.49	2.51*	-0.17	4.45	-3.69
Peak	1.56*	0.75*	1.37*	0.22	7.69*	2.24
	Generalised Impulse Response Functions					
T=1	1.26*	0.81*	0.78*	0.20	10.05*	6.94*
T=3	2.00*	0.48	1.38*	-0.27	19.00*	4.98
Peak	1.21*	0.87*	0.97*	0.31	9.19*	7.13*

Table 3: Annualized cumulative responses of output (columns 1-2), consumption (columns 3-4) and residential investment (columns 5-6) to a one percentage point cut in the personal income tax rate. An asterisk * denotes one standard error statistical significance.

Figures

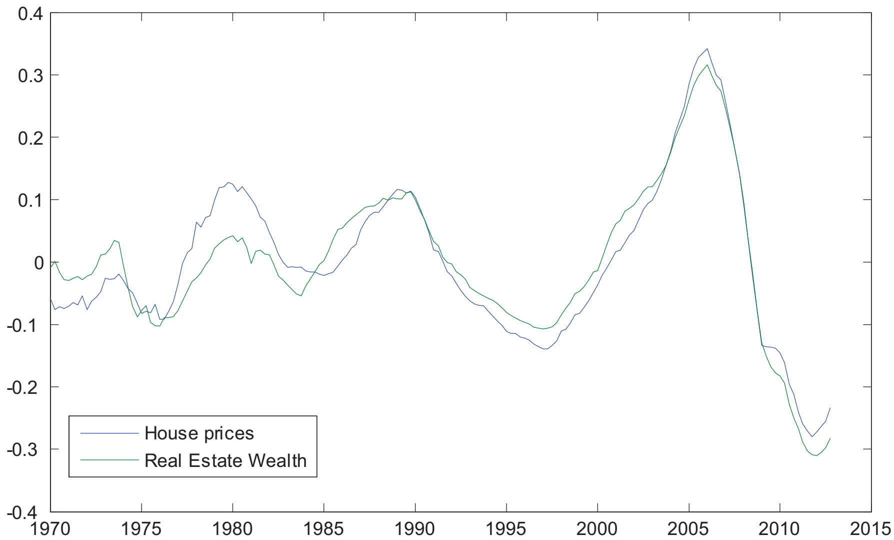

Figure 1: Real house prices and real estate wealth of households (Detrended series)

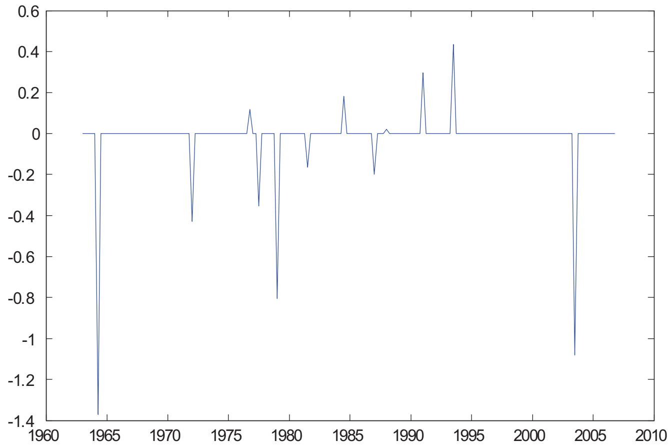

Figure 2: The narrative measure of personal income tax rate shock. (Source: Mertens and Ravn (2013))

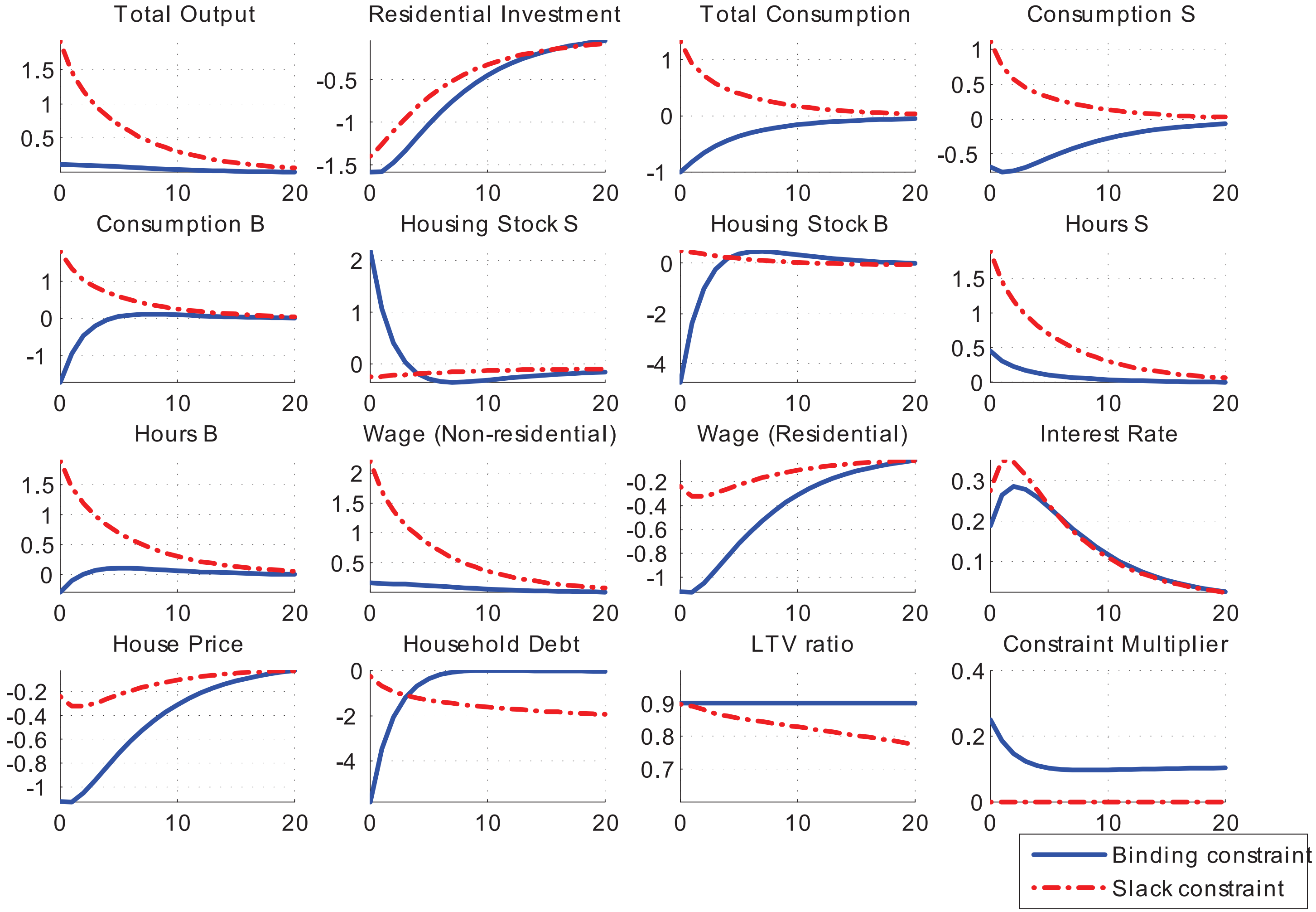

Figure 3: Regime-dependent responses to a government consumption increase equal to 1% of GDP. Binding versus slack collateral constraint. "S": Savers, "B": Borrowers.

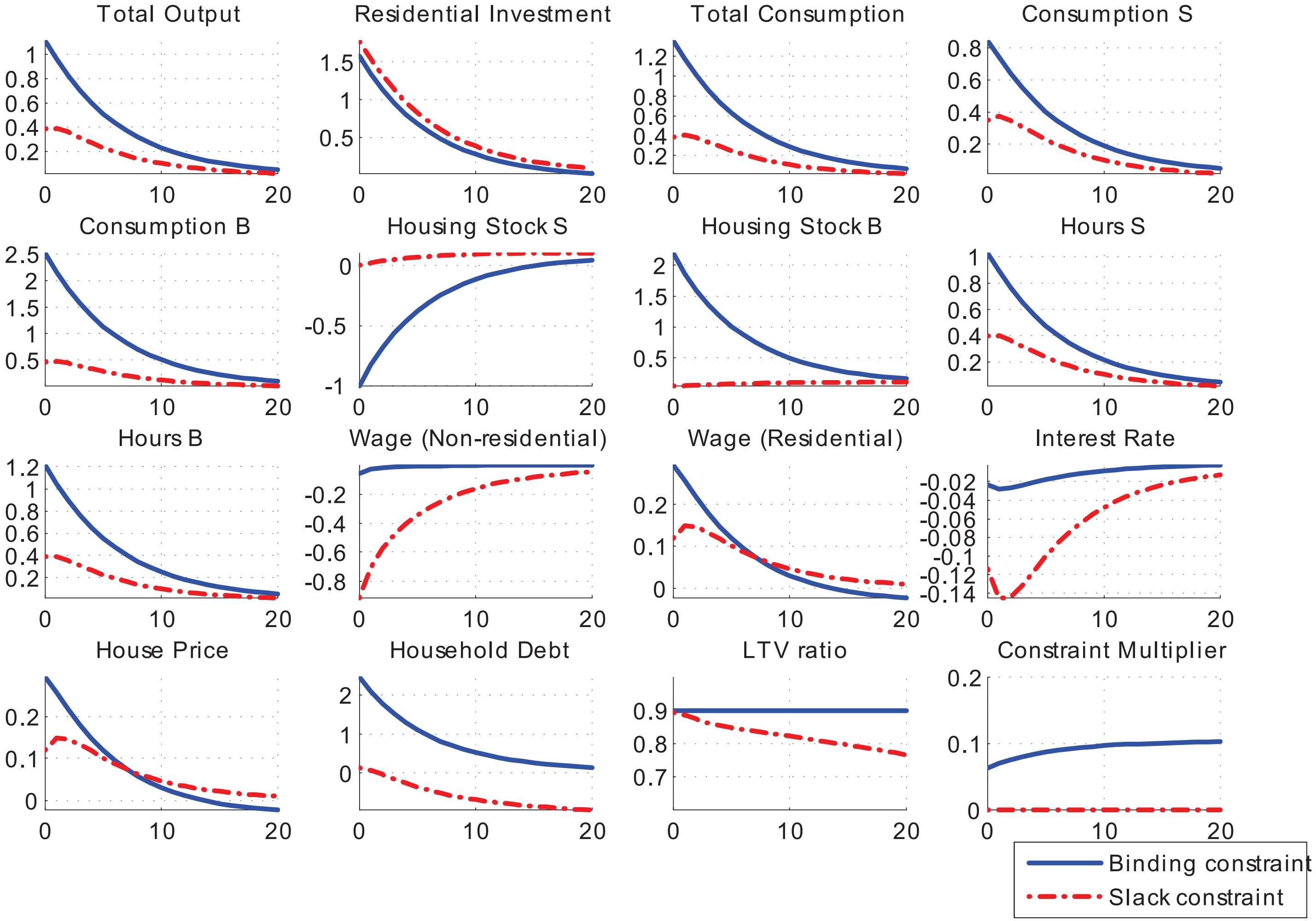

Figure 4: Regime-dependent responses to a 1 percentage point cut in the income rax rate. Binding versus slack collateral constraint. "S": Savers, "B": Borrowers.

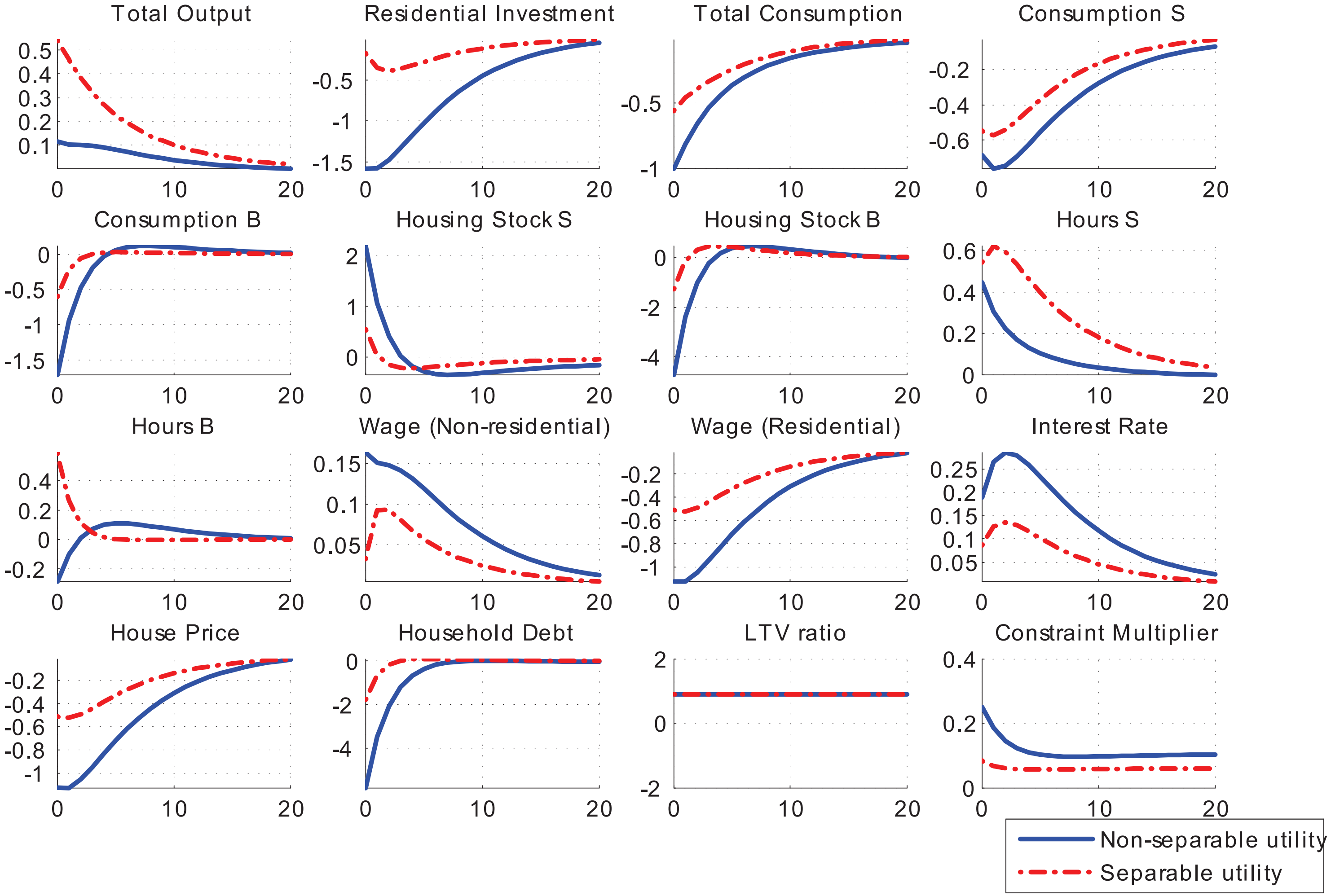

Figure 5a: Responses to a government consumption increase equal to 1% of GDP when the collateral constraint binds. Separable utility versus non-separable utility. "S": Savers, "B": Borrowers.

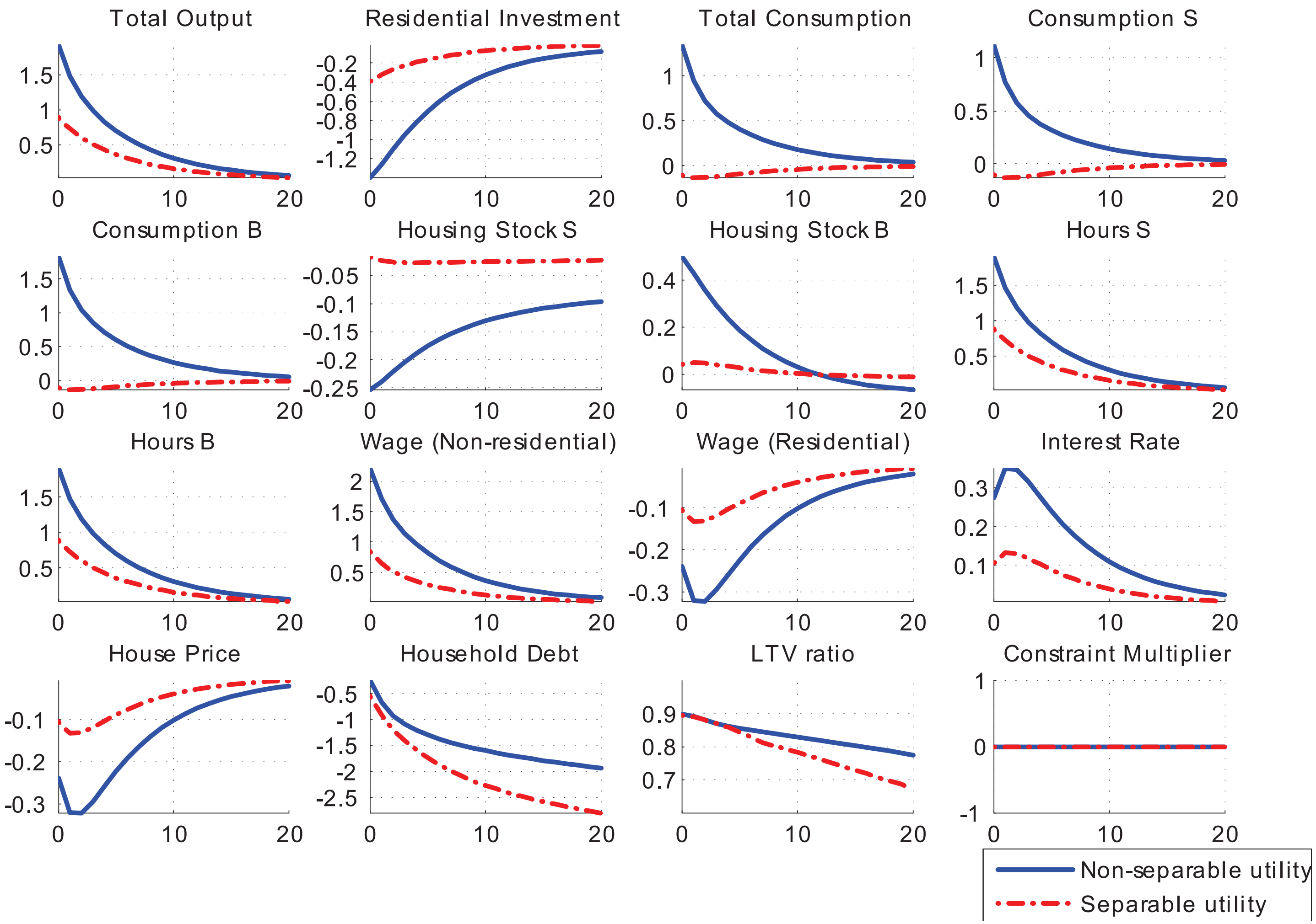

Figure 5b Responses to a government consumption increase equal to 1% of GDP when the collateral constraint is slack.

Separable utility versus non-separable utility. "S": Savers, "B": Borrowers.

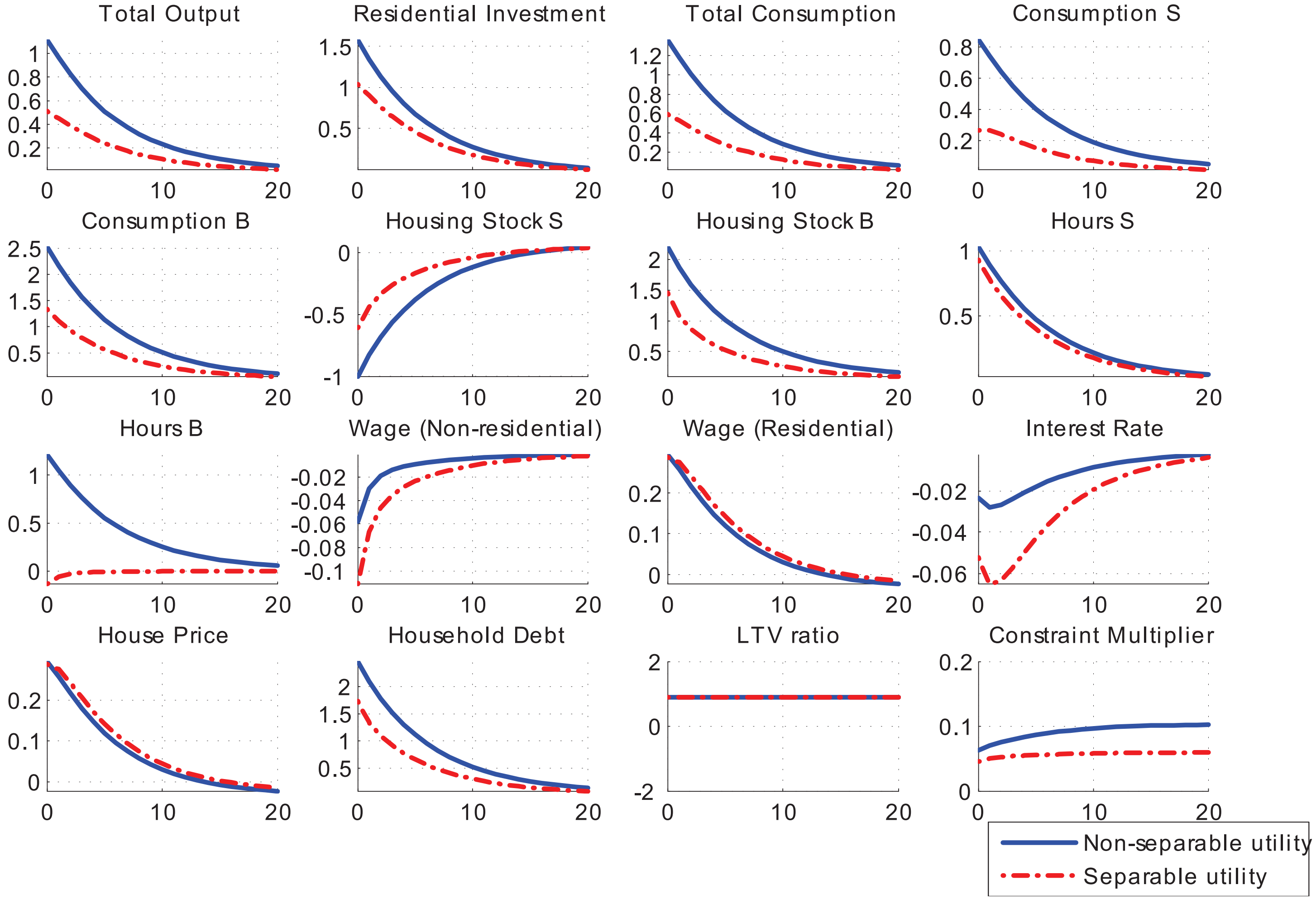

Figure 6a: Responses to a 1 percentage point cut in the income rax rate when the collateral constraint binds. Separable utility versus non-separable utility. "S": Savers, "B": Borrowers.

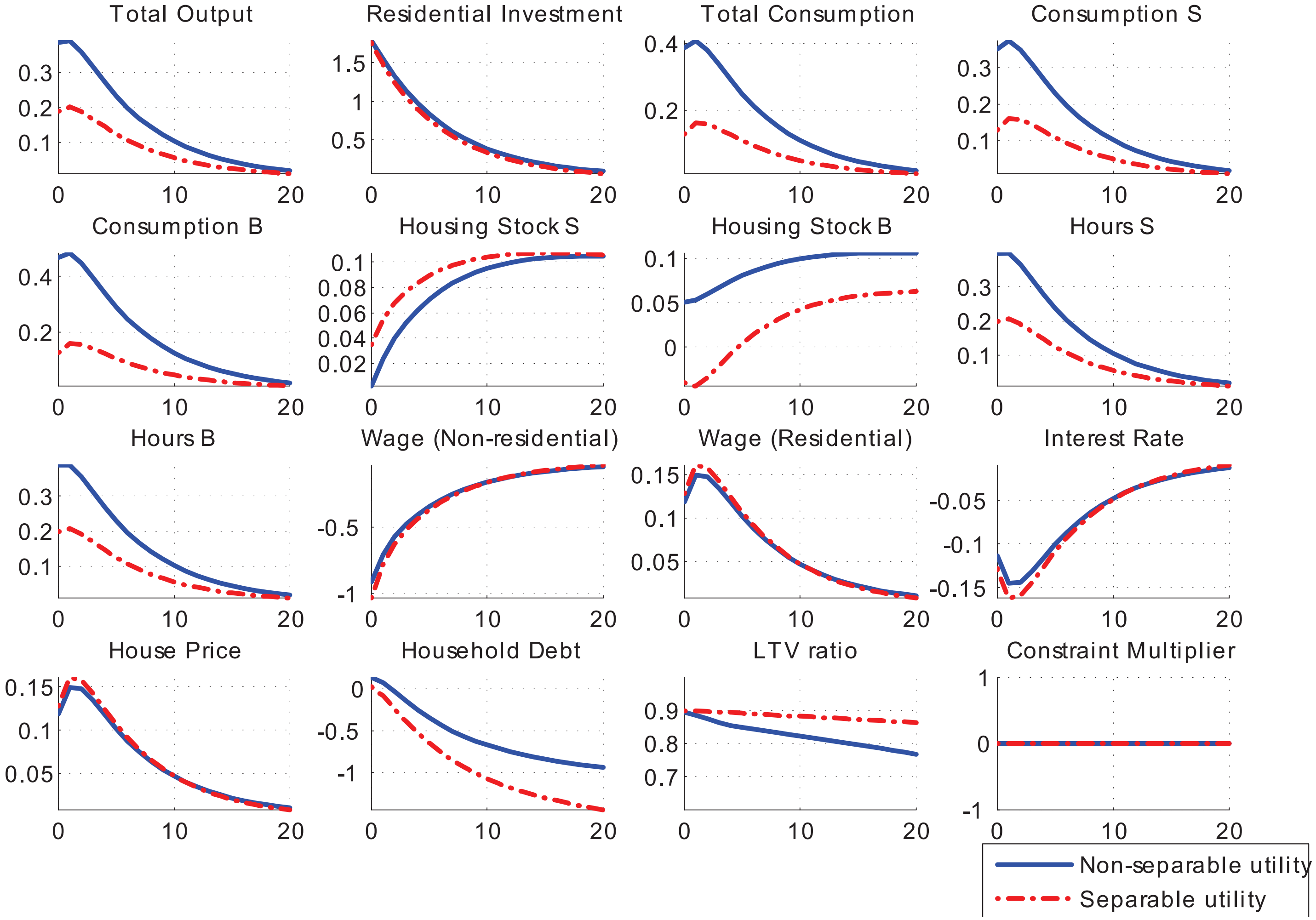

Figure 6b: Responses to a 1 percentage point cut in the income rax rate when the collateral constraint is slack. Separable utility versus non-separable utility. "S": Savers, "B": Borrowers.

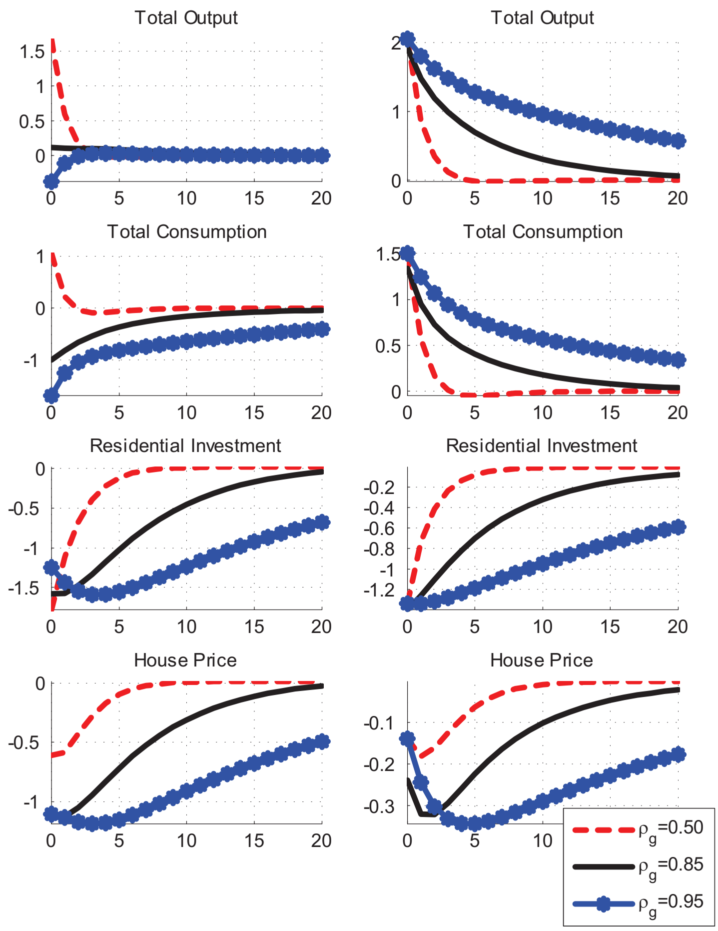

Figure 7a: Responses to a government consumption increase equal to 1% of GDP. Sensitivity analysis with respect to the shock persistence, ϱ_g. Binding collateral constraint (left column) versus slack constraint (right column).

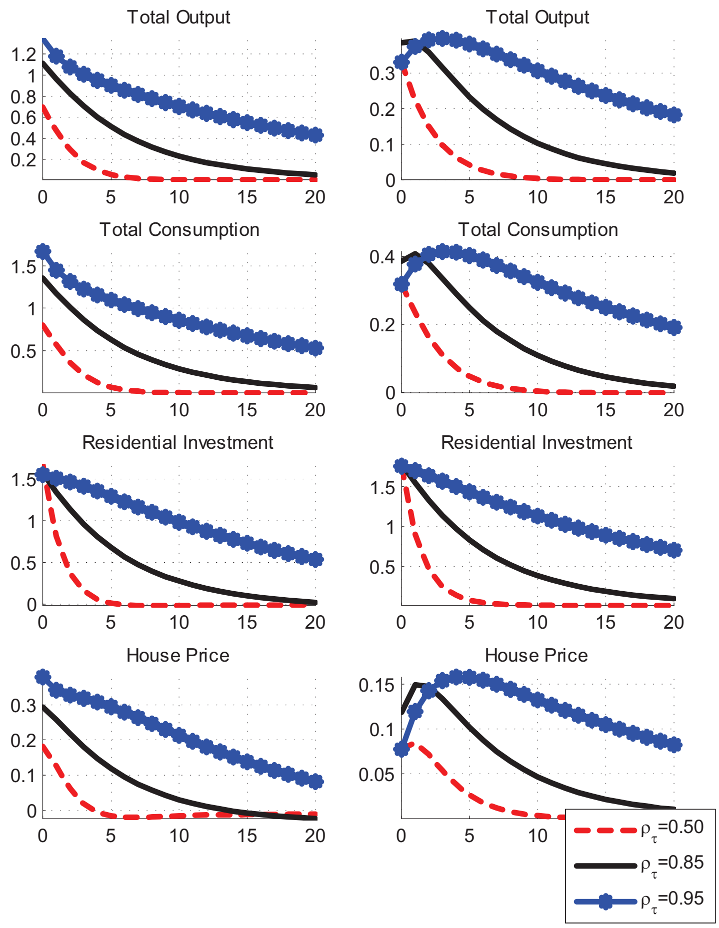

Figure 7b: Responses to a one percentage point cut in the labor income tax rate. Sensitivity analysis with respect to the shock persistence, ϱ_τ. Binding collateral constraint (left column) versus slack constraint (right column).

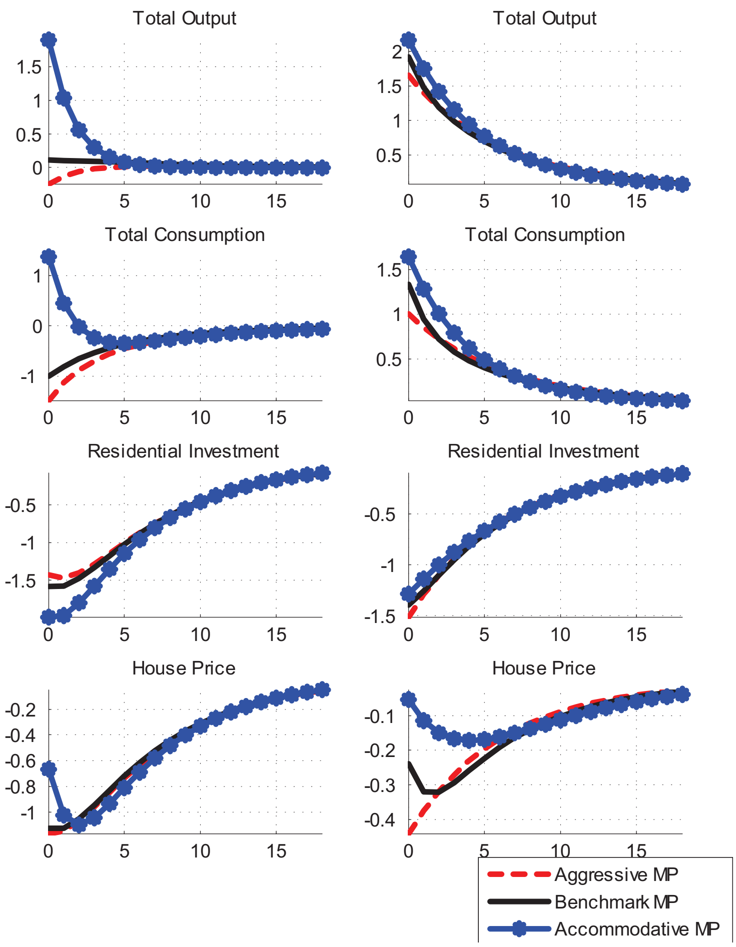

Figure 8a: Responses to a government consumption increase equal to 1% of GDP. Sensitivity analysis with respect to the monetary policy stance, ϕ_{π}, ρ_{π}. Binding collateral constraint (left column) versus slack constraint (right column).

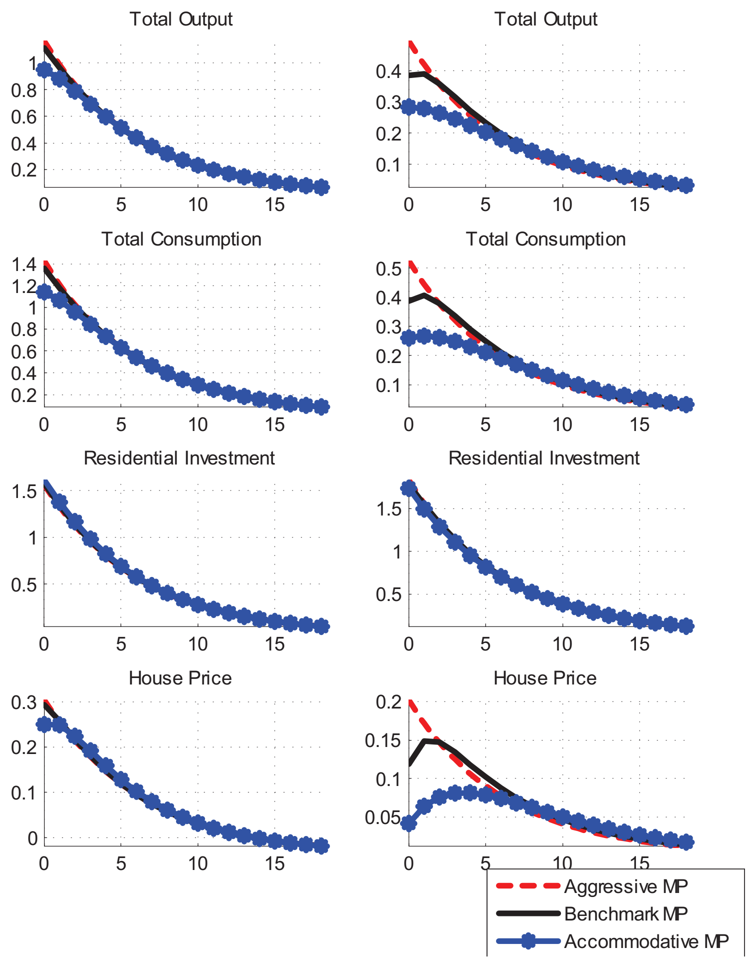

Figure 8b: Responses to a one percentage point cut in the labor income tax rate. Sensitivity analysis with respect to the monetary policy stance, ϕ_π, ρ_π. Binding collateral constraint (left column) versus slack constraint (right column).

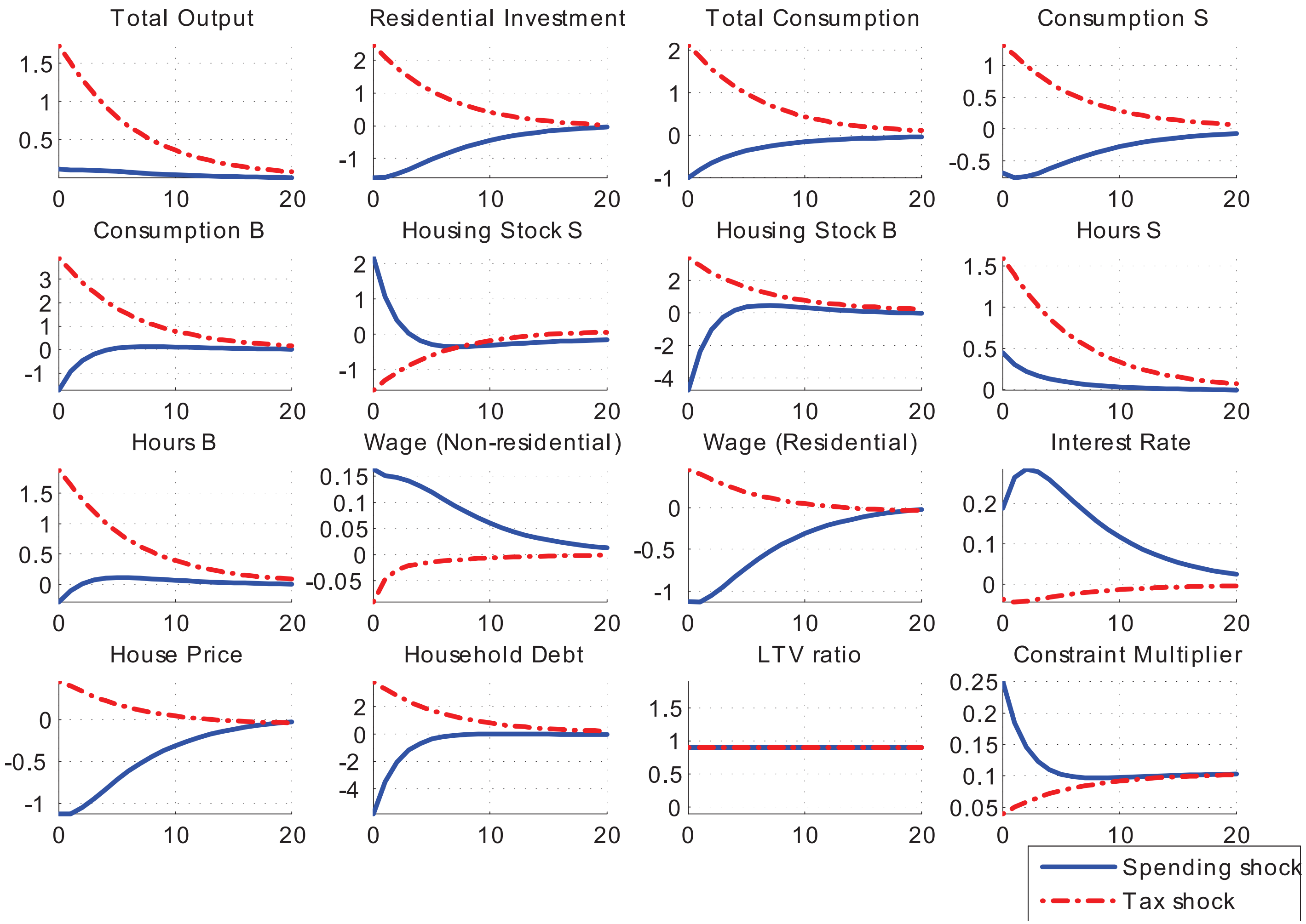

Figure 9: Responses to a government consumption increase versus an income tax revenue cut equal to 1% of GDP. Binding collateral constraint. "S": Savers, "B": Borrowers.

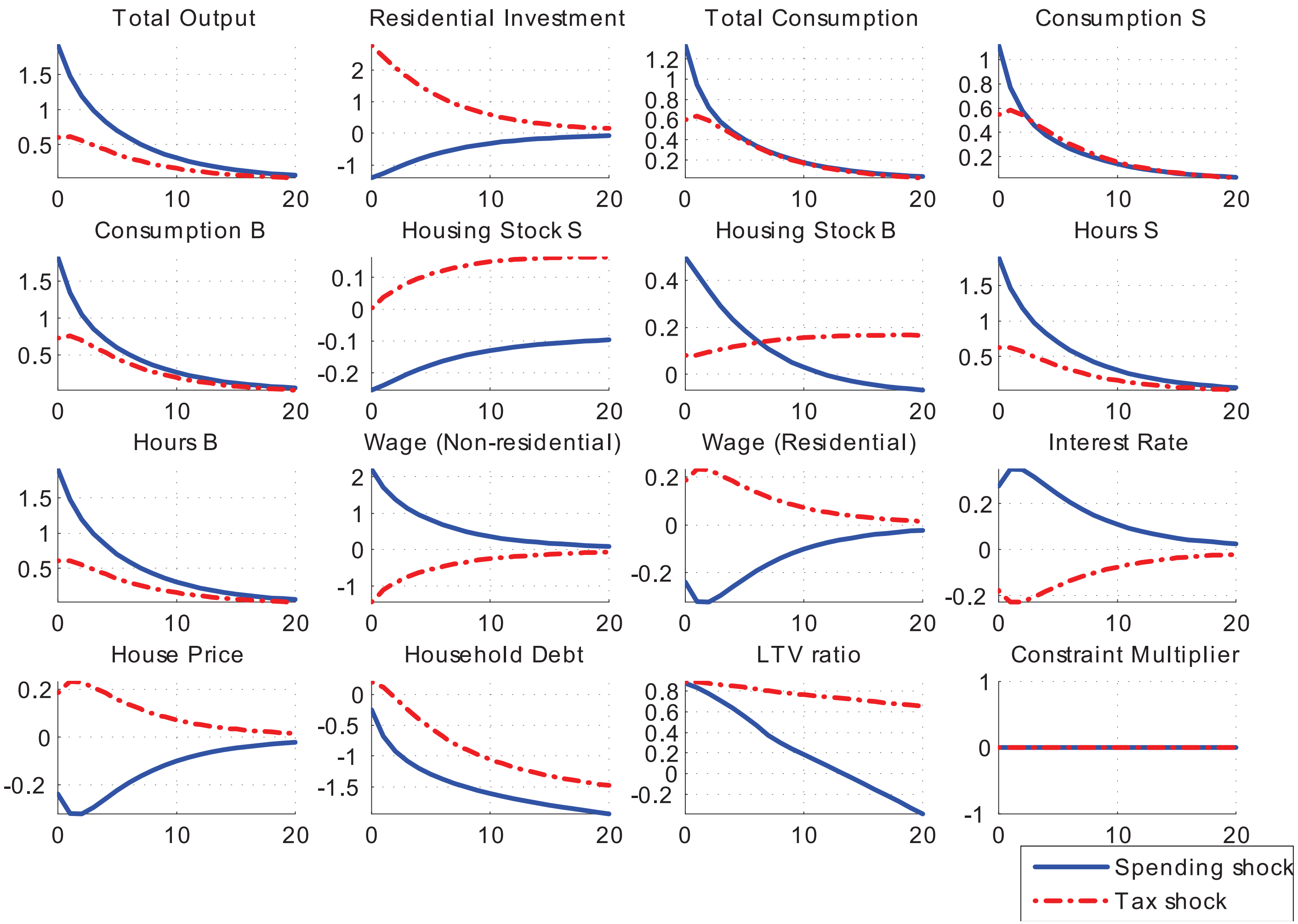

Figure 10: Responses to a government consumption increase versus an income tax revenue cut equal to 1% of GDP. Slack collateral constraint. "S": Savers, "B": Borrowers.

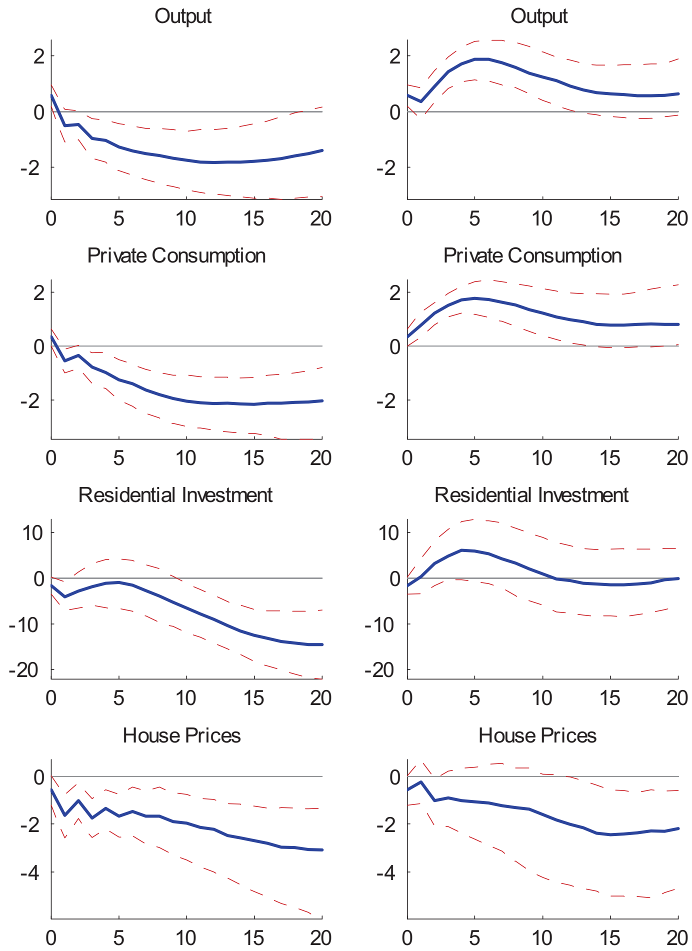

Figure 11a: Regime-dependent responses to a government consumption shock equal to 1% of GDP. Low house price regime (left column) versus high house price regime (right column).

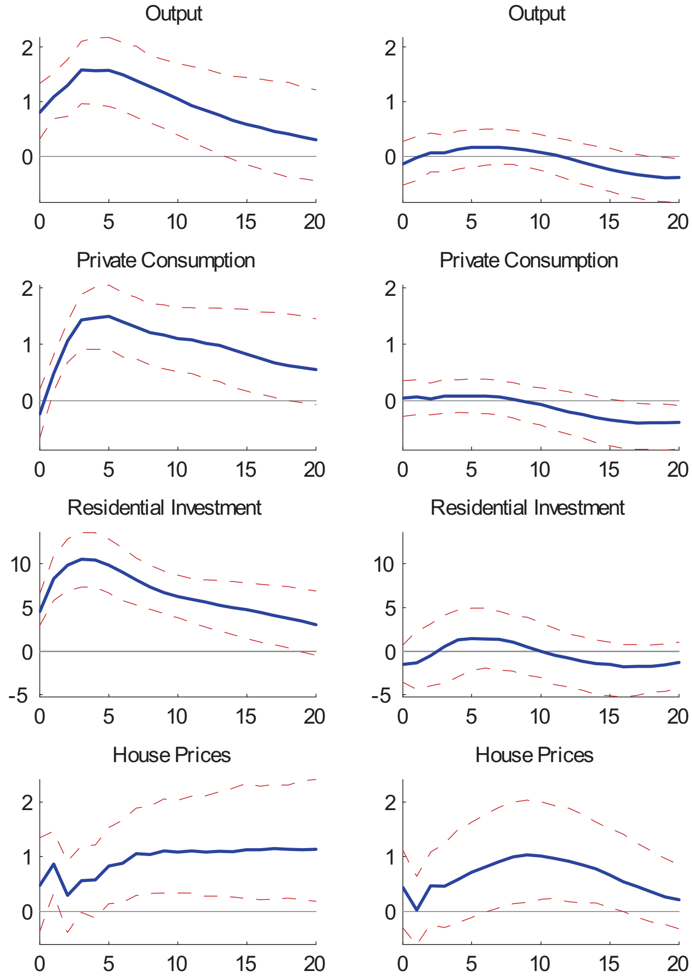

Figure 11b: Regime-dependent responses to one percentage point cut in the average personal income tax rate. Low house price regime (left column) versus high house price regime (right column).

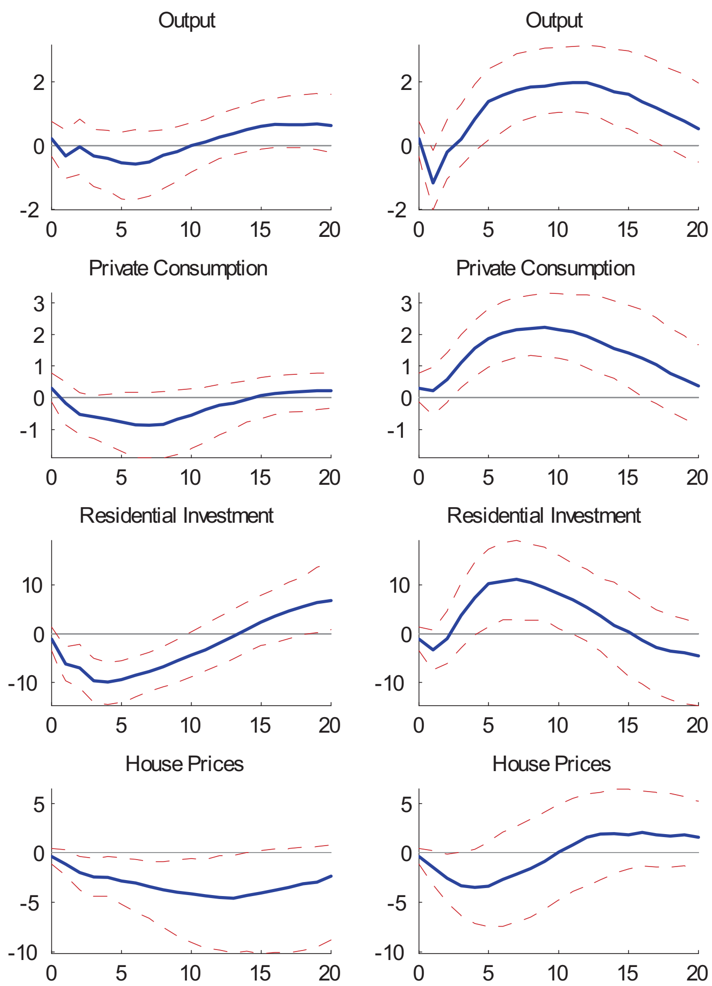

Figure 12a: Regime-dependent responses to a government consumption shock equal to 1% of GDP. Low house price regime (left column) versus high house price regime (right column). Alternative house price series (BIS prices).

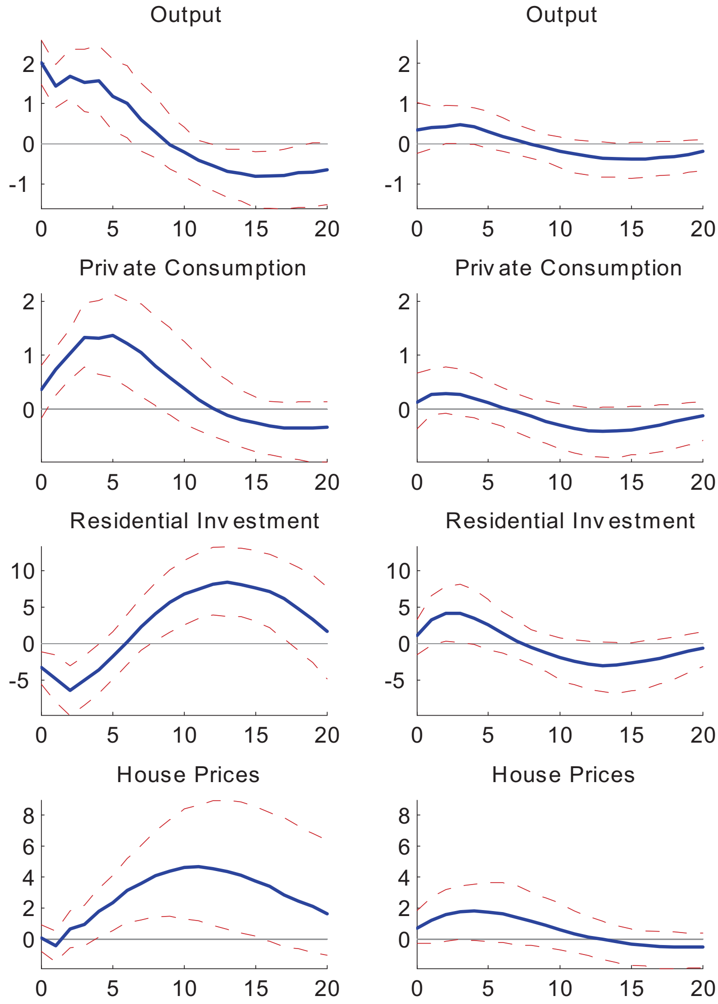

Figure 12b: Regime-dependent responses to one percentage point cut in the average personal income tax rate. Low house price regime (left column) versus high house price regime (right column). Alternative house price series (BIS prices).

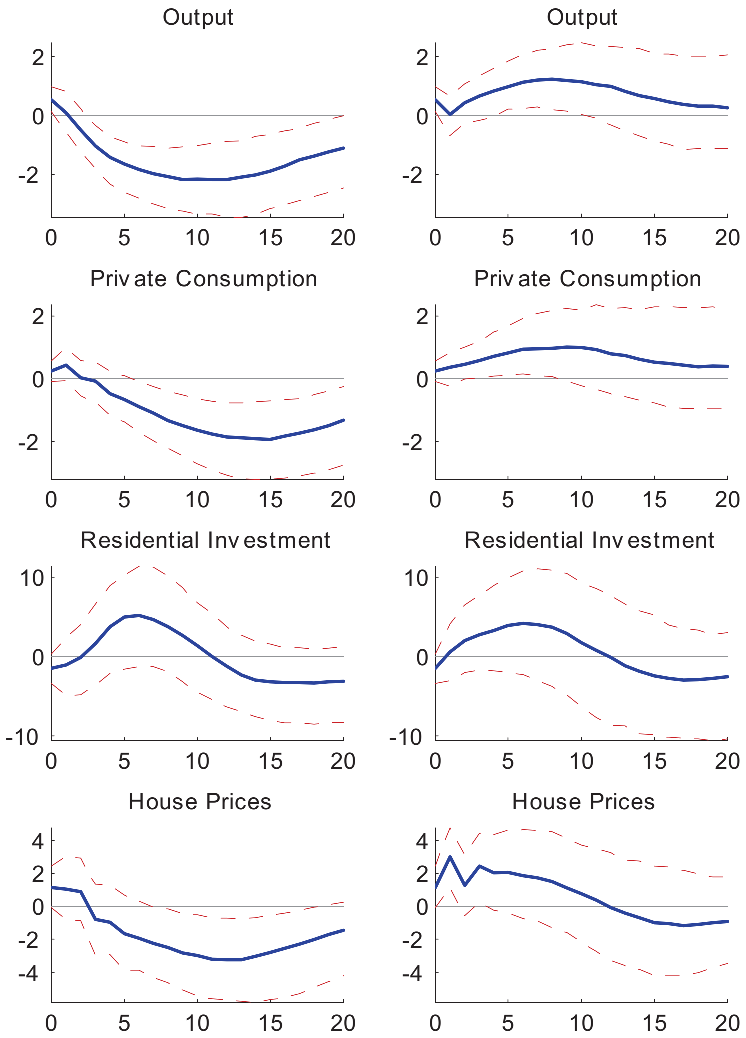

Figure 13a: Regime-dependent responses to a government consumption shock equal to 1% of GDP. Low house price regime (left column) versus high house price regime (right column). Alternative house price series (US Census prices).

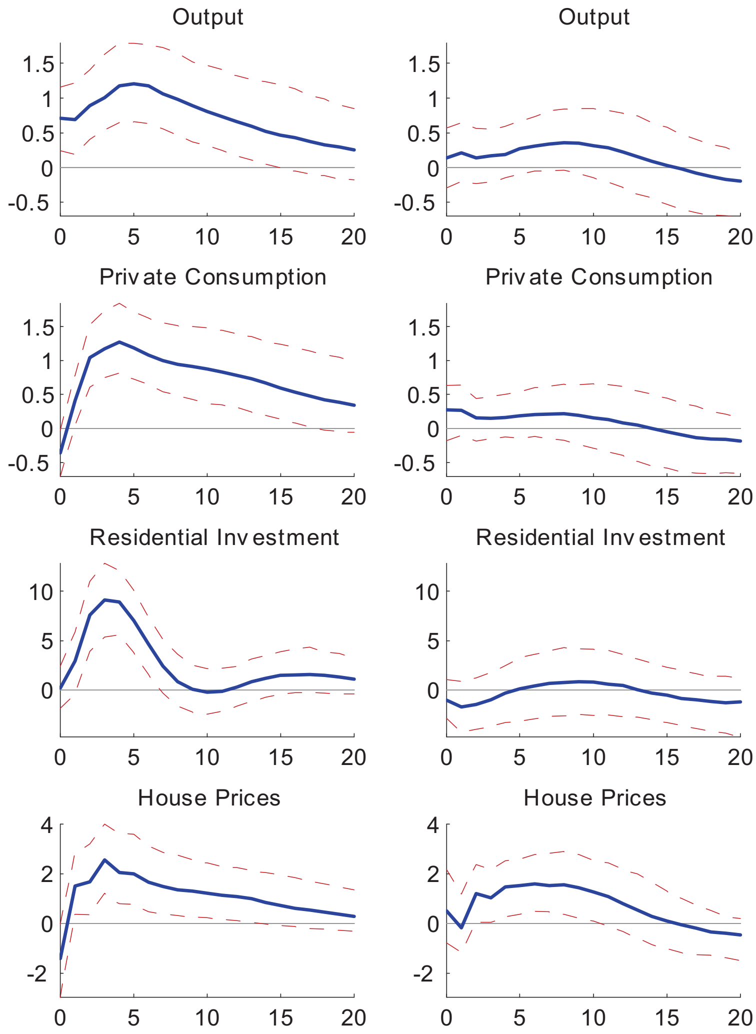

Figure 13b: Regime-dependent responses to one percentage point cut in the average personal income tax rate. Low house price regime (left column) versus high house price regime (right column). Alternative house price series (US Census prices).

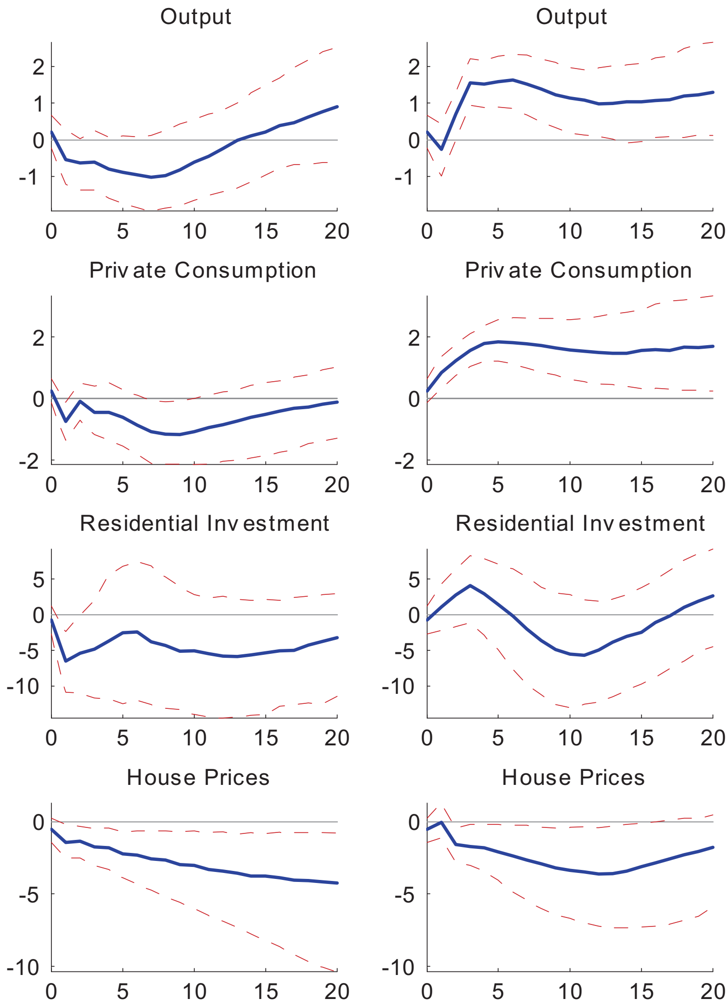

Figure 14: Regime-dependent responses to an unexpected government consumption shock equal to 1% of GDP. Controlling for anticipation effects. Low house price regime (left column) versus high house price regime (right column).

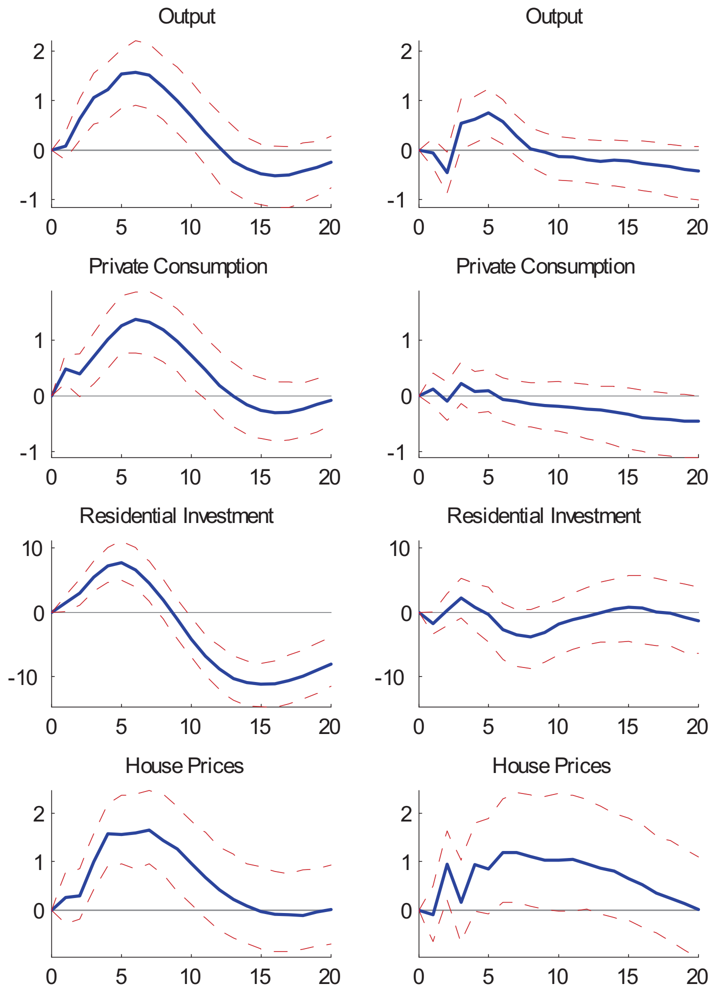

Figure 15: Regime-dependent responses to one percentage point cut in the average personal income tax rate. Low house price regime (left column) versus high house price regime (right column). SVAR-based tax shocks.

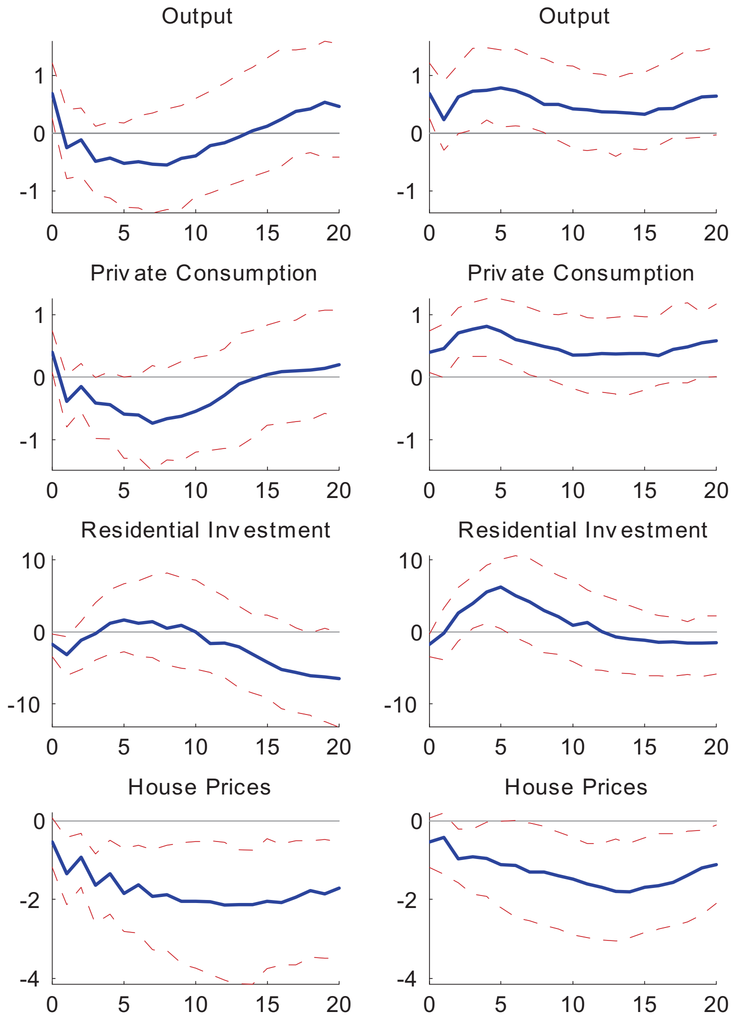

Figure 16a: Generalised impulse responses to a government consumption shock equal to 1% of GDP. Low house price regime (left column) versus high house price regime (right column).

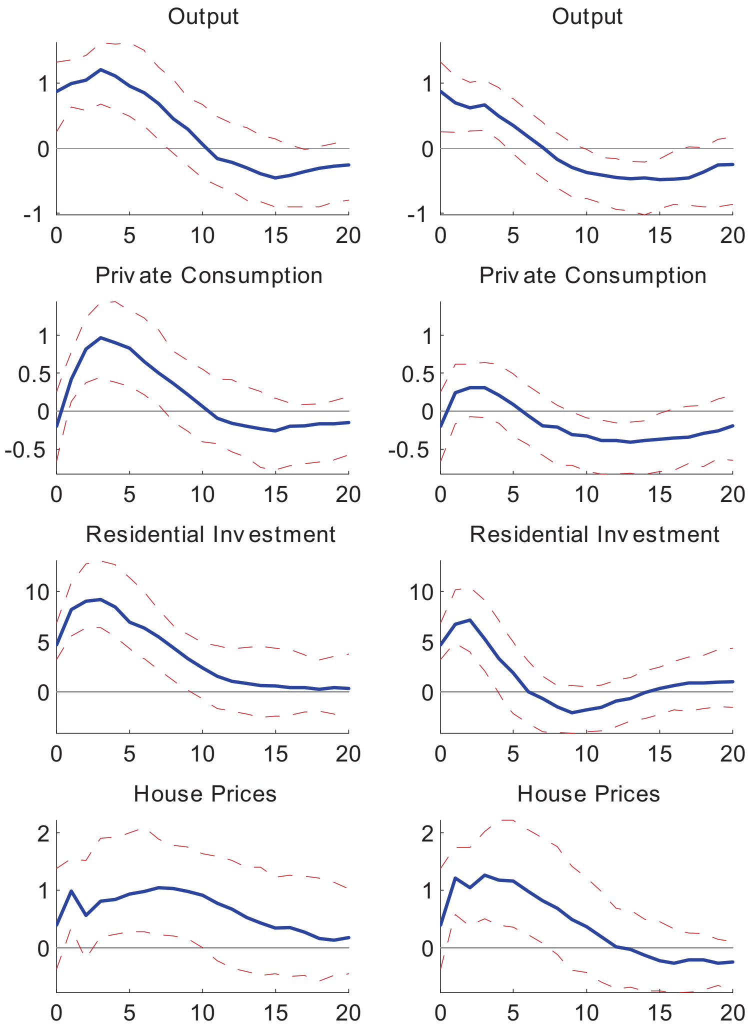

Figure 16b: Generalised impulse responses to one percentage point cut in the average personal income tax rate. Low house price regime (left column) versus high house price regime (right column).

Chapter 2

Spending cuts and their effects on output, unemployment and the deficit

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1 Introduction

How does an economy react to budget cuts? This question has become central in academic and policy circles over the last years. Recovery from financial distress has been rather slow and fragile in many regions of the world. Growth has been throttled by excessive government debt and financial distress transformed into a fiscal crisis in many countries, calling for fiscal consolidation on the policy front.

Austerity measures are usually expected to imply short-term contractionary effects on output. Alesina et al. (2012) and Leigh et al. (2010) suggest that output effects depend on how the consolidation occurs. Using multi-year fiscal consolidation episodes identified in Devries et al. (2011) they show that fiscal adjustments based upon spending cuts are less costly in terms of output losses than tax-based ones. On the theoretical front, Erceg and Lindé (2013) focus on the interactions between fiscal consolidation and monetary policy and show, using a two-country Dynamic Stochastic General Equilibrium (henceforth, DSGE) model of a monetary union, that the effects of tax-based versus expenditure-based consolidations depend on the degree of monetary accommodation.

The current fiscal retrenchment primarily involves cuts in expenditures in many countries, since taxes are usually adjusted less frequently and more painfully. Most of the recent existing analysis considers general cuts in government expenditures, but are all components of goverment spending equally harmful in reducing demand, or is there a lever which is stronger for a given amount cut? This paper compares the losses in terms of output and unemployment and the gains in terms of deficit reductions generated by adjustments in different types of government outlays. We use a structural VAR and identify fiscal shocks via sign restrictions derived from theory.[1] To this end, we build a general DSGE model with matching frictions, endogenous labor force participation, and unemployment that can be either long- or short-term, extending the model of Brückner and Pappa (2012) by incorporating a public sector. Using sign restrictions we identify shocks to government (a) consumption, (b) investment, (c) employment through vacancy cuts and (d) wages in order to assess which item is the least detrimental and most effective to cut. The analysis focuses on the US, but to robustify inference we also look at three other OECD countries for which we have data (Canada, Japan and the UK). Once shocks are identified, we compute medium term output and unemployment multipliers to quantify the losses associated with the different types of spending cuts. We also compute a measure that quantifies how much the deficit-to-GDP ratio is reduced after a fiscal contraction.

When we apply our methodology to identify total expenditure cuts, we obtain results which are similar to the ones in the existing literature: Government spending cuts reduce output significantly, and have no significant effects in increasing unemployment in most countries and horizons, except for the US after one year. Yet, when we consider shocks to different spending components, we find that the associated output and unemployment multipliers differ significantly. Cuts in the wage bill component identified as government vacancy cuts generate the largest output losses and achieve the smallest deficit reductions, regardless of the sample and the country, and significant unemployment losses in the US and the UK, while wage cuts have, if anything, insignificant expansionary effects and achieve the largest deficit reductions. Our results are robust to different identification schemes, specifications of the SVAR, sample periods and countries.

We use our model to explain the empirical findings: shocks to government consumption and investment decrease public demand but increase private consumption and investment, inducing mild contractions in economic activity. Instead, public wage cuts can be expansionary since they reallocate jobseekers from the public to the private sector, shifting labor supply in the private sector and leading to a fall in real wages and increases in private hiring as well as a reduction

[1] There are different approaches for the identification of fiscal shocks and reported effects of fiscal policy often depend on the approach adopted. According to the 'Dummy Variable' approach, which considers fiscal shocks as episodes of significant exogenous and unforeseen increases in government spending for national defense (see, e.g., Rotemberg and Woodford (1992), Ramey and Shapiro (1998), Edelberg et al. (1999), and Burnside et al. (2004) among others), multipliers are typically small; According to the Structural Vector Autoregression (SVAR) methodology, which identifies fiscal shocks assuming that fiscal variables do not contemporaneously react to changes in economic conditions (see, e.g., Blanchard and Perotti (2002), Perotti (2002), Fatas and Mihov (2001), Galí et al. (2007) among others), estimated multipliers vary in the range of (0.8, 1.2); Canova and Pappa (2006) and (2007), Pappa (2009), Canova and Paustian (2011), Mountford and Uhlig (2009), and Forni and Gambetti (2010) have used sign restrictions to identify fiscal shocks and find output multipliers larger than one, and even higher tax multipliers. Perotti (2007) and Caldara and Kamps (2008) reconcile the results of the different approaches.

in unemployment. On the other hand, a cut in public jobs induces a smaller reallocation of workers from the public to the private sector and, most importantly, it induces a fall in labor force participation and an inward shift of private labor supply, propagating the initial fiscal contraction. Hence, our model demonstrates that changes in government spending components have an impact not only on government employment, as in Ramey (2012), but also on private employment. Also, contrary to Michaillat (2014), a fall in public employment does not increase private employment since many long-term unemployed decide to exit labor force as they face a lower probability of finding a job.

Earlier studies have investigated the effects of fiscal consolidations in different types of government outlays. Alesina and Perotti (1995) and Perotti (1996) found that the most successful episodes of consolidations are based on spending cuts on transfers and on the wage bill, while Lane and Perotti (1998) found that cuts in the wage component of government consumption cause much stronger contractions in exports. More recently and in accordance to our findings, Hernández de Cos and Moral-Benito (2011) also conclude, using Bayesian model-averaging techniques, that cuts in public wages are the most appropriate ingredients of successful fiscal consolidations. Also, Burgert and Gomes (2011) highlight potential problems of using aggregate data of government spending to estimate its effects on output and other variables and examine how changes in different government outlays propagate in the economy. In accordance with our findings, they report higher government employment multipliers, but contrary to us they also report high multipliers from increases in public wages. Since both the methodology to recover the fiscal shocks and the model used are different, it is difficult to pin down the reasons for the differences in results. We believe that our empirical methodology is more general, since it can account for the correlation between the different fiscal components, and that by looking at different countries we are able to establish stylized facts for the behavior of the economy in response to the different components and provide a model that can explain the empirical regularities.

The facts we uncover are useful to policymakers in a number of ways. First, estimating the output losses of total government spending cuts may be misleading, since different items of the budget have different macroeconomic effects. Second, unexpected contractions in government vacancies appear to be the most harmful austerity measure in terms of output losses. Contrary to common wisdom, government investment cuts do not generate stronger output effects at the horizons of interest. Third, government wage cuts seem the most preferable austerity measure, since they have insignificant output and unemployment effects and reduce the deficit significantly. Fourth, although all spending components reduce deficits, only government employment cuts in the US and the UK seem to affect unemployment, thus implying that government spending cuts in consumption, investment or wages do not significantly affect unemployment. Fifth, while it is difficult to draw general conclusions, the contractionary effects of vacancy cuts and the expansionary effects of wage cuts in the public sector seem to have been significantly amplified during the last two decades. Our model gives some guidance in explaining changes in the transmission of these shocks over time: decreases in public job protection and a more aggressive monetary policy increase the absolute size of the government vacancy and wage multipliers. For instance, the fact that Japan and Canada have experienced significant changes in employment protection and replacement rates (see, Gnocchi and Pappa (2012)), the adoption of explicit inflation targeting in Canada and the UK, and the appointment of Paul Volcker as chairman of the Federal Reserve Board can therefore explain the changing effects of fiscal shocks to the wage bill component of public spending over the last three decades.

The rest of the paper is organized as follows. The next section describes the methodology for extracting fiscal shocks. Empirical results appear in Section 3 and Section 4 studies their robustness. Section 5 investigates how we can reconcile the empirical evidence with our theoretical model and Section 6 concludes.

2 Methodology

The methodology to examine the effects of fiscal shocks in the data involves four steps (see also Pappa (2009)). In the first step, we establish robust theoretical restrictions for the comovements of the deficit, employment, tax revenues, and the government wage bill for the fiscal shocks we consider. In the second step, we describe restrictions that allow us to distinguish fiscal from other shocks in the model. In the third step, we show how model-based restrictions can be used to identify fiscal shocks in the data. Finally, we compute the magnitude of the output, unemployment and deficit-to-GDP multipliers generated by the identified fiscal shocks.

2.1 The model

We consider a model with search and matching frictions, endogenous labor participation choice, heterogeneous unemployed jobseekers, and sticky prices. There are three types of firms in the economy: (i) a public firm that produces a good used for productive and utility-enhancing purposes; (ii) private competitive intermediate firms that use private inputs and the public good for production; (iii) monopolistic competitive retailers that use all intermediate varieties to produce the final good. Price rigidities arise at the retail level, while search frictions occur in the intermediate goods sector. The household members consist of employees, unemployed, and labor force non-participants.

2.1.1 Labor market

The process through which workers and firms find each other is represented by a matching function that accounts for imperfections and transaction costs in the labor market. These frictions prevent some unemployed from finding a job. In this context, Campolmi and Gnocchi (2011) have added a labor force participation choice and Brückner and Pappa (2012) jobseekers' heterogeneity in DSGE models with nominal rigidities. Following Ravn (2008), the participation choice is modelled as a trade-off between the cost of giving up leisure to engage in labor search activities and the foregoing benefits associated with the prospect of finding a job. The unemployed are of two types: short-term and long-term unemployed, with the latter being less advantageous in the job searching process. Long- and short-term unemployed in turn can search for a job either in the public or the private sector.

In particular, at any point in time a fraction n_t^p (n_t^g) of the representative household's members are private (public) employees, a fraction u_t^S (u_t^L) are short- (long-) term unemployed but actively searching, and a fraction l_t are out of the labor force, so that:

$$n_t^p + n_t^g + u_t^S + u_t^L + l_t = 1 \tag{1}$$

The difference between the two types of unmatched agents is that labor force non-participants are not currently looking for a job, while the unemployed are active jobseekers. In line with Quadrini and Trigari (2007) and Gomes (2012), we assume that the unemployed choose in which sector they want to search. A share s_t^S (s_t^L) of the short- (long-) term unemployed looks for a public job, while the remaining part, $1 - s_t^S$ ($1 - s_t^L$), is seeking a private job.

In each period, jobs in each sector $j = p, g$ (i.e. private/public) are destroyed at a constant fraction σ^j and a measure m^j of new matches are formed. The evolution of each type of employment is thus given by:

$$n_{t+1}^j = (1 - \sigma^j) n_t^j + m_t^j \tag{2}$$

assuming that in general $\sigma^p > \sigma^g$ in order to capture the fact that, relatively speaking, public employment is more permanent than private employment.

Workers that experience a termination of their match enter into a period of short-term unemployment and in the next period, they may either remain unemployed, find a new job match, or become long-term unemployed. Short-term unemployed become long-term unemployed with probability $\xi \in [0, 1]$. The transition equation for short-term unemployment is given by:

$$u_{t+1}^S = (1-\xi)u_t^S + \sigma^p n_t^p + \sigma^g n_t^g - m_t^{pS} - m_t^{gS} \tag{3}$$

where m_t^{jS} denote matches for short-term unemployed in each sector $j = p, g$. The aggregate matches in each sector are given by:

$$m_t^p = \underbrace{\rho_m^{pS}(\upsilon_t^p)^\alpha[(1-s_t^S)u_t^S]^{1-\alpha}}_{m_t^{pS}} + \underbrace{\rho_m^{pL}(\upsilon_t^p)^\alpha[(1-s_t^L)u_t^L]^{1-\alpha}}_{m_t^{pL}} \tag{4}$$

$$m_t^g = \underbrace{\rho_m^{gS}(\upsilon_t^g)^\alpha \left(s_t^S u_t^S\right)^{1-\alpha}}_{m_t^{gS}} + \underbrace{\rho_m^{gL}(\upsilon_t^g)^\alpha \left(s_t^L u_t^L\right)^{1-\alpha}}_{m_t^{gL}} \tag{5}$$

where we assume that the matching efficiency is higher for the short- rather than the long-term unemployed, i.e. $\rho_m^{jS} > \rho_m^{jL}$, and υ_t^j for $j = p, g$ denotes vacancies. Notice that short-term unemployed are likely to be better off searching than non-participating since they are faced with a better matching technology. Long-term unemployed instead have to decide whether they should participate in the labor market by taking into account the fact that they are penalized in matching with firms.

From the matching functions specified above we can define the probabilities of a short- (long-) term unemployed being hired, ψ_t^{hjS} (ψ_t^{hjL}), and of a vacancy being filled, ψ_t^{fj}:

$$\begin{aligned}
\psi_t^{hp} &\equiv \frac{m_t^p}{(1-s_t)u_t}, \quad \psi_t^{hg} \equiv \frac{m_t^g}{s_t u_t} \\
\psi_t^{hpS} &\equiv \frac{m_t^{pS}}{(1-s_t^S)u_t^S}, \quad \psi_t^{hgS} \equiv \frac{m_t^{gS}}{s_t^S u_t^S} \\
\psi_t^{hpL} &\equiv \frac{m_t^{pL}}{(1-s_t^L)u_t^L}, \quad \psi_t^{hgL} \equiv \frac{m_t^{gL}}{s_t^L u_t^L}
\end{aligned} \tag{6}$$

$$\psi_t^{fj} \equiv \frac{m_t^j}{\upsilon_t^j} \tag{7}$$

Finally, market tightness in the two sectors is defined as:

$$\theta_t^p \equiv \frac{v_t^p}{(1-s_t^S)u_t^S + (1-s_t^L)u_t^L}, \quad \theta_t^g \equiv \frac{v_t^g}{s_t^S u_t^S + s_t^L u_t^L} \tag{8}$$

2.1.2 Household's behavior

Each household is infinitely lived and derives utility from private consumption, c_t^p, the public good, y_t^g, which is supplied free of cost by the government, and the fraction of members that are out of the labor force and enjoy leisure, l_t:

$$U(c_t^p, y_t^g, l_t) = \Theta_t \frac{(c_t^p + z y_t^g)^{1-\eta}}{1-\eta} + \Phi \frac{(l_t)^{1-\psi}}{1-\psi} \tag{9}$$

where $z \geq 0$ determines the size of the utility gains from the consumption of the public good, $\frac{1}{\eta}$ is the intertemporal elasticity of substitution, $\Phi > 0$ is a preference parameter related to leisure, ψ is the inverse of the Frisch elasticity of labor supply, $\Theta_t \equiv (C_t^p + z y_t^g)/Z_t$, $Z_t \equiv Z_{t-1}^{\gamma}(C_t^p + z y_t^g)^{1-\gamma}$, $0 < \gamma < 1$, and C_t^p is aggregate consumption (taken as given by each individual household). Notice that if γ takes values close to one, changes in consumption will have small effects on labor supply. In other words, parameter γ regulates the strength of the wealth effect in the utility function. Since many studies (see e.g. Hall (2009) and Woodford (2011)) show that the size of the wealth effect is crucial for determining the effects of fiscal shocks, this specification allows us to study the robustness of our restrictions to changes in γ.

The household owns the private capital stock, which evolves over time according to:

$$k_{t+1}^p = i_t^p + (1-\delta^p)k_t^p - \frac{\omega}{2}\left(\frac{k_{t+1}^p}{k_t^p} - 1\right)^2 k_t^p \tag{10}$$

where δ^p is a constant depreciation rate and $\frac{\omega}{2}\left(\frac{k_{t+1}^p}{k_t^p} - 1\right)^2 k_t^p$ are adjustment costs, paid by the household.

The household keeps its financial wealth in terms of bond holdings, B_t, and the intertemporal budget constraint is given by:

$$(1+\tau^c)c_t^p + i_t^p + \frac{B_{t+1}}{p_t R_t} \leq \left[r_t^p - \tau^k(r_t^p - \delta^p)\right] k_t^p + (1-\tau_t^n)(w_t^p n_t^p + w_t^g n_t^g) + b u_t + \frac{B_t}{p_t} + \Pi_t^p - T_t \tag{11}$$

where p_t is the price level, w_t^j for $j = p, g$ is the real wage in the two sectors, r_t^p is the real return to private capital, b denotes unemployment benefits, R_t is the gross nominal interest rate, and Π_t^p are the profits of the monopolistically competitive firms (see below). Finally, τ^c, τ^k, τ_t^n and T_t represent taxes on private consumption, capital income (allowing for depreciation), labor income and lump-sum taxes, respectively. We assume that the labor tax rate evolves according to:

$$\tau_t^n = (1 - \rho_{\tau_n})\tau^n + \rho_{\tau_n}\tau_t^n + \varepsilon_t^{\tau_n} \tag{12}$$

where ε_t^n is an i.i.d.

The optimization problem involves choosing sequences of c_t^p, u_t^L, s_t^L, s_t^S, u_{t+1}^S, n_{t+1}^p, n_{t+1}^g, k_{t+1}^p, B_{t+1} so as to maximize expected lifetime utility subject to (1), (2), (3), (6), (10), and (11):

$$n_{t+1}^p = (1 - \sigma^p)n_t^p + \psi_t^{hpS}(1 - s_t^S)u_t^S + \psi_t^{hpL}(1 - s_t^L)u_t^L \tag{13}$$

$$n_{t+1}^g = (1 - \sigma^g)n_t^g + \psi_t^{hgS}s_t^S u_t^S + \psi_t^{hgL}s_t^L u_t^L \tag{14}$$

$$u_{t+1}^S = \sigma^p n_t^p + \sigma^g n_t^g + (1 - \xi)u_t^S - \left[\psi_t^{hpS}(1 - s_t^S) + \psi_t^{hgS}s_t^S\right] u_t^S \tag{15}$$

where (13)-(15) correspond to (2)-(3) after using (6). The first-order conditions from the household's maximization problem are presented in the Companion Appendix.[2]

The expected marginal value to the household of having an additional member employed in the private sector, $V_{n^p t}^H$, is:

$$V_{n^p t}^H = \Theta_t \left(c_t^p + z y_t^g\right)^{-\eta} (1 - \tau_t^n)w_t^p - U_{l,t} + (1 - \sigma^p)\lambda_{n^p t} + \sigma^p \underbrace{\beta E_t V_{u^S t+1}^H}_{\lambda_{u^S t}} \tag{16}$$

According to (16), $V_{n^p t}^H$ has the following components: first, the increase in utility given by the real after-tax wage; second, the decrease in utility from lower leisure; third, the continuation utility values, which depend on the separation probability: a private employee may continue having the same job next period with probability $1 - \sigma^p$ or experience a termination of his match and become a short-term unemployed with probability σ^p.

[2]The Companion Appendix is available online at www.eui.eu/Personal/Pappa/research.html.

2.1.3 The production side

Intermediate goods firms Intermediate goods are produced with a Cobb-Douglas technology:

$$y_t^p = (\varepsilon_t^A n_t^p)^{1-\varphi}(k_t^p)^{\varphi}(y_t^g)^{\nu} \tag{17}$$

where ε_t^A is an aggregate technology shock that follows an AR(1) process with persistence ρ_A, k_t^p and n_t^p are private capital and labor inputs, and y_t^g is the public good used in productive activities, taken as exogenous by the firms. The parameter ν regulates how the public input affects private production: when ν is zero, the government good is unproductive.

Since current hires give future value to intermediate firms, the optimization problem is dynamic and hence firms maximize the discounted value of future profits. The number of workers currently employed, n_t^p, is taken as given and the employment decision concerns the number of vacancies posted in the current period, υ_t^p, so as to employ the desired number of workers next period, n_{t+1}^p.[3] Firms also decide the amount of the private capital, k_t^p, needed for production. The problem of an intermediate firm with n_t^p currently employed workers consists of choosing k_t^p and υ_t^p to maximize:

$$Q^p(n_t^p, k_t^p) = \max_{k_t^p, \upsilon_t^p} \left\{ x_t(\varepsilon_t^A n_t^p)^{1-\varphi}(k_t^p)^{\varphi}(y_t^g)^{\nu} - w_t^p n_t^p - r_t^p k_t^p - \kappa \upsilon_t^p + E_t\left[\Lambda_{t,t+1} Q^p(n_{t+1}^p, k_{t+1}^p)\right] \right\} \tag{18}$$

where x_t is the relative price of intermediate goods, κ is a utility cost associated with posting a new vacancy, and $\Lambda_{t,t+1} = \frac{\beta^s U_{c_{t+s}}}{U_{c_t}}$ is a discount factor. The maximization takes place subject to the private employment transition equation:

$$n_{t+1}^p = (1-\sigma^p)n_t^p + \psi_t^{fp}\upsilon_t^p \tag{19}$$

The first-order conditions are:

$$x_t \varphi \frac{y_t^p}{k_t^p} = r_t^p \tag{20}$$

$$\frac{\kappa}{\psi_t^{fp}} = E_t \Lambda_{t,t+1}\left[x_{t+1}(1-\varphi)\frac{y_{t+1}^p}{n_{t+1}^p} - w_{t+1}^p + \frac{(1-\sigma^p)\kappa}{\psi_{t+1}^{fp}}\right] \tag{21}$$

[3] Firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker. According to Hansen (1985), most of the employment fluctuations arise from movements in this margin.

According to (20) and (21) the value of the marginal product of private capital should be equal to the real rental rate and the marginal cost of opening a vacancy should equal the expected marginal benefit. The latter includes the marginal productivity of labor minus the wage plus the continuation value, knowing that with probability σ^p the match can be destroyed.

The expected value of the marginal job for the intermediate firm, $V^F_{n^p t}$ is:

$$V^F_{n^p t} \equiv \frac{\partial Q^p}{\partial n^p_t} = x_t(1-\varphi)\frac{y^p_t}{n^p_t} - w^p_t + \frac{(1-\sigma^p)\kappa}{\psi^{fp}_t} \qquad (22)$$

Retailers There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods. Note that the relative price of intermediate goods, x_t, coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i. Final goods can be expressed as:

$$y^p_t = \left[\int_0^1 (y^p_{it})^{\frac{\varepsilon-1}{\varepsilon}} di\right]^{\frac{\varepsilon}{\varepsilon-1}} \qquad (23)$$

where $\varepsilon > 1$ is the constant elasticity of demand for intermediate goods. The retail good is sold at its price, $p_t = \left[\int_0^1 p_{it}^{1-\varepsilon} di\right]^{\frac{1}{1-\varepsilon}}$. The demand for each intermediate good depends on its relative price and aggregate demand:

$$y^p_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\varepsilon} y^p_t \qquad (24)$$

Following Calvo (1983), we assume that in any given period each retailer can reset her price with a fixed probability $1-\chi$. Hence, the price index is:

$$p_t = \left[(1-\chi)(p^*_t)^{1-\varepsilon} + \chi(p_{t-1})^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \qquad (25)$$

The firms that are able to reset their price, p^*_{it}, choose it so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s}(p^*_{it} - x_{t+s}) y^p_{it+s}$$

The resulting expression for p_{it}^{*} is:

$$p_{it}^{*}=\frac{\varepsilon}{\varepsilon-1}\frac{E_t\sum_{s=0}^{\infty}\chi^s\Lambda_{t+s}x_{t+s}y_{it+s}^{p}}{E_t\sum_{s=0}^{\infty}\chi^s\Lambda_{t+s}y_{it+s}^{p}} \tag{26}$$

2.1.4 Bargaining over the private wage

Wages are determined by ex post (after matching) Nash bargaining. Workers and private firms split rents and the part of the surplus they receive depends on their bargaining power. If $\vartheta\in(0,1)$ is the firm's bargaining power, the problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^p}\left\{(1-\vartheta)\ln V_{n^pt}^{H}+\vartheta\ln V_{n^pt}^{F}\right\}$$

where $V_{n^pt}^{H}$ and $V_{n^pt}^{F}$ have been defined in (16) and (22), respectively. The optimization problem leads to:

$$(1-\vartheta)(1-\tau_t^n)\Theta_t\left(c_t^p+zy_t^g\right)^{-\eta}V_{n^pt}^{F}=\vartheta V_{n^pt}^{H} \tag{27}$$

As we show in detail in the Companion Appendix, solving (27) for w_t^p, using the household's FOC, results in:

$$w_t^p=(1-\vartheta)\left[x_t(1-\varphi)\frac{y_t^p}{n_t^p}+\frac{\kappa}{\psi_t^{fp}}\psi_t^{hpO}\right]+\frac{\vartheta}{(1-\tau_t^n)}\left[b-\sigma^p\frac{\beta E_tV_{u^It+1}^{H}}{\Theta_t\left(c_t^p+zy_t^g\right)^{-\eta}}\right] \tag{28}$$

Hence, the equilibrium wage is the sum of the value of the marginal product of employment and the value to the firm of the marginal job multiplied by the hiring probability for a long-term unemployed, weighted by the worker's bargaining power, and the outside option of being unemployed minus the expected value of becoming a short-term unemployed next period if the match is terminated, weighted by the firm's bargaining power. In equilibrium, the value of working is the same for short- and long-term unemployed because otherwise firms could make profits by hiring fewer workers with a lower value and more workers with a higher value. In other words, there are decreasing returns to unemployment in matching, so in equilibrium the value of work should be the same to avoid arbitrage opportunities. The wage paid to matched short-term unemployed will therefore be the same as the wage paid to matched long-term ones.

2.1.5 Government

The government sector produces a public good using public inputs (capital and labor) and vacancy costs are deducted from production[4]:

$$y_t^g = (\varepsilon_t^A n_t^g)^{1-\mu}(k_t^g)^\mu - \kappa v_t^g \tag{29}$$

where μ is the share of public capital in the public production. The public good provides productivity- and utility-enhancing services.

The government holds the public capital stock. As for private capital, the government capital stock evolves according to:

$$k_{t+1}^g = i_t^g + (1-\delta^g)k_t^g - \frac{\omega}{2}\left(\frac{k_{t+1}^g}{k_t^g} - 1\right)^2 k_t^g \tag{30}$$

Following Quadrini and Trigari (2007), who reported -using US data over the period 1970-2003 - that public wages comove with private wages with an elasticity equal to 0.94, and Gomes (2012), we assume that the government sets the public wage according to the rule:

$$\log w_t^g = \log w^g + \pi_w(\log w_{t-1}^p - \log w^p) + \varepsilon_t^{w_g} \tag{31}$$

where $\varepsilon_t^{w_g}$ is a shock to the public wage and $\pi_w > 0$ is the elasticity of the public wage to changes in the private one.[5]

Government's income consists of tax revenues, while expenditures consist of consumption and investment purchases, salaries and wages and unemployment benefits. The government deficit is defined by:

$$DF_t = c_t^g + i_t^g + w_t^g n_t^g + bu_t - \tau^k(r_t^p - \delta^p)k_t^p - \tau_t^n(w_t^p n_t^p + w_t^g n_t^g) - \tau^c c_t^p - T_t \tag{32}$$

[4] See also Gomes (2012).

[5] If the labor market was frictionless, then the wages should be equal across sectors. However, this is not the case with labor market frictions that are not symmetric across sectors. Note that we have also assumed a rule in which public wages react contemporaneously to changes in private wages, i.e. $\log w_t^g = \log w^g + \pi_w(\log w_t^p - \log w^p) + \varepsilon_t^{w_g}$. Such a rule changes the dynamics of deficits to a government wage shock by making the reaction of deficits to the shock immediate. In exercises that are available upon request we show that the timing of the restriction in deficits regarding the public wage shock is not crucial for the results we present.

and the government budget constraint is given by:

$$B_t + P_t DF_t = R_t^{-1} B_{t+1} \tag{33}$$

where B_t denotes government bonds. To ensure determinacy of equilibrium and a non-explosive solution for debt (see e.g. Leeper (1991)), we assume a debt-targeting rule of the form:

$$T_t = \overline{T} \exp(\zeta_{\text{ß}}(\text{ß}_t - \overline{\text{ß}})) \tag{34}$$

where $\overline{\text{ß}}$ is the steady state level of debt to GDP ratio, $\text{ß}_t = \frac{B_t}{y_t}$.

If $\Psi^g = c^g$, i^g, υ^g denotes the different fiscal instruments, we assume fiscal rules of the form:

$$\Psi_t^g = \overline{\Psi}^g \left(\Psi_{t-1}^g\right)^{\boldsymbol{\varrho}_g^{\psi}} \exp(\boldsymbol{\varrho}_g^{\psi y} \Delta y_t + \boldsymbol{\varrho}_g^{\psi b}(\text{ß}_t - \overline{\text{ß}}) - \varepsilon_t^{\psi g}) \tag{35}$$

where Δy_t is total output growth defined as $\Delta y_t \equiv \Delta \left(y_t^p + \frac{p_t^g}{p_t} y_t^g \right)$ with $\frac{p_t^g}{p_t}$ being the implicit relative price of public goods determined by the consumers' demand for public goods, $\varepsilon_t^{\psi g}$ is a zero-mean, white-noise disturbance, ρ_g^{ψ} determines the persistence of the different government components processes, $\boldsymbol{\varrho}_g^{\psi y}$ determines the degree of procyclicality of government spending and $\boldsymbol{\varrho}_g^{\psi b}$ determines the elasticity of the fiscal instrument to changes in the debt target.

2.1.6 Monetary policy

There is an independent monetary authority that sets the nominal interest rate according to the rule:

$$R_t = \bar{R} \exp(\zeta_\pi \pi_t + \zeta_y \widetilde{y}_t + \varepsilon_t^R) \tag{36}$$

where ϵ_t^R is a monetary policy shock, π_t measures inflation in deviation from the steady state and $\widetilde{y}_t$ measures deviations of output from its flexible-price counterpart.

2.1.7 Closing the model

The aggregate resource constraint is given by:

$$y_t^p = c_t^p + i_t^p + c_t^g + i_t^g + \kappa \upsilon_t^p \tag{37}$$

The model features seven exogenous disturbances: The shocks to public vacancies and fiscal spending components, as described in (35), the labor-income tax shock described in (12), the productivity, the public wage and the monetary policy shocks. The vector of the last three shocks, $S_t = [\varepsilon_t^A, \varepsilon_t^{w_g}, \varepsilon_t^R]'$, is parameterized as:

$$\log(S_t) = (I - \rho)\log(\bar{S}) + \rho\log(S_{t-1}) + V_t \tag{38}$$

where V is a (3×1) vector of innovations, I is a (3×3) identity matrix, ρ is a (3×3) diagonal matrix, and $\bar{S}$ is the mean of S. The innovation vector V is a stationary, zero-mean, white noise process, and the roots of ρ are all less than one in modulus.

We solve the model by approximating the equilibrium conditions around a non-stochastic steady state (setting all shocks equal to their mean values) in which all prices are flexible, the price of the private good is normalized to unity, and inflation is zero. The derivation of the steady state relationships is presented in the Companion Appendix.

In sketching the model we have left some features out of the analysis on purpose. For example, we do not consider a model of a small open economy as in this case the interest rate would be given. We would therefore be unable to study the interaction between monetary and fiscal policy, which as Christiano et al. (2011) and Canova and Pappa (2011) show, are very important for determining the size of the multiplier. Also, we have not considered the case of sticky private wages given that such rigidities in combination with matching frictions distort aggregate job creation and create inefficient dispersion in hiring rates across firms (Thomas (2008)). We believe that those abstractions, though, are not crucial for the robustness of our sign restrictions.

2.2 Robust restrictions

2.2.1 Parameter ranges

The model period is a quarter. We let $\theta = (\theta_1, \theta_2)$, where θ_1 represents the parameters which are fixed to a particular value to avoid indeterminacies or because of steady state considerations, while θ_2 are the parameters which are allowed to vary. The intervals for the remaining parameters are centered around calibrated values and include values that have been either estimated in the literature or assumed in calibration exercises (See Table 1). Although the intervals for the majority of parameters should be uncontroversial, the selection of some ranges needs to be discussed. The share of public goods in total consumption, z, is usually set to zero. Theoretical considerations suggest that z has to be low since the size of the private wealth effect following fiscal shocks crucially depends on this parameter. For that reason we limit z to the [0.0, 0.5] interval. The parameter ν controls the interactions between public and private goods in production. We choose a range that includes both the case of unproductive government goods and most of the estimates for the elasticity of output to changes in public inputs in the literature. Parameter γ determines the size of the wealth effect after an increase in the government's absorption we allow for a wide range of this parameter to control for the robustness of our results to the utility specification assumed. Finally, the parameter ranges for the steady state values of the fiscal variables are chosen to match the average values of their US data counterparts.

2.2.2 Dynamics

Figure 1 plots pointwise 68% probability bands for the responses of output, total employment, the nominal interest rate, deficit, the government wage bill and tax revenues to a surprise 1% change in government consumption (first row), government investment (second row), public vacancies (third row), public wages (fourth row), TFP (fifth row), interest rate (sixth row) and income taxes (last raw) when parameters vary over the ranges reported in Table 1. We normalize all shocks to be contractionary.

All fiscal shocks, except for government wage cuts, robustly decrease total employment one or more periods after the shock and the deficit on impact. Yet, using restrictions on employment and deficits would not help distinguish TFP or interest rate from fiscal shocks. In order to distinguish such shocks from fiscal shocks we take advantage of the opposite movements of output and interest rates: Since negative TFP shocks increase inflation, the interest rate typically increases after a contractionary supply shock on impact. Also, a contractionary monetary policy shock, by definition, reduces output with a lag. On the other hand, with fiscal shocks the interest rate and output commove. We orthogonalize the fiscal shocks to disturbances that move output and the interest rates in opposite directions on impact for TFP shocks. We also require our shocks to be orthogonal to shocks that induce a negative lag correlation between the interest rate and output and the government wage bill in order to exclude the possibility of confusing interest rate with wage cuts.

Besides, income tax hikes imply similar restrictions with government spending cuts, especially in the case of government consumption and investment, since they decrease employment and deficits on impact and increase the government wage bill with a lag. Yet, tax shocks increase tax revenues on impact, while spending shocks robustly reduce deficits with a lag. In order to distinguish tax hikes from government spending contractions in consumption or investment we require the identified shocks to be orthogonal to shocks that move deficits and tax revenues in opposite direction on impact, and deficits and the wage bill in opposite direction with a lag. Notice that such orthogonalization is sufficient to distinguish tax shocks from government vacancy and wage shocks as well. Finally, to account for possible correlation among the four fiscal components, we shut the responses of the unshocked government spending variables on impact.

Table 2 summarizes our robust restrictions. Notice that output and unemployment responses are left unrestricted for the identification of fiscal shocks since it is exactly the dynamics of those variables that we want to evaluate in our empirical exercise. On the other hand, deficit dynamics are restricted on impact and similarly for all the shocks considered.

2.3 Data and the reduced form model

We use quarterly, seasonally adjusted data for Canada and the UK from 1970 to 2007, Japan from 1962 to 2007 and the US from 1960 to 2007, thus, excluding the current financial crisis. The series come from the OECD Economic Outlook.

The reduced form model contains a constant, a linear trend and nine endogenous variables: The log of real per capita GDP, the log of total employment, the log of real per-capita net tax revenues, the log of real per capita government expenditure in goods purchases, defined as government expenditures minus government wage expenditures, and in gross fixed investment, the log of average real (GDP deflated) public wage per job, the log of government employment and a measure of the short term interest rate. We also include a labor market variable in the system that alternates between (i) the unemployment rate, (ii) the labor force participation rate, or (iii) the log of average real (GDP deflated) private wage per job. Finally, we include oil prices as exogenous in order to control for global supply effects. We set the lag length of the VAR to two. We use flat priors on the coefficients of the model and the covariance matrix of the shocks and Bayesian techniques to compute posterior distributions.[6]

[6] We have also examined other variants of the model (e.g.revenues and expenditures expressed in percentage of GDP or in growth rates). In addition, we have tried specifications in which (a) we include five endogenous variables by considering one spending component at a time; (b) we include a factor for the various labor market variables, instead of alternating variables in the VAR; (c) we use the wage bill deflator, instead of the average wage. Results are not significantly affected in all cases and are available upon request or presented in the Online Appendix.

Before proceeding with the results, notice that the use of sign restrictions allows us to identify shocks in public vacancies even if we do not have actual series in the data. What we label as 'public employment shock' is actually a shock in public vacancies in the theoretical model that we are able to recover in the data, since we have enough identifying restrictions to distinguish shocks to public vacancies from other fiscal disturbances.

In order to take a preliminary view of the variations in our data, we plot in Figure 2 the cyclical component of the quarterly growth changes in the different fiscal components we consider in our exercise for the US. As can be readily seen, deviations are not correlated: public investment falls substantially in the last quarter of 1970 and peaks in the last quarter of 1978, while government consumption peaks in the last quarter of 1966 and decreases substantially in 1983 and 2008. The data point to a significant increase in public employment in 1966 - when the National Historic Preservation Act led to major changes in the federal and state employment in historic preservation fields; in 1977 after Carter's appointment and job creation stimulus; in 1990 when President Bush increased government employment for defense in the face of the German reunification; and to a fall in public employment in 1980, after Reagan won the presidential election and cut the Comprehensive Employment and Training Act of 1974. Significant changes in government wages are observed in 1964, after the Civil Rights Act was passed, making the discrimination of employees based on race illegal; when the minimum wage increased to $1.30 per hour in February 1969 and with the Minimum Wage Act of 1983.[7]

3 Results

We present in Figure 3 the responses of output, total employment, the real wage, the labor force participation and the unemployment rate in the US to the four fiscal shocks considered. Shocks are scaled to be the same by representing a 1% cut of total government spending. Each graph presents median estimates (solid line) and pointwise 68% credible bands (shaded area). Output decreases significantly for some periods after the first three shocks and it increases insignificantly with respect to government wage cuts. Not surprisingly, total employment decreases

[7] To provide further evidence on the effects of government vacancy shocks, we also use a narrative approach for identifying these shocks, based on the suspension of conscription in 29 European countries. We apply a difference-in-difference estimation using as treatment group countries that have gone through changes in conscription and as control group countries that have not. Reforms in conscription increase GDP and the government wage bill significantly, while they do not have a significant effect on the real wage, suggesting that this special category of government vacancy shocks indeed generates significant output effects. Results are available in the Online Appendix.

significantly in response to the first three shocks, but increases insignificantly with respect to government wage cuts. The responses of the real wage, the unemployment rate and labor force participation are only significant for government employment shocks.

Although responses are similar qualitatively, there are striking quantitative differences: output is strongly reduced and unemployment significantly increased after a public employment shock. A similar pattern arises in other OECD countries. In Figure 4 we present the output responses after a government consumption (first column), investment (second column), employment (third column) and wage (last column) shock in Canada, Japan, and the UK. The public employment cuts significantly contract output in all three countries, while the other three shocks have mostly insignificant output effects. [8]

The difference in the impulse responses translates into differences in the output multipliers and, hence, output losses. Table 3 presents point estimates of the impact output, unemployment, and deficit-to-GDP multipliers and the medium-run cumulative multipliers one, three and five years after the shock. Multipliers are computed by dividing the cumulative response of output by the cumulative response of total government spending after a shock to each spending component. Similarly, unemployment multipliers measure what the percentage-point change in the unemployment rate is when total government spending increases by 1% of GDP after a shock to each spending component. Finally, the deficit-to-GDP multipliers express the percentage change in the deficit-to-GDP ratio. Values for which corresponding 68% credible intervals do not include zero are indicated with an asterisk.

For the US, shocks to the government wage bill originating from cuts in public vacancies have the highest output multipliers at all horizons. A 1% of GDP decrease in government spending, induced by a shock to government consumption, investment and employment respectively, implies a fall in output on impact by 2.27%, 2.62% and 3.58%, respectively. After three years the cumulative effect on output is 1.82%, 1.22% and 2.74% and after five years 1.43%, 1.09%, and 2.33%, respectively. Long run output multipliers are statistically significant for government employment shocks only, while only government investment and employment shocks generate significant output effects on impact. The results for the other countries are similar: the output multipliers of the government vacancy shocks are always higher and significant. For Canada and the UK, government consumption shocks also induce significant output losses in the short run and for Canada the output losses after government investment shocks are significant on impact. In contrast, government wage cuts generate insignificant and very often

[8] The complete set of impulse responses for all countries are provided in the Companion Appendix.

positive output effects in all countries. Unemployment multipliers are significant only for government employment shocks in the US and the UK. In terms of deficit reductions, government wage cuts appear to be the most successful tool in reducing deficits in all countries, except for Japan. Although government employment shocks are associated with the highest output losses in all countries and significant unemployment losses in the US and the UK, they do not seem to generate significant deficit reductions. Hence, government employment cuts seem the most destructive and government wage cuts the least harmful means of reducing the government's budget.

According to Burgert and Gomes (2011) using aggregate data for government spending to estimate its effects on output might be problematic. To investigate whether aggregation is important or misleading, we have identified a shock to total government expenditures by using our theoretical restrictions for the first three components of spending. According to our restrictions, a shock to total government spending increases employment with a lag and deficits on impact and is orthogonal to shocks that move output and the interest rate in opposite directions and to shocks that move deficits and tax revenues in opposite direction contemporaneously. Output multipliers from this exercise appear in the seventh column of Table 3, while the twelfth column reports unemployment multipliers and the last column deficit gains. The output multipliers are mostly insignificant in the medium and long run. Unemployment multipliers are insignificant for all countries, but the US one year after the shock, while deficit multipliers, apart from Canada, are small and only significant on impact. Our exercise suggests that by summing up the different series a lot of useful information is lost and, therefore, offers an additional motivation for investigating the effects of different spending components separately.

4 Robustness

4.1 Subsample analysis

There are reasons to believe that our sample is likely to be heterogeneous. For example, it is well known that the volatility and the persistence of the US real and nominal variables have fallen after the 1980s (see, Kim and Nelson (1999), McConell and Perez-Quiros (2000), and Stock and Watson (2003)). There is some evidence that the dynamic effects of fiscal shocks have changed over time (see, e.g., Perotti (2002)). To take sample heterogeneity into account we repeat the analysis for two subsamples, up to 1985 and from 1987 onwards.

In Table 4 we present impact and cumulative output multipliers one, three and five years after the shock for each of the two sub-periods, as well as the difference between the two sub-periods. The structural changes of the 1980s have significantly changed the transmission of government spending shocks. The impact and one-year effects of government vacancy shocks on output have substantially increased in the second subsample for all countries, while the medium-run output effects of government wage cuts in Canada have reversed sign and in the US have become significantly larger in absolute value on impact, implying stronger expansionary effects of the wage cut in the second sample. After the 80's medium-run deficit multipliers are higher for public wage cuts, while there is no general pattern of changes for unemployment multipliers[9].

4.2 An alternative identification scheme

For readers who prefer a simple recursive (Cholesky) identification to extract the fiscal shocks from the data to sign restrictions, we have also run four different VARs. Each has the government spending variable ordered first and the rest of the variables are in the following order: real per capita GDP, unemployment rate, tax revenues and interest rate. The results of the Cholesky identification have to be taken with caution; first, in these estimations there is no control for movements in other fiscal spending components when extracting the fiscal shocks and second, strictly speaking, in the absence of data on government vacancies, the identified shocks might not be necessarily a cut in public jobs.

Impulse responses of the VAR for the US are in Figure 5. As in our benchmark specification, a public vacancy cut leads to a persistent and pronounced recession and government wage cuts do not imply significant output gains. Although not restricted, total employment reduces significantly some periods after a public employment shock and, as in the benchmark model, unemployment increases and labor force participation falls significantly after the shock. Contrary to the benchmark model, the output effects of government consumption and investment shocks are significant; yet as demonstrated in Table 5, the ranking of the multipliers is similar to the one obtained when we use sign restrictions to recover the shocks.

[9] In the online Companion Appendix we present impulse responses to the various shocks for the US economy as well as unemployment and deficit multipliers for the two subsample periods.

4.3 Controlling for expectations

Following the work of Ramey (2011) one has to worry about anticipation effects of fiscal consolidations, since the timing of fiscal shocks plays a critical role in identifying the effect of unanticipated fiscal shocks. To control for expectations we add real-time forecasts for US government spending from the Survey of Professional Forecasters (SPF) of the Federal Reserve Bank of Philadelphia in our benchmark specification and add an orthogonality restriction that ensures that our identified shocks are orthogonal contemporaneously to these series. The ordering of multipliers is unchanged (see last row of Table 5).[10]

5 Reconciling the evidence with the theory

Summarizing the empirical evidence: (i) government vacancy cuts are typically the most destructive means of fiscal adjustment in terms of output (and unemployment) losses and the least effective in deficit gains and (ii) government wage cuts for most countries in the sample and identification schemes are related to insignificant increases in output and a significant fall in the deficit-to-GDP ratio. In this section, we use the theoretical model of Section 2 to explain our findings. In Figures 6-9 we present the main macroeconomic variable responses to a shock in government consumption, investment, vacancies and wages, respectively. Continuous lines correspond to the benchmark model in which public goods are assumed to be both utility and productivity enhancing (i.e., $\nu = 0.1, z = 0.1$), dotted lines correspond to the case in which the public good is assumed to only enhance private utility (i.e., $\nu = 0, z = 0.1$), dashed dotted lines the case in which the public good is assumed to be only productive (i.e., $\nu = 0.1, z = 0$), and dashed lines the case in which the public good is a complete waste (i.e., $\nu = 0, z = 0$).

As is well known, a government consumption cut induces a wealth effect that decreases labor participation and increases private consumption in Figure 6. The fall in labor force participation is associated with a fall on impact in the fraction of long-term unemployed jobseekers in both sectors, given that it is more difficult for them to find a job. This is combined with a negative demand effect due to price rigidities, which decreases labor demand, generating a fall in private vacancies and, consequently, in private employment. Jobseekers shift from the private to the public sector increasing short-term unemployment in this sector. The fall in long-term unemployment implies also a fall in total unemployment on impact, while the up-

[10] The responses of the macro variables for the US are presented in the online appendix.

ward movement of short-term unemployment, which adjusts one period after the shock, causes a similar movement in total unemployment. The combined shifts of labor supply and demand in the private sector induce an increase in the private wage after the shock, which leads subsequently to an increase in the public wage. Public employment increases, since the tightness of the public job market decreases, and as a result, public output increases as well. Total output falls one period after the shock due to the drop in private output. Responses for the different model specifications look similar since public consumption is assumed to be a waste and does not affect labor supply decisions.

In Figure 7, the assumption on the productivity of the public good now matters for the results. When the public good is a waste (dashed lines), or utility enhancing only (dotted lines), the responses of the economy to a cut in public investment are very similar qualitatively with the responses to a government consumption shock in Figure 6, with the exception of public output, which falls persistently since the negative investment shock reduces future public capital persistently. When the public good is productive, the wealth and demand effects are combined with a negative effect of the shock on future private production. The contemporaneous responses are qualitatively similar to the ones produced by a government consumption shock, but the lagged effects are quite different: private and, hence, total output fall persistently.

Like the other two austerity measures, public job cuts induce a fall in the labor force participation and, unlike the other two shocks, a reallocation of jobseekers from the public to the private sector (see Figure 8). Yet, the fall in labor force participation is relatively stronger, leading to a fall in private employment and an increase in the real wage a period after the shock. This is because the cut in public vacancies reduces the probability that an unemployed household member will be matched next period and, as a result, strengthens the reaction of long-term unemployed to exit labor force, decreasing significantly the private labor supply[11]. Assuming that the public good is productive does not change the main propagation mechanism, but adds persistence to the responses through the accumulation of public employment, which increases the future public good. In terms of output losses, the impact multipliers are not affected significantly by the assumption of public good productivity, but this assumption makes a difference for the cumulative effect of the shock. Hence, it is crucial in order for the model to match the empirical responses.

Again as a reduction in government's absorption a public wage cut is associated with a

[11] The assumption of heterogeneous unemployed is crucial. In exercises available upon request we show that with homogenous unemployed the fall in labor supply is relatively smaller and a government vacancy cut for some calibrations can actually be expansionary in our model.

positive wealth effect that decreases labor force participation. At the same time, this shock triggers a stronger reallocation of both short- and long-term unemployed jobseekers towards the private sector than a public vacancy cut. The different reaction of the long-term unemployed comes from the fact that a public wage cut does not imply for them more adverse prospects of finding a job as is the case of a public vacancy cut. In other words, the cut in the public wage does not decrease the probability of long-term unemployed for finding a job and become more efficient in their matching and for that reason it does not reduce labor force participation by as much as a government vacancy cut. The increase in the relative supply of labor in the private sector leads to increases in private vacancies and employment for a lower wage and private output rises with a lag. This might not seem surprising when government output is assumed to be unproductive (dashed and dotted lines in Figure 9). However, the expansionary effects are limited when public output is productive (continued and dash-dotted lines in Figure 9). The reason behind this result is very simple. A public wage cut reduces the supply of labor in the public sector and, hence, public output. If public output is assumed to be productive, such a fall will imply a decrease in the productive capacity of the economy and, hence, private output will increase less than in the case in which the public good is a waste. Hence, the assumption on the productive nature of public goods is crucial in explaining our empirical findings. The insignificant output and unemployment multipliers can be perfectly rationalized if one is willing to accept that public goods enhance to some degree private productivity.

Looking through Figures 6-9, and the multipliers depicted with continuous lines for the benchmark model in Figure 10, it is apparent that the model can replicate qualitatively the empirical evidence. When the public good is assumed to be productive, government vacancy cuts do generate the highest output and unemployment losses and insignificant deficit gains in the model, while government wage cuts generate the lowest losses in terms of output and unemployment and the highest gains in terms of deficit reductions. Since wage cuts lead to moderate expansions in the model it is not surprising that they generate the highest deficit gains. On the other hand, the fall in private consumption and investment and in labor force participation after a vacancy cut limit the deficit gains after the fiscal contraction.

Moreover, the model predicts that government wage cuts reallocate jobseekers from the public to the private sector, increasing private employment and, instead, in response to vacancy cuts both private and public employment fall due to a fall in labor force participation. Figure 3 confirms that labor force participation falls significantly in the US in the benchmark empirical model after government employment cuts. In Figure 11 we present the responses of private employment in response to the two fiscal shocks from a VAR in which we use restrictions on output rather than employment to identify the government employment shock and we use private rather than total employment series. Notice that the responses of private employment are left unrestricted for both shocks. The first column on Figure 11 reconfirms our intuition, the fall in labor force participation is significant, as in the benchmark model, and leads to a significant fall in private employment. When we look at government wage cuts, according to our theoretical predictions, private employment increases.

5.1 Sensitivity analysis

It is important to study the sensitivity of our results to changes in the parameterization of the model. In Figure 10 we present how theoretical cumulative output, unemployment and deficit multipliers, which are computed in accordance with their empirical counterparts, vary when we change some key parameters of the model.

The size of replacement rates affects the propagation of government vacancy shocks significantly. A higher replacement rate ($b/w^p = 0.45$) decreases substantially the wealth effect from government vacancy shocks since when unemployment benefits are high agents have fewer incentives to leave the labor market and labor force participation is not reduced so strongly. Hence, output multipliers are smaller. The public job destruction rate also affects the persistence of the cut in public jobs and, hence, the probability of finding a job for long term unemployed. The dotted lines in Figure 10 show that assuming more secure public jobs ($\sigma^g = 0.03$) implies an increase in the output multiplier for public vacancies, and hence bigger output losses from a vacancy cut, since safer public jobs imply lower job creation in the public sector in the coming years, which in turn discourages further labor force participation.

The analysis of Erceg and Lindé (2013) suggests that the interactions between monetary and fiscal policy are crucial for determining the size of the output losses of fiscal consolidations. The dashed-circled lines in Figure 10 depict multipliers when we assume a less aggressive monetary policy ($\zeta_\pi = 1.5$). In line with other studies, such a policy substantially increases the effects (i.e. output and unemployment multipliers) of government consumption and investment shocks. Yet a laxer monetary policy seems to reduce the negative output and unemployment effects of government vacancy cuts by limiting the exit of long-term unemployed from the labor market since limited movements in the interest rate limit the wealth effect that induces an increase in consumption and a fall in labor force participation.

There are several other parameters that might affect the output multiplier for government spending shocks. We examine the sensitivity of our results to changes in the size of capital adjustment costs ($\omega = 3$) and in the parameter associated with the wealth effect in the utility function ($\gamma = 0.1$). All the parameter changes considered, although they affect the size, do not substantially change the ranking of multipliers for the different spending cuts: cutting government wages is always ranked as the best fiscal consolidation policy in terms of output and unemployment losses, while cutting public vacancies is the worst policy a government can adopt, especially when replacement rates are low and public jobs are of a more temporary nature.

6 Conclusions

To identify deficit-financed expenditure shocks we use sign restrictions that hold for many variants and parameterizations of a very general DSGE model with real and nominal frictions. Output losses from government employment cuts are the largest, while they are the smallest for government wage cuts for all countries, identification schemes and samples considered. Government wage cuts are also the most effective in reducing deficits in the medium run.

Determining whether these facts have a common underlying explanation is a challenging task. We employ our model to highlight which features are necessary to justify the empirical responses: government employment cuts are the most detrimental austerity measure because, apart from generating the standard wealth and demand effects after decreases in government absorption, they have an additional effect on the labor participation decision of the household: it discourages long-term unemployed from participating in the labor market. This latter effect depends crucially on the size of the unemployment benefits and on the monetary policy stance. Since the empirical results point to a significant increase in the output effects of government employment shocks in the post-1980s period, our model predictions suggest that the reforms in replacement rates and the change in the monetary policy stance in the countries considered could be a possible explanation for this pattern.

Finally, we have abstracted from analyzing cuts in government transfers as an alternative austerity measure. In our theoretical model such cuts could be modeled as shocks to the lump-sum transfers or the unemployment benefits. We have decided to exclude cuts in transfers from the current analysis for the following reasons. First, transfer shocks typically work via many additional instruments, such as subsidies to firms or energy support for poor households, so it would be restrictive to consider as transfer cuts, only cuts to unemployment benefits or lump-sum transfers. Second, it would be much more difficult to apply our empirical methodology, since the identification of shocks in the data becomes more cumbersome, given that it is practically difficult to make so many shocks orthogonal to each other and at the same time to satisfy many sign restrictions. For these reasons, we leave the exploration of transfer cuts and their macroeconomic consequences in our top priorities for future research.

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Tables

Table 1: Parameter ranges and values

Varying parameters		Ranges	Values	Varying parameters		Ranges	Values
η	risk aversion coefficient	[0.5,6]	1.0	$\frac{\kappa}{w^p}$	vacancy cost - wage ratio	[0.035,0.065]	0.045
z	preference parameter for y^g	[0,0.5]	0.1	$\frac{u}{1-l}$	unemployment rate	[0.04,0.1]	0.065
$\frac{1}{\psi}$	Frisch elasticity	[0.1,10]	0.25	$\frac{n^g}{n}$	public employment share	[0.12,0.2]	0.16
ν	productivity of public goods	[0,0.5]	0.1	$\frac{u^{gL}}{u^{pL}}$	long-term unemployed allocation	[0.25,0.35]	0.3
γ	size of the wealth effect	[0.05,0.95]	0.8	ψ^{fp}	priv. vacancy filling probability	[0.4,0.9]	0.5
$\frac{C^g}{Y}$	steady-state C^g/Y ratio	[0.05,0.2]	0.08	ψ^{hp}	private hiring probability	[0.4,0.9]	0.9
$\frac{K^g}{K^p}$	steady-state K^g/K^p ratio	[0.27,0.35]	0.31	$\frac{\psi^{hjS}}{\psi^{hjL}}$	short- vs. long-term unemployed	[1.005,1.02]	1.015
δ^j	capital depreciation rate	[0.02,0.03]	0.025		hiring probability		
φ, μ	productivity of capital stocks	[0.3,0.4]	0.36	$\frac{b}{w^p}$	replacement rates	[0.0,0.5]	0.4
ω	adjustment costs parameter	[0,10]	5.5	$\frac{w^g}{w^p}$	steady-state wage ratio	[0.95,1.25]	1.03
τ^n	average labor tax rate	[0,0.4]	0.2	π_ω	public wage elasticity to w^p	[0.9,1.2]	0.94
τ^k	average capital tax rate	[0,0.4]	0.2	$\frac{u^L}{u}$	long-term unemployment share	[0.1,0.2]	0.18
τ^c	average consumption tax rate	[0,0.1]	0.045	ϑ	firms bargaining power	[0.3,0.6]	0.4
$\bar{\text{ß}}$	debt to GDP ratio	[0.4,0.8]	0.6	$1-l$	labor participation rate	[0.6,0.7]	0.65
$\zeta_{\text{ß}}$	debt coefficient	[1,4]	2.0	σ^g	public separation rate	[0.02,0.06]	0.04
ζ_π	Taylor's π coefficient	[1,5]	2.5	σ^p	private separation rate	[0.02,0.06]	0.05
ζ_y	Taylor's y coefficient	[0,1]	0.0	$\frac{\varepsilon}{\varepsilon-1}$	steady-state markup	[1.09,1.16]	1.1
ϱ, ϱ_g^ψ	persistence of shocks	[0.0,0.95]	0.85	χ	price stickiness	[0.4,0.8]	0.75
$\varrho_g^{\psi b}$	debt stabilization coefficient	[-0.5,0.0]	0.0				
$\varrho_g^{\psi y}$	output stabilization coefficient	[-0.05,0.05]	-0.05				

Notes: $j = p, g$ and $\psi = c^g, i^g, \upsilon^g, \tau^n$

Table 2: Identifying restrictions

	shocks						
restricted variables	ε_t^{cg}	ε_t^{ig}	ε_t^{vg}	$\varepsilon_t^{w_g}$	ε_t^{A}	ε_t^{R}	$\varepsilon_t^{\tau_n}$
output					$+$ $k=0$	$-$ $k=1$	
interest rate					$-$ $k=0$	$+$ $k=0$	
employment	$+$ $k=1,2$	$+$ $k=1,2$	$+$ $k=1,2$				
deficits	$+$ $k=0$	$+$ $k=0$	$+$ $k=0$	$+$ $k=0$			$-$ $k=0$
gov.wage bill			$+$ $k=1,2$	$+$ $k=1,2$		$-$ $k=1,2$	$+$ $k=1,2$
tax revenues							$+$ $k=0$
gov. consumption	$+$ $k=0$	0 $k=0$	0 $k=0$	0 $k=0$			
gov. investment	0 $k=0$	$+$ $k=0$	0 $k=0$	0 $k=0$			
gov. employment	0 $k=1,2$	0 $k=1,2$	$+$ $k=1,2$	0 $k=1,2$			
gov. wages	0 $k=0$	0 $k=0$	0 $k=0$	$+$ $k=0$			

Notes: k refers to the horizon of the restrictions
ε_t^{cg}: government consumption shock, ε_t^{ig}: government investment shock, ε_t^{vg}: government employment shock
ε_t^{wg}: government wage shock, ε_t^{A}: TFP shock, ε_t^{R}: interest rate shock, $\varepsilon_t^{\tau_n}$: labor income tax shock

Table 3: Benchmark VAR

		output multipliers associated with shocks to:					unemployment multipliers associated with shocks to:					deficit/GDP multipliers associated with shocks to:				
		c^g	i^g	υ^g	w^g	G	c^g	i^g	υ^g	w^g	G	c^g	i^g	υ^g	w^g	G
Canada	0	1.48*	1.97*	1.40*	-0.83	1.75*	-0.20	-0.10	-0.49	0.06	-0.46	1.05*	1.18*	1.13	1.18*	1.96*
	4	1.48	1.76	2.31*	-2.25	1.71	-0.28	-0.24	-0.52	0.03	-0.43	0.88*	0.97	0.88	1.49*	1.87*
	12	1.50	0.94	2.39	0.62	1.45	-0.16	-0.38	-0.40	-0.28	-0.19	0.99*	0.86	0.64	1.68*	1.91*
	20	1.37	0.55	2.07	2.14	1.30	-0.13	-0.48	-0.23	-0.50	-0.10	1.06	0.66	0.66	1.53*	1.85*
Japan	0	1.49	1.37	2.54*	0.90	1.66	-0.04	-0.04	-0.10	0.03	-0.12	0.89*	0.91*	0.66*	0.82*	0.86*
	4	2.26	2.71	3.22	1.34	1.88*	-0.03	-0.04	-0.20	-0.02	-0.18	0.51*	0.45*	0.22	0.81	0.73
	12	2.95	3.39	3.15	-0.67	2.42*	-0.06	-0.08	-0.29	-0.12	-0.13	0.03	-0.29	0.04	0.87	1.04
	20	3.85	3.45	3.27	-2.10	3.07	-0.16	-0.10	-0.21	-0.13	-0.19	-0.41	-0.33	-0.21	0.48	0.74
UK	0	2.00*	0.75	3.95*	0.44	1.17	0.17	-0.08	-0.64*	0.02	-0.11	1.30*	1.05*	1.11*	1.39*	1.06*
	4	1.59*	1.00	2.98*	0.41	1.19*	0.16	0.04	-0.73*	0.03	-0.23	0.81	0.71	0.71	1.52*	0.80
	12	1.15	1.08	2.06*	0.85	0.92	-0.48	-0.19	-0.60	-0.22	-0.01	0.73	0.55	0.40	1.22*	0.73
	20	1.13	1.23	1.64	1.01	0.70	-0.64	-0.51	-0.17	-0.23	-0.10	0.62	0.43	0.33	0.95	0.87
US	0	2.27	2.62*	3.58*	-0.38	2.24*	-0.43	-0.62	-0.88*	1.33	-0.56	1.42*	1.32*	1.10*	3.80*	1.47*
	4	2.56*	1.87*	3.50*	-0.83	2.10*	-0.74	-0.64	-1.11*	1.34	-0.71*	0.52	0.99	0.75	3.10*	0.87
	12	1.82*	1.22	2.74*	0.76	1.24	-0.33	-0.44	-0.66	0.19	-0.18	0.51	1.09*	0.64	2.14*	0.88
	20	1.43	1.09	2.33*	1.44	1.22	-0.15	-0.34	-0.19	0.06	-0.15	0.74	1.06*	0.81	1.46	0.77

Note: $G = c^g + i^g + w^g n^g$, An * indicates multipliers that are significantly different from zero at one standard deviation.

Table 4: Subsample analysis: Output multipliers, pre- and post-1980s

		Canada				Japan				UK				US			
shock		0	4	12	20	0	4	12	20	0	4	12	20	0	4	12	20
c^g	pre	0.92	0.80	2.62	2.96	1.55	0.01	-0.01	-0.28	2.78*	1.45	0.41	0.03	0.90	0.96	0.90	0.86
	post	1.19	-0.87	3.57	3.95	2.26*	2.67	2.68	2.67	1.21	0.75	0.36	0.69	3.37*	1.97	0.62	0.24
	dif.	0.27	-1.66	0.95	0.99	0.71	2.66	2.69	2.94	-1.57*	-0.70	-0.05	0.67	2.47*	1.01	-0.28	-0.62
i^g	pre	-0.01	1.41*	2.58	2.99	0.93	0.76	0.42	0.00	3.42	2.94	0.74	0.14	1.54*	1.39*	1.09*	0.93
	post	1.08	1.86	4.24	3.17	1.92	2.48	2.52	2.08	0.19	0.28	0.34	1.14	3.37	2.06*	0.97	0.49
	dif.	1.09	0.45	1.66	0.18	0.98	1.72	2.10	2.07	-3.22	-2.66	-0.41	1.00	1.83	0.66*	-0.13*	-0.44
υ^g	pre	1.19*	1.71*	2.85*	2.63	1.67*	1.05	0.00	-0.27	1.60	0.96	0.52	0.27	2.52*	2.24*	1.74	1.18
	post	2.16*	2.23*	1.67	0.92	3.95*	3.38*	2.52	2.26	3.18*	1.76*	1.30*	1.09	3.88*	3.12*	1.51	1.26
	dif.	0.97*	0.52*	-1.18	-1.71	2.29*	2.33*	2.52	2.53	1.57*	0.81*	0.79*	0.82	1.36*	0.88*	-0.23	0.07
w^g	pre	-0.14	-0.79	3.44	3.13	1.09	0.51	0.01	-0.16	-0.24	-0.22	-0.14	-0.12	-0.07	0.09	0.97	1.23
	post	-0.07	-1.04	-1.72*	-0.72	-0.15	0.46	1.77	3.48	-0.30	-0.63	-0.60	0.19	-3.36*	1.05	1.25	0.57
	dif.	0.07	-0.25	-5.15*	-3.84	-1.24	-0.05	1.76	3.64	-0.07	-0.40	-0.46	0.31	-3.29*	0.95	0.28	-0.66

Note: An * indicates multipliers that are significantly different from zero at one standard deviation.

Table 5: Robustness analysis

		output multipliers associated with shocks to:					unemployment multipliers associated with shocks to:				
		c^g	i^g	v^g	w^g	G	c^g	i^g	v^g	w^g	G
Canada	0	0.76*	0.44	1.27*	-0.67*	0.32*	0.06	-0.32*	-0.45*	0.39*	0.08*
(Cholesky)	4	0.84*	0.25	2.05*	-2.85*	-0.05	0.09	-0.23	-0.59*	1.33*	0.16*
	12	1.40*	-0.71	1.66*	0.48	-0.03	0.10	-0.28	0.00	0.16	0.12
	20	0.94	-1.22	1.75*	1.77	-0.08	0.34	-0.16	0.24	-0.03	0.17
Japan	0	0.62*	0.93*	4.42	1.01	0.81*	0.02	-0.03	0.02	-0.05	-0.23
(Cholesky)	4	2.02	1.56*	0.79	1.28	1.22*	-0.01	-0.04	0.13	-0.03	0.23
	12	3.50	1.52*	0.52	1.15	1.47*	-0.05	-0.06	0.32*	-0.01	2.71
	20	3.68	0.57	2.60	1.34	1.32	-0.04	0.01	0.33	0.01	3.99*
UK	0	0.45*	0.05	1.82*	0.48*	0.31*	-0.02	0.03	-0.11	0.01	0.02
(Cholesky)	4	0.16	0.01	1.20*	0.61*	0.23*	0.07	0.11	-0.08	-0.02	0.08*
	12	0.25	0.37	1.56*	0.91	0.37*	0.15	0.08	0.02	-0.30*	0.10
	20	0.65	0.77	1.16	0.78	0.47	0.03	-0.05	0.27	-0.44*	0.11
US	0	1.40*	1.85*	3.66*	-0.92*	1.48*	-0.02	-0.07	0.04	0.19	-0.05
(Cholesky)	4	1.73*	1.10*	3.37*	-1.28	1.05*	-0.13	0.01	-0.27	0.62	-0.06
	12	1.63*	0.94	3.43*	0.32	1.27*	-0.20	-0.23	-0.50*	0.07	-0.17*
	20	1.34*	1.09*	2.95*	1.72	1.45*	-0.07	-0.24	-0.18	-0.21	-0.17
US	0	2.82*	2.36	3.44*	-2.87	2.35*	-0.72	-0.44	-0.25	1.04	-0.52*
(Expectations)	4	1.93	1.81	2.74	0.16	2.29*	-0.41	-0.21	-0.09	-0.01	-0.55*
	12	1.44	1.09	1.79	0.97	0.68	-0.08	-0.31	-0.06	-0.23	0.08
	20	0.61	0.49	1.38	0.66	0.07	0.07	-0.17	0.05	0.14	0.07

Note: An * indicates multipliers that are significantly different from zero at one standard deviation.

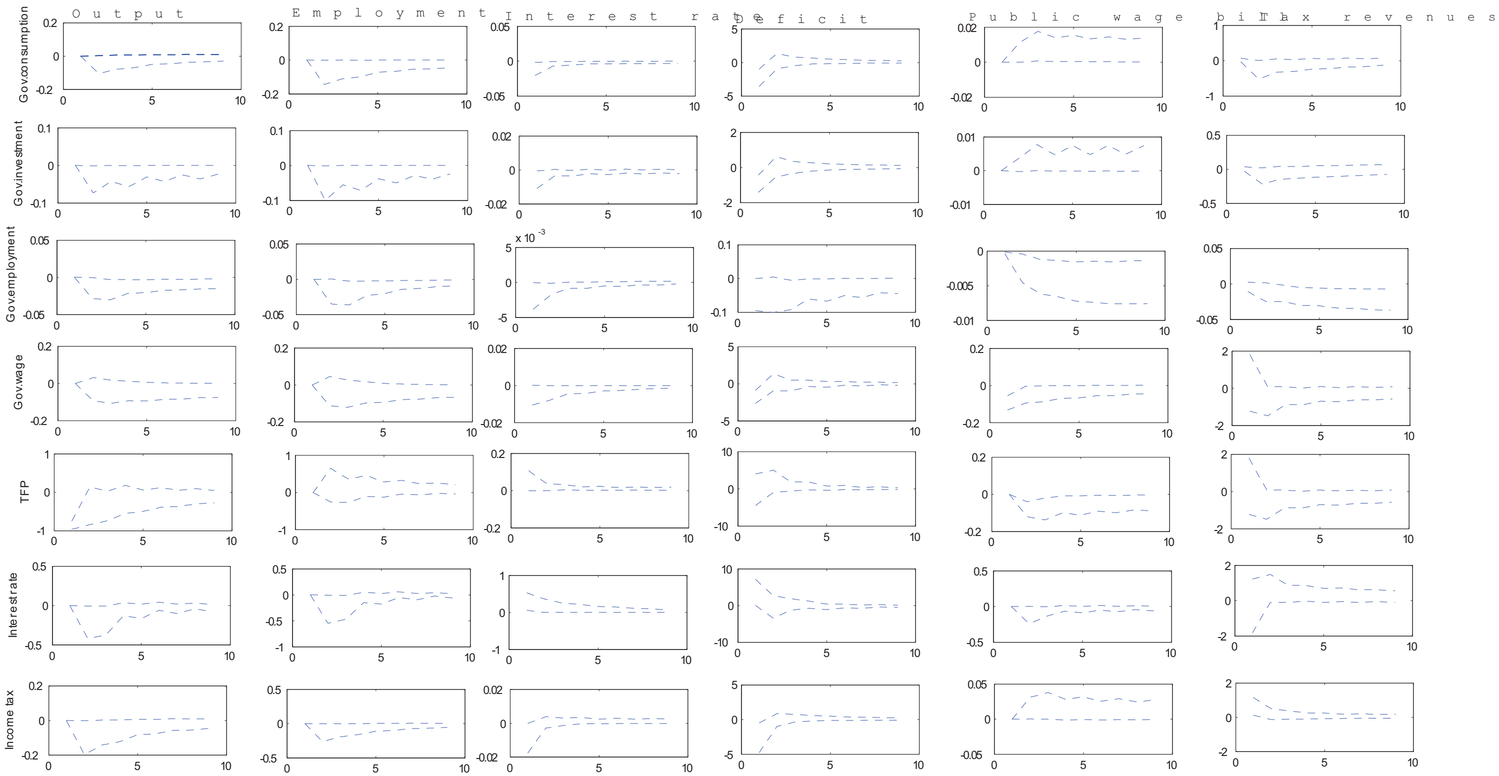

Figure 1: Robust sign restrictions, theoretical responses to negative shocks

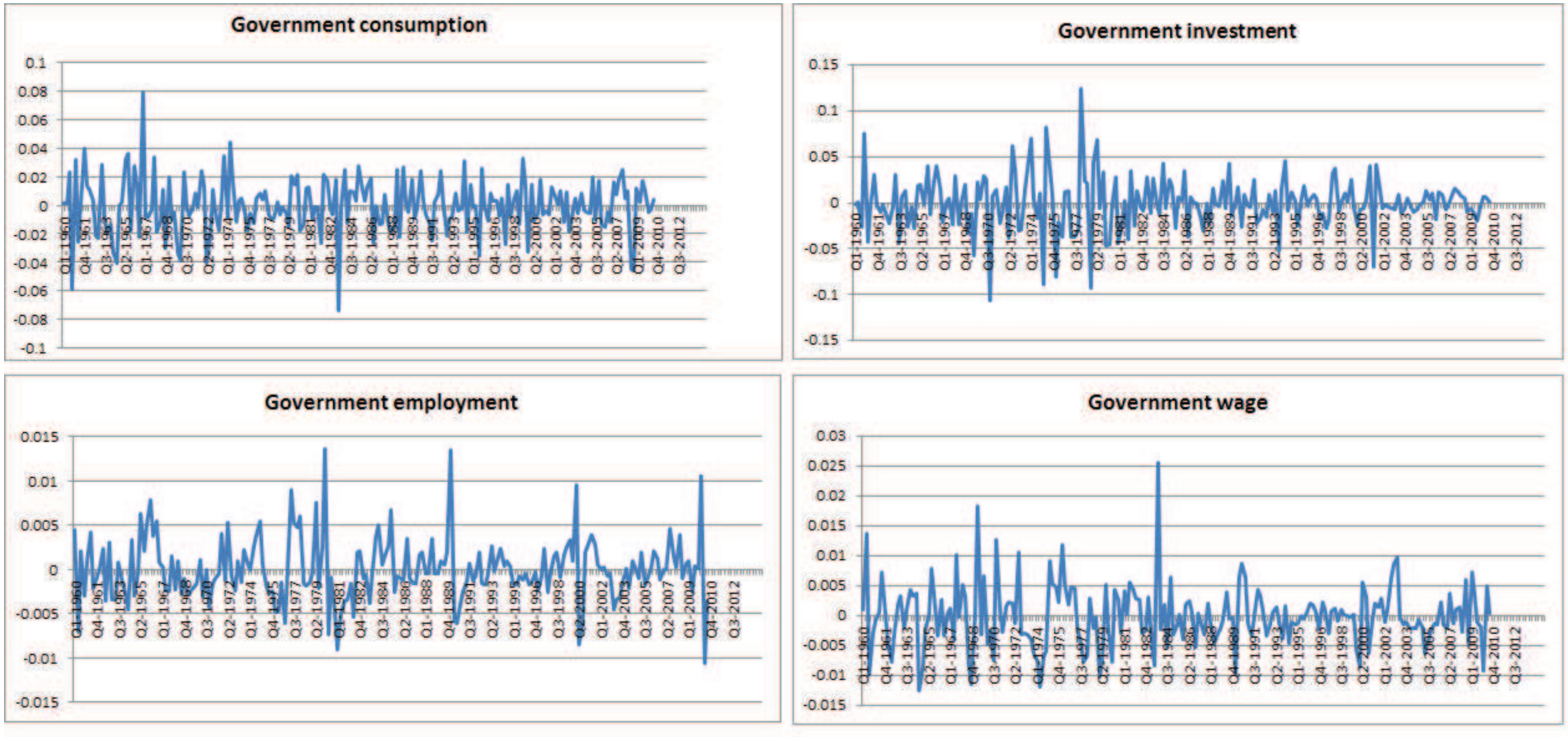

Figure 2: The cyclical component of the quarterly growth changes in the US fiscal variables

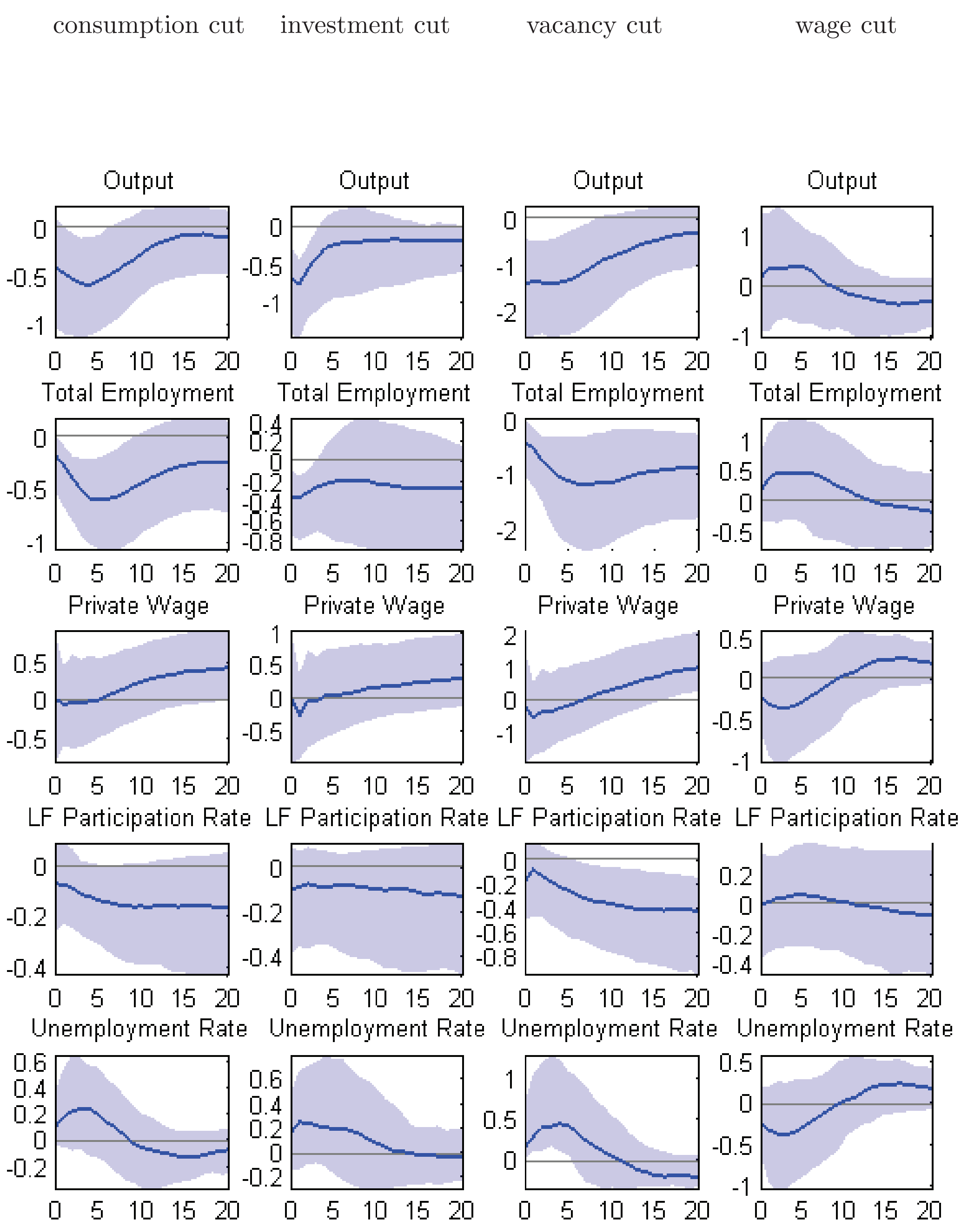

Figure 3: Impulse responses to fiscal shocks in the US

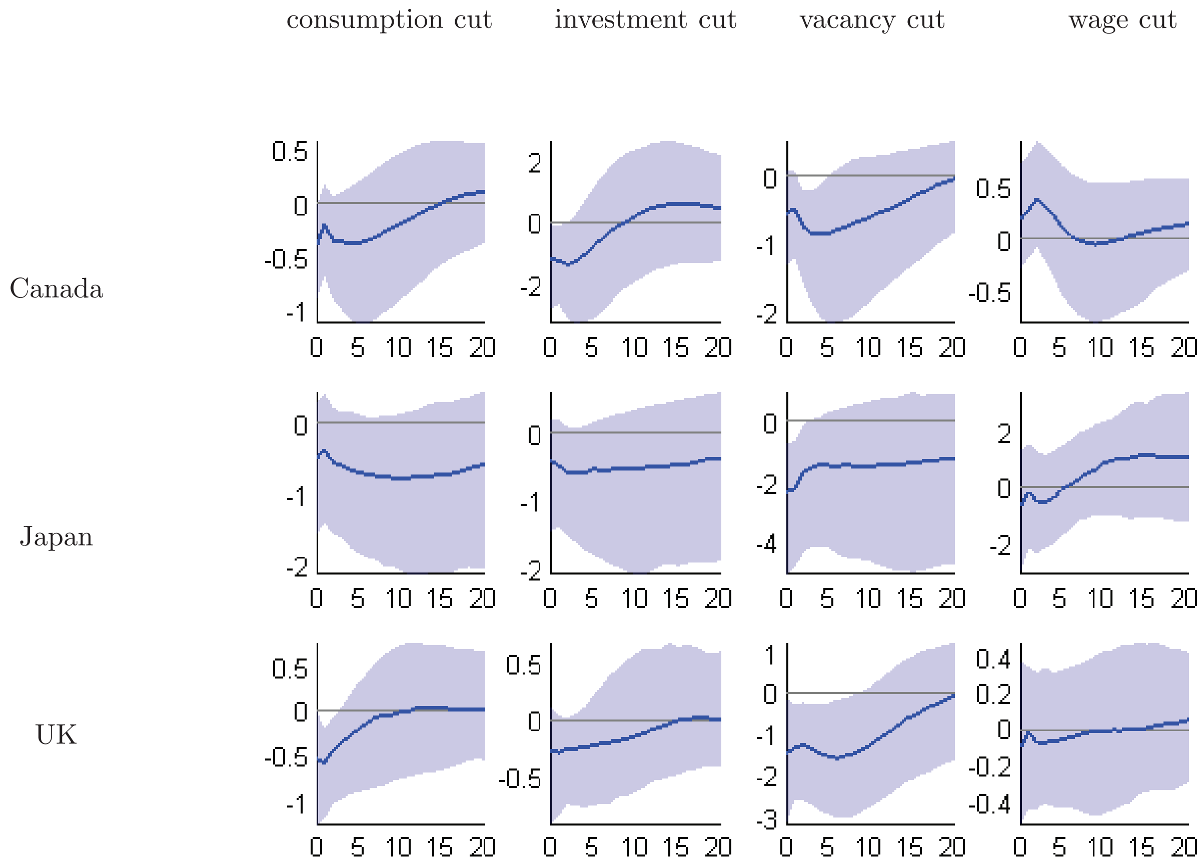

Figure 4: Output responses to fiscal shocks in other OECD countries

consumption cut investment cut vacancy cut wage cut

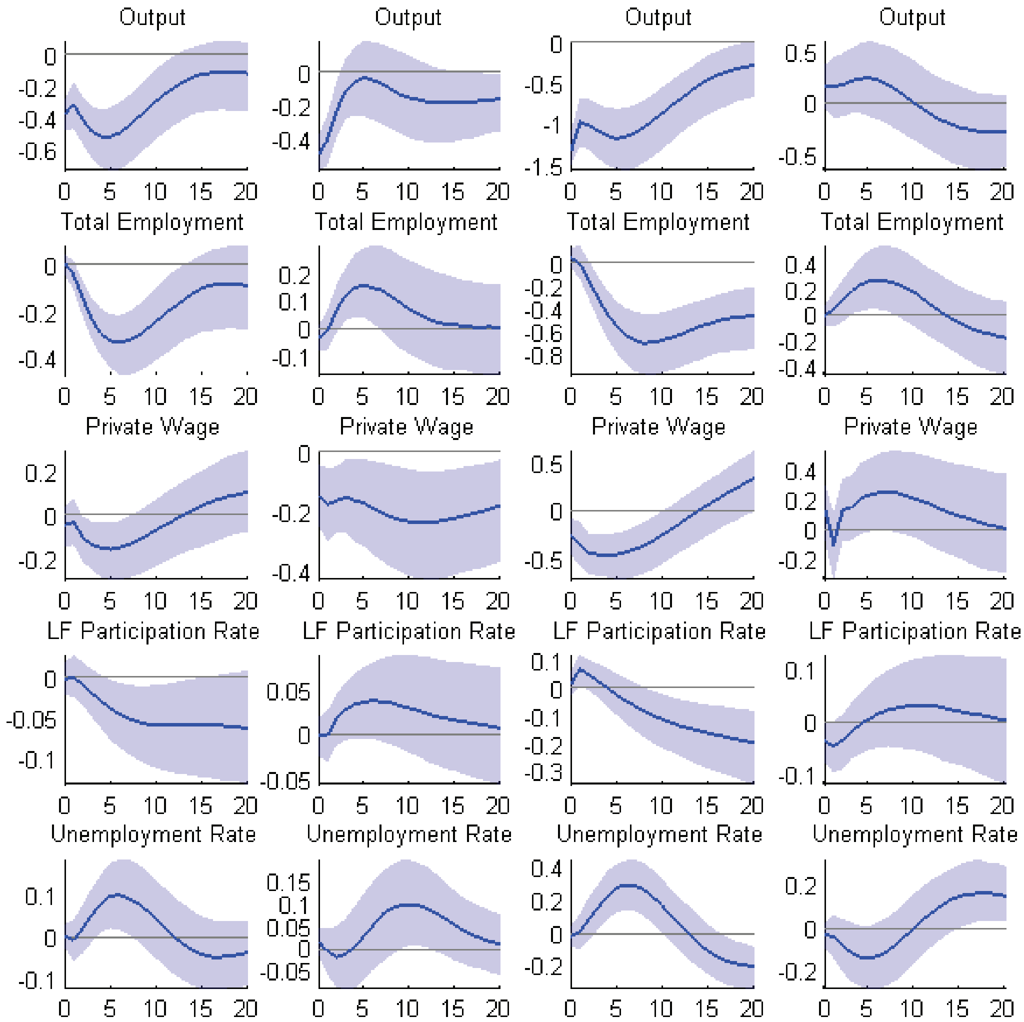

Figure 5: Impulse responses to fiscal shocks in the US, Cholesky identification

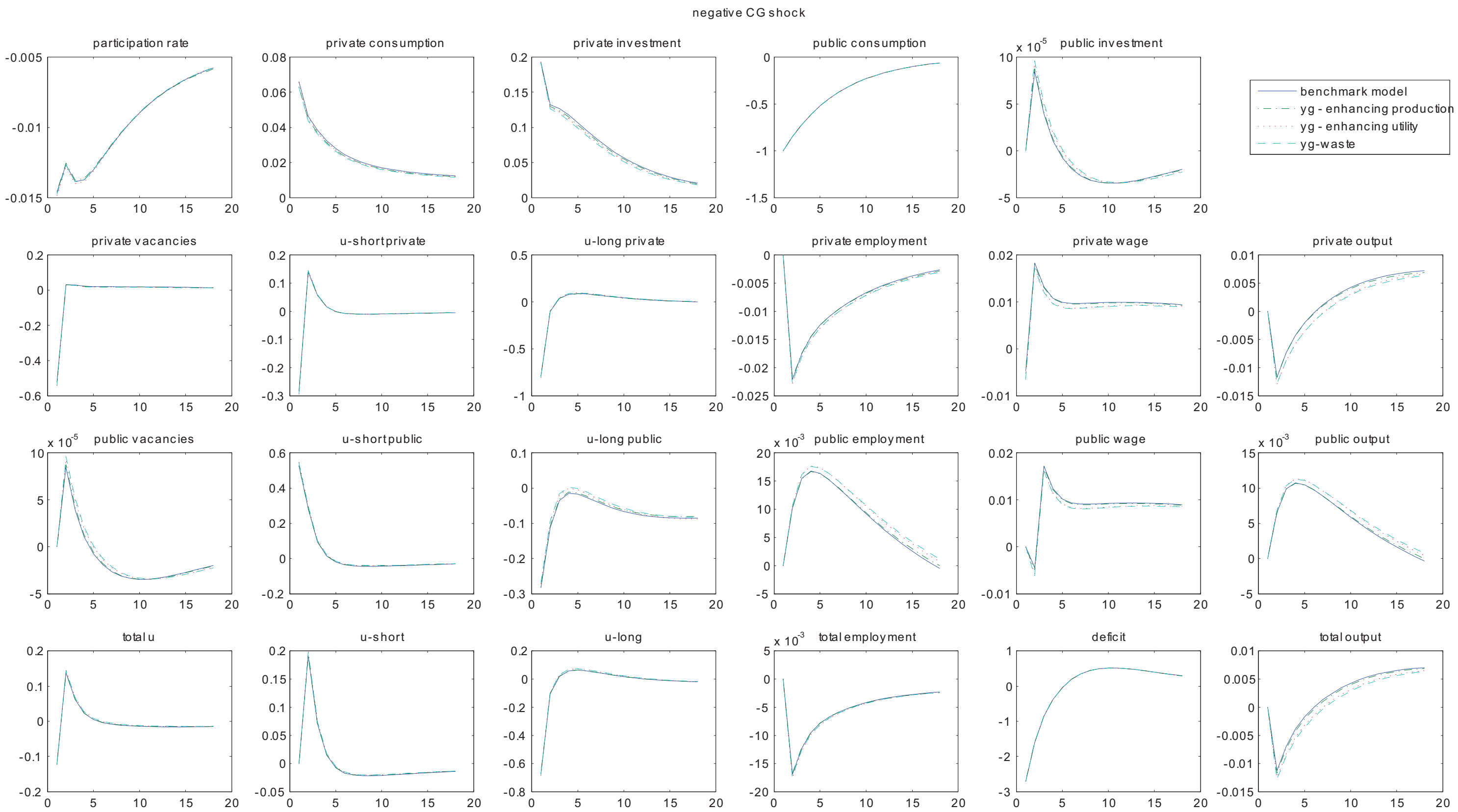

Figure 6: Theoretical impulse responses to a government consumption cut

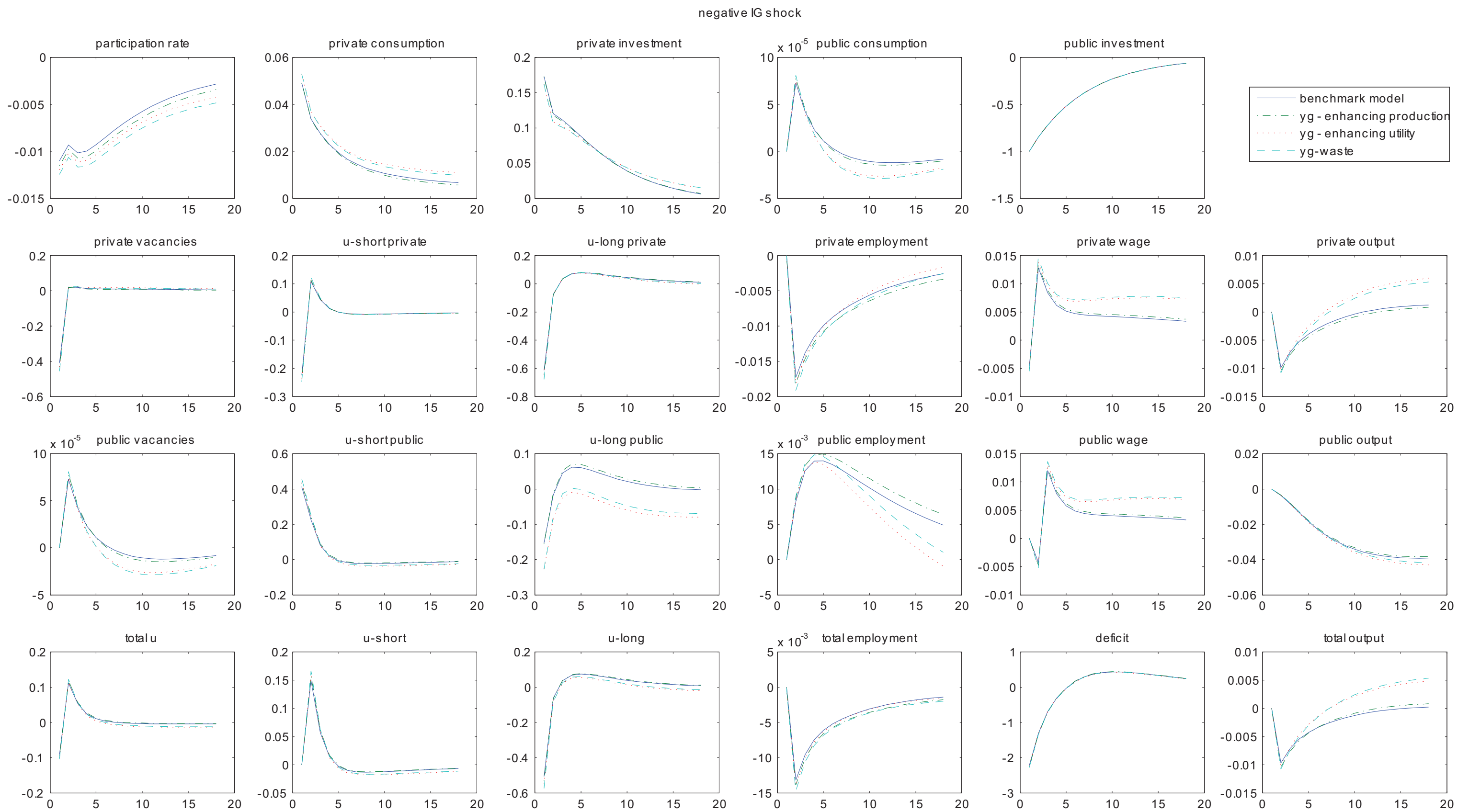

Figure 7: Theoretical impulse responses to a government investment cut

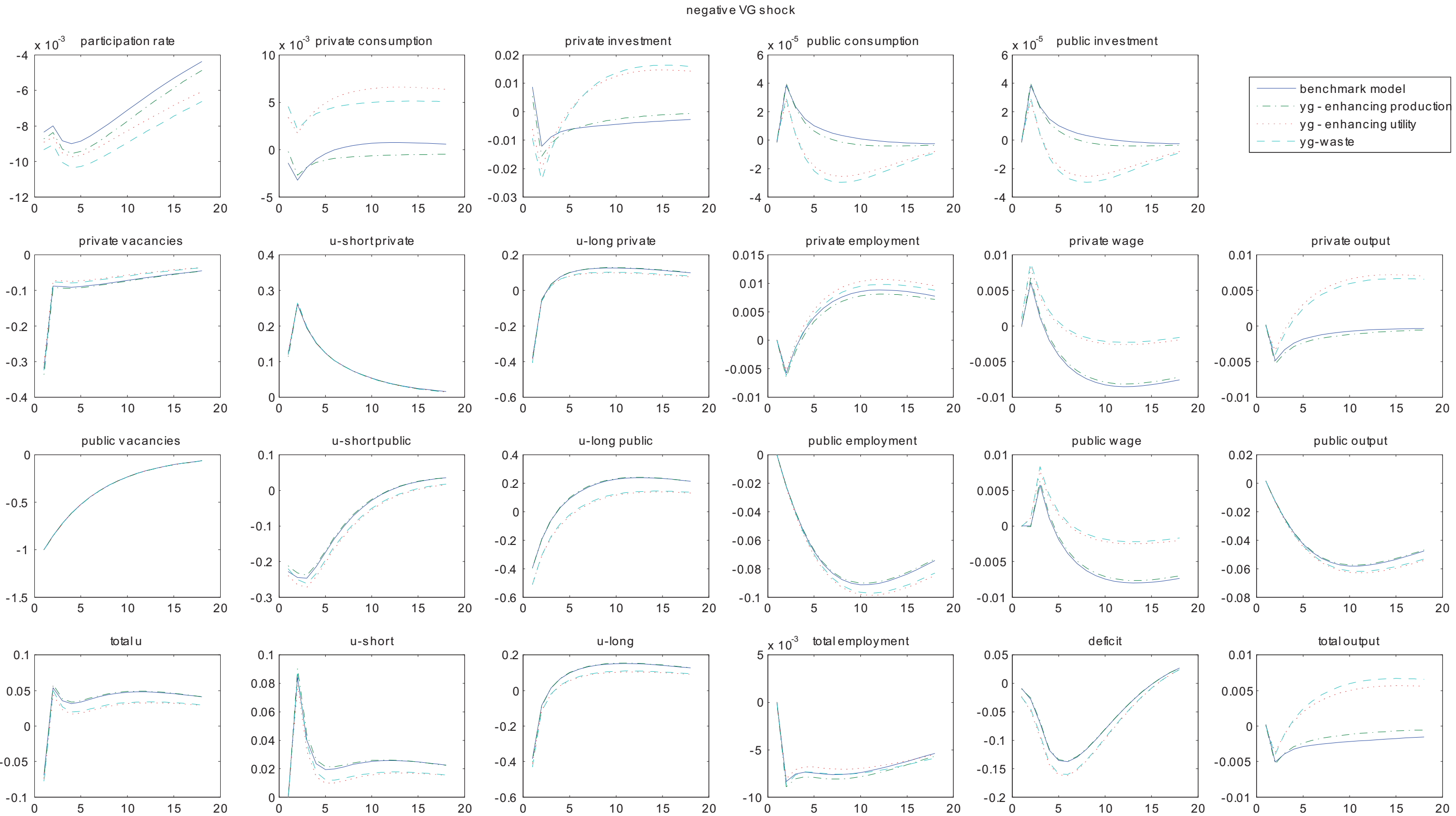

Figure 8: Theoretical impulse responses to a government vacancy cut

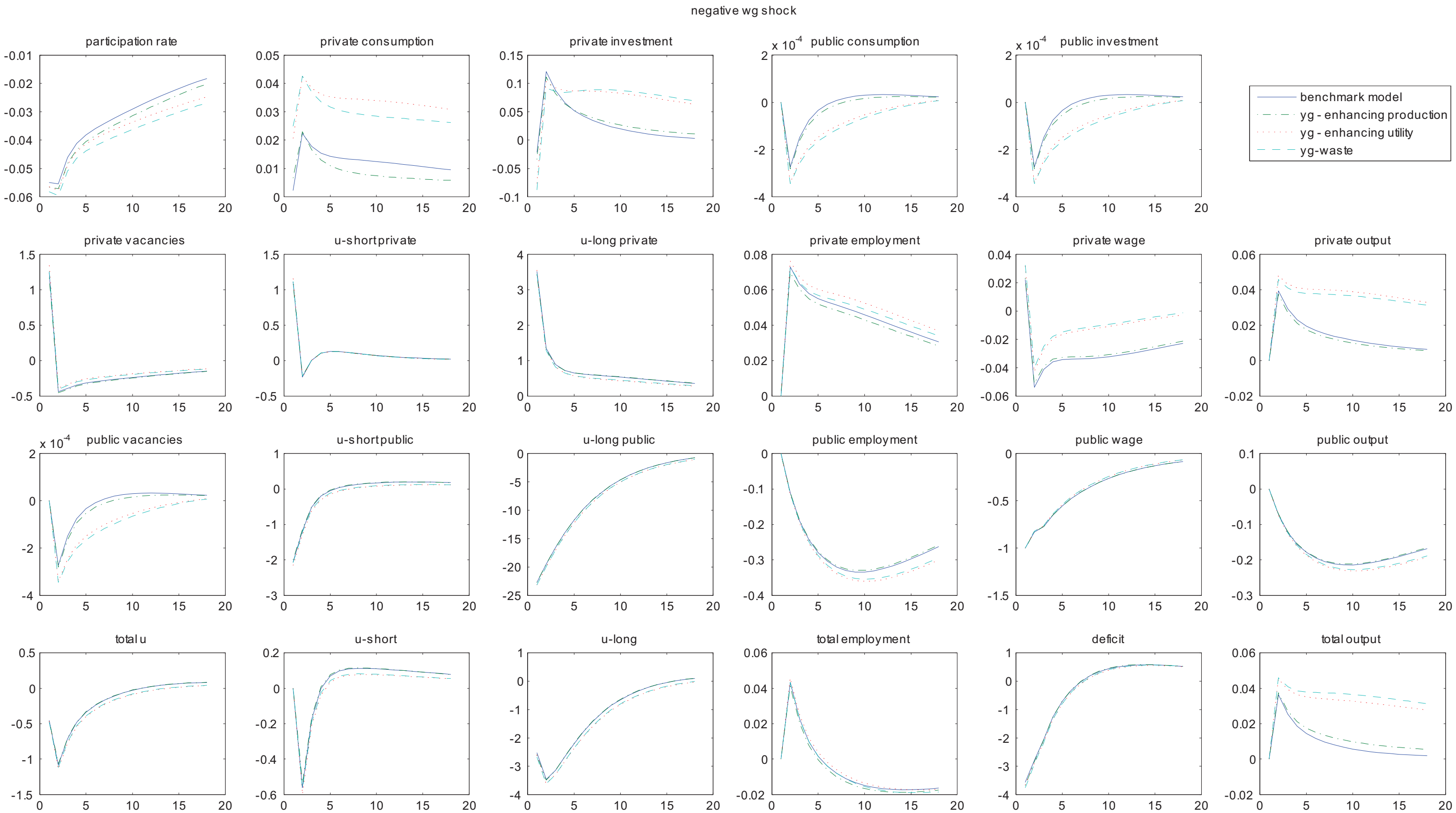

Figure 9: Theoretical impulse responses to a government wage cut

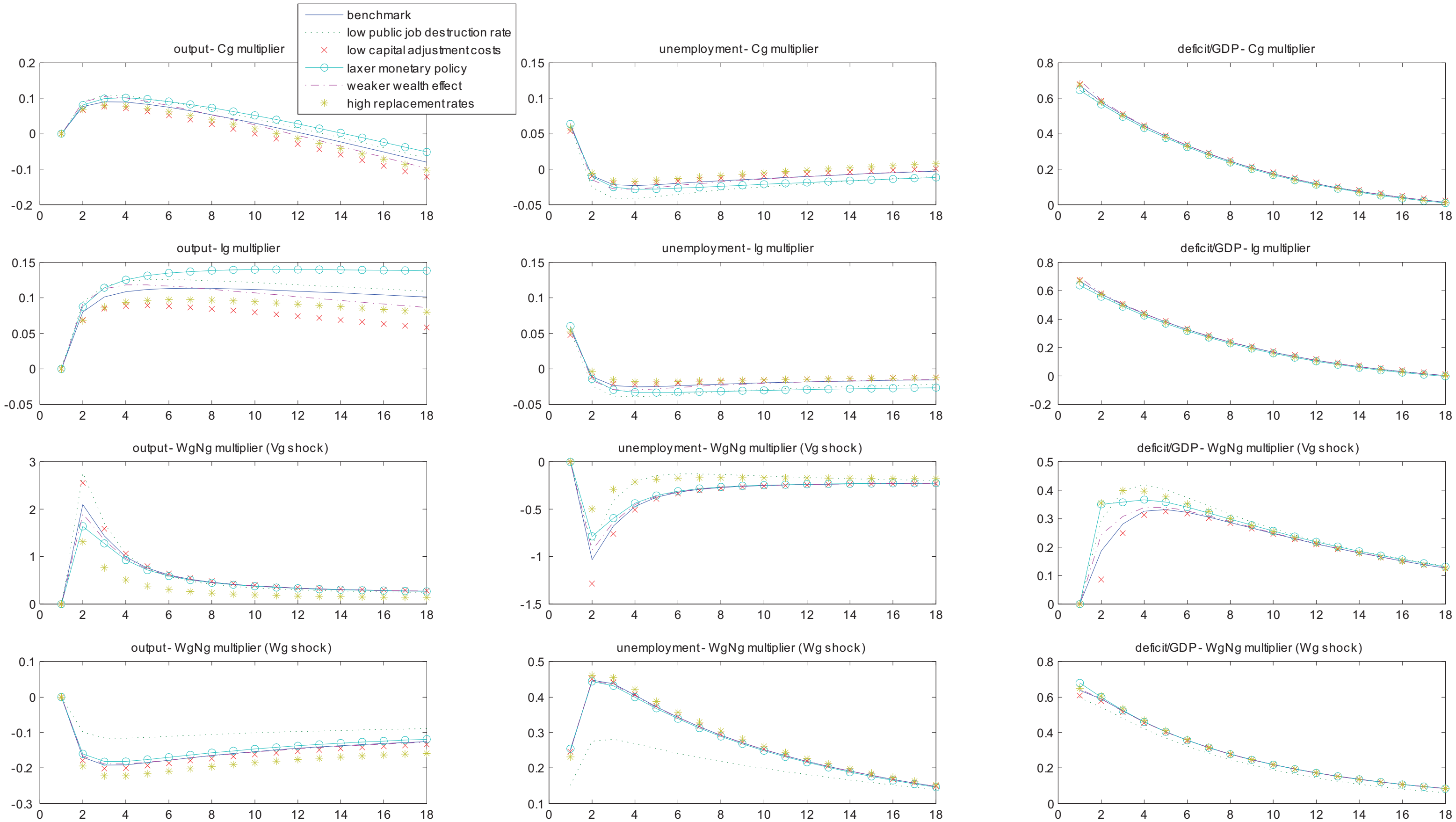

Figure 10: Sensitivity analysis for output, unemployment and deficit-to-GDP multipliers

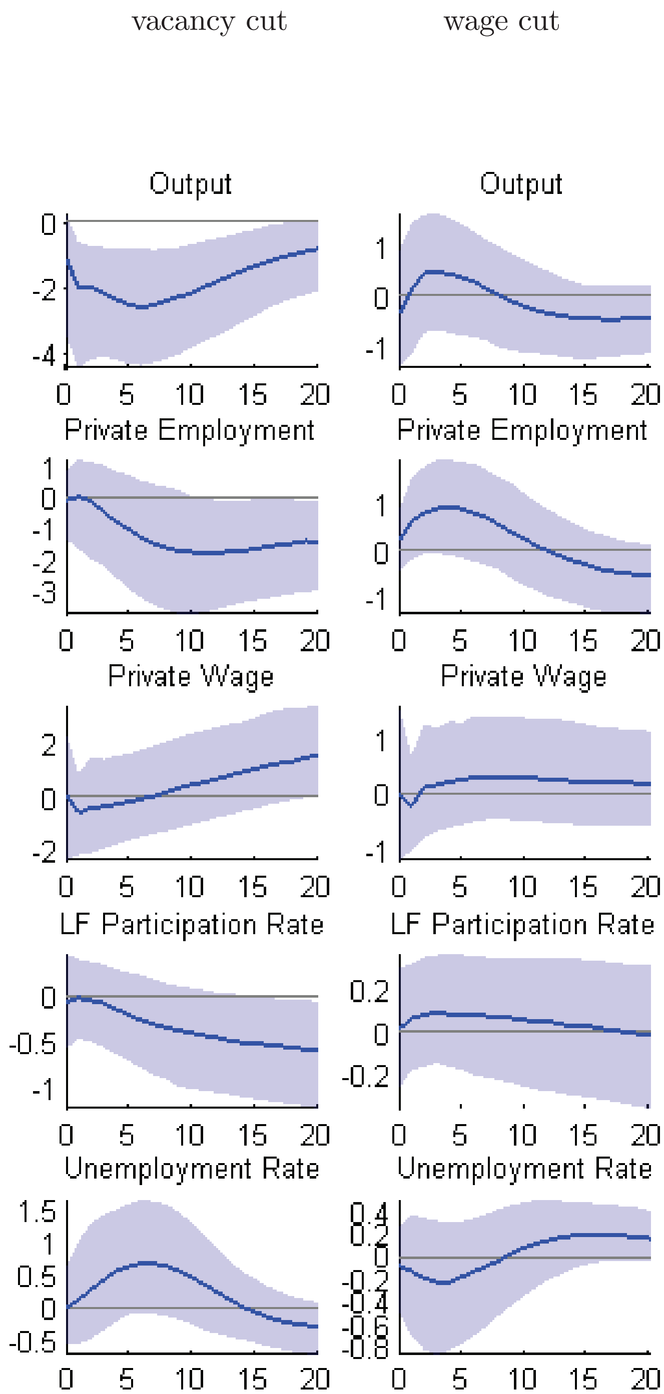

Figure 11: Impulse responses to fiscal shocks in the US
from a VAR with private employment

Chapter 3

Fiscal policy composition and its effects on international trade

1 Introduction

After the global financial crisis of 2008 governments increased substantially their public expenditure in an attempt to stimulate private activity and avoid a prolonged recession. Other countries since then have experienced sovereign risk debt problems and they were forced to undertake large consolidation plans. When discretionary fiscal policy is employed either as a stimulative tool or as a debt consolidation tool there are many doubts about the effectiveness in terms of the domestic absorption of the policy benefits. The latter critically depends on the reaction of the terms of trade, the real exchange rate and the trade balance to fiscal shocks. The standard Mundell-Fleming model, for example, can rationalize the success of fiscal contractions in terms of the trade competitiveness; according to the model, a fiscal retrenchment improves the trade balance through the depreciation of the nominal domestic currency and the subsequent real depreciation caused by the assumption of nominal rigidities. Yet, the crucial relationship of the fiscal discretionary policy and international trade still remains a controversy. In the empirical research, VAR studies like Ravn, Schmidt-Grohe and Uribe (2007) and Monacelli and Perotti (2010) find that after a fiscal expansion private consumption rises, the trade balance deteriorates and the real exchange rate depreciates. This evidence supports the twin-deficit hypothesis. However, other empirical studies, conclude the opposite. For instance, Kim and Roubini (2008) find that a deficit-financed fiscal expansion leads to improvement of the trade balance and a real depreciation. Some more recent literature has emphasized the crucial role of fiscal foresight for the proper identification of truly unexpected fiscal policy shocks. Gambetti (2012) estimates the effects of government spending on the real exchange rate and the trade balance in the US using VARs and spending forecast revisions. He concludes that when one controls for anticipation effects, a fiscal expansion induces a real appreciation and a deterioration of the trade balance.

However, all open economy studies so far focus on the effects of the aggregate government spending, without investigating the potential distinct effects that may arise from shocks to different types of expenditure. Research on the short-run effects of disaggregated government expenditure on output and private demand has proliferated only last years[1]. In the empirical literature, Perotti (2007) breaks total spending into purchases of goods and wage bill, and estimates fiscal multipliers for output using a structural VAR approach. Pappa (2009) estimates the effects of public consumption, investment and employment shocks in the US labor market using theoretical sign restrictions. Bermperoglou et al. (2013) extract sign restrictions from a general equilibrium model with labor market frictions and sticky prices, and identify public consumption, investment, employment and wage shocks in VAR models. Research devoted to disaggregated fiscal instrument analysis in open economies is more scarse. Benetrix and Lane (2009) estimate the effects of government non-wage consumption, wage consumption and investment shocks on the Irish exhange rate. Galstyan and Lane (2009) present a two-sector small open economy model and show that the composition of government spending influences the long-run behavior of the real exchange rate. Ganelli (2010) distinguishes between spending on consumption and spending on public employment in a two-country model, and concludes that increases in public employment in one country raises relative private consumption and appreciates the domestic exchange rate.

This paper contributes further to this direction of research by investigating the effects of disaggregated public spending shocks on trade. Main motive was one of our previous work (Bermperoglou, Pappa and Vella (2013)) where we emphasize the distinct transmission role of shocks to public employment and public average wages. If we translate the results of that paper in terms of fiscal expansions, the prediction is that public employment shocks will be more effective in stimulating the economy while positive wage shocks may be contractionary. On the other hand, non-wage consumption and investment shocks have more modest effects on output than employment shocks. The implied dynamics in the labor market after the four shocks are quite different and help to explain the empirical evidence. This paper goes one step further and asks whether spending disaggregation also matters for the transmission of fiscal policy on the international trade in the short-run. To the best of our knowledge, we are the first to conduct such an empirical analysis of shocks to those four government spending components. In the first part, the paper presents some empirical evidence for the distinct effects of government (non-wage) consumption, employment, wage and investment shocks on the trade balance and the real exchange rate of the US. The main findings are the following. Government consumption

[1] For theoretical contributions see in Forni et al. (2012), Linnemann (2009), Leeper et al. (2010) and Bermperoglou et al. (2013). For empirical analysis see in Perotti (2007), Cavallo (2005), Pappa (2009) and Bermperoglou et al. (2013).

shocks cause private consumption to fall, while the real exchange rate depreciates and the US trade balance improves. Public investment shocks imply a real depreciation with net exports initially falling and then rising. On the other hand, public employment shocks generate quite significant effects on all variables; output and private consumption significantly rise, while the exchange rate depreciates and the trade balance improves substantially. Finally, shocks to the average wage lead to a decline in private consumption, a real appreciation and a deterioration of the trade balance. In the next part, we extend the model proposed by Bermperoglou et al. (2013) to a two country model with complete international financial markets in order to compare theoretical predictions with empirical evidence, and give further insights in the transmission mechanisms of those shocks.

The remainder of the paper is organized as follows; section 2 presents the empirical analysis. Section 3 presents the theoretical model, while the results are shown in section 4. Section 5 revises both empirical and theoretical findings and contributes to the discussion of some international Macroeconomics' puzzles. Section 6 concludes.

2 Empirical Analysis

2.1 The reduced form model

We use quarterly, seasonally adjusted data for the US. The data span from 1975q1 to 2007q4, thus concentrating on the post Bretton-Woods period. All series, except for interest rates and exchange rates, come from the NIPA tables. Interest rates are sourced from the FRED database while the real effective exchange rate is taken from the Bank for International Settlements (BIS). Details are provide in the appendix A.

A VAR(3) with a constant, a linear trend and five endogenous variables is estimated. The endogenous variables enter the VAR in the following order: a measure of government spending, gross domestic product, private consumption of non-durables and services, the trade balance (net exports as a percentage of GDP) and the real effective exchange rate. The first variable rotates between (i) government non-wage consumption, (ii) government investment, (iii) government employment and (iv) public wage rate. The first three variables are expressed in log per capita terms and are deflated by the GDP deflator. The real exchange rate is transformed in logarithms, and an increase means real depreciation in the US against the rest of the world. The number of lags in the VAR is set to four.

2.2 Identifying the shocks

A key challenge in this framework is the identification of the fiscal shocks. Many identification approaches have been suggested in the past and still there is no conclusive empirical work on determining the best way of identifying fiscal shocks in the data. To recover government spending shocks we use a recursive identification according to the SVAR literature, as in Blanchard and Perotti (2002) and Fatas and Mihov (2001). This identification method assumes that the reduced VAR residuals u_t are a linear combination of structural uncorrelated shocks ε_t, and that government spending cannot be contemporaneously affected by any other variable in the system. When using quarterly data it is reasonable to assume that public spending decisions cannot be revised within a quarter and thus cannot react to current economic conditions. Those two assumptions are satisfied if i) the contemporaneous matrix that links the VAR errors with the structural shocks is given by the Cholesky factor of the estimated VAR error covariance matrix, and ii) government consumption is ordered first in the VAR system (as shown in the following figure). Then, given the estimated Cholesky factor and the estimated VAR residuals, one can recover the government spending shocks.

$$\begin{bmatrix} u_t^g \\ u_t^y \\ u_t^c \\ u_t^{tb} \\ u_t^r \end{bmatrix} = \begin{bmatrix} a_{gg} & 0 & 0 & 0 & 0 \\ a_{yg} & a_{yy} & 0 & 0 & 0 \\ a_{cg} & a_{cy} & a_{cc} & 0 & 0 \\ a_{tb,g} & a_{tb,y} & a_{tb,c} & a_{tb,tb} & 0 \\ a_{rg} & a_{ry} & a_{rc} & a_{r,tb} & a_{rr} \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^c \\ \varepsilon_t^{tb} \\ \varepsilon_t^r \end{bmatrix}$$

2.3 Empirical results

Figure 1 shows the median response and the 68% confidence band of the US output, private consumption, trade balance and real effective exchange rate (an increase is real depreciation) after a positive shock to public (non-wage) consumption, public investment, public employment and public average wage. All responses are scaled to correspond to a shock equal to 1% of total government spending in order to make comparisons more clear. After a government consumption shock (first column) output falls and private consumption is crowded-out with a minimum at -0.23%. Moreover, the real exchange rate sharply depreciates and the trade balance improves by a maximum of 0.05 percentage points of GDP in the second quarter. A government investment shock (column 2) cause similar effects. While private consumption does not move significantly, the real exchange rate depreciates and the trade balance switches response from negative to positive. A public employment increase (column 3) is the one that generates the most pronounced responses of all variables; output and private consumption significantly increase, while the real exchange rate sharply depreciates and the net exports rise by almost 0.25 percentage points at the peak. On the contrary, a sudden increase in the public average wage leads to a slight decline in private consumption, a domestic appreciation and a deterioration of the trade balance by almost -0.12 percentage points in the ninth quarter.

In a similar framework but for aggregate spending shocks, Monacelli and Perotti (2010) and Ravn, Schmidt-Grohe and Uribe (2007) find that a shock to total government expenditure leads to an increase in private consumption, a real depreciation and a deterioration of the trade balance. On the other hand, Kim and Roubini (2008) find that a deficit-financed fiscal expansion leads to improvement of the trade balance and a real depreciation which is closer to what we also find. However, notice that all authors pool all types of spending together as one variable. In the next section we will show how our disaggregated results, in part, improve upon the match between empirics and theory, and at the same time raise some more interesting questions for research.

2.4 Robustness analysis

2.4.1 VAR specification

We have tried several variants of the VAR model to test whether the results are sensitive to the number of lags, the inclusion of a quadratic trend, ot the inclusion of other critical variables. All specifications yield very similar to the benchmark results. In figure 2 we present the most important of all those alternative specifications which controls for tax and monetary policy. To this end, the VAR containts all existing variables and, additionally, the log real per capita net (of transfers) tax revenue and the Fed Funds rate. According to figure 2, the benchmark results remain quite robust: shocks to government consumption, investment and employment induce real depreciation and an improvement of the trade balance, while wage shocks imply exactly opposite responses.

2.4.2 Controlling for expectations

Ramey (2011) argues that the timing of fiscal shocks plays a critical role in identifying the effect of unanticipated fiscal shocks. In addition, Forni and Gambetti (2010) and Gambetti (2012) discuss that fiscal foresight is a very crucial element that can contaminate fiscal spending shocks thus resulting to confuse unexpected with expected fiscal policy. To control for expectations we add real-time forecasts for the US government spending from the Survey of Professional Forecasters (SPF) of the Federal Reserve Bank of Philadelphia. I order the forecast variable first in the VAR as it is predetermined and then government spending follows. In this way, the government spending variable will be regressed on the current and lag values of the forecast variable, and spending shocks would better capture the unanticipated changes in government spending. As figure 3 shows, the results for all shocks and variables remain unchanged, and therefore our benchmark specification is reliable.

3 The theoretical model

We consider a two-country model which is a modified version of the model introduced in chapter 2. It is characterized by search and matching frictions, endogenous labor participation choice, unemployment heterogeneity and sticky prices. There are three types of firms in each economy: (i) a public firm that produces a free good that can be used for productive and utility-enhancing purposes (ii) private competitive intermediate firms that use private inputs and the public good to produce a good for sale in the domestic and the foreign market; (iii) monopolistic competitive retailers that use intermediate goods of both countries to produce a variety of final goods sold to households or the government. Price rigidities arise at the retail level, while search frictions occur in the intermediate goods sector. The representative household's members consist of employees, unemployed, and labor force non-participants. Households rent physical capital to the intermediate firms and supply labor both to the intermediate firms and to the government. We assume no international linkages of the labor market. However, the home and foreign country engage in trade of a complete set of state contingent Arrow securities. The two countries' structure is symmetric and they are of equal size. Since the two countries are symmetric, we present only the structure of the home economy.

3.1 The labor market

The process through which workers and firms find each other is represented by a matching function that accounts for imperfections and transaction costs in the labor market. These frictions prevent some unemployed from finding a job. In this context, Campolmi and Gnocchi (2011) have added a labor force participation choice and Brückner and Pappa (2012) jobseekers' heterogeneity in DSGE models with nominal rigidities. Following Ravn (2008), the participation choice is modelled as a trade-off between the cost of giving up leisure to engage in labor search activities and the foregoing benefits associated with the prospect of finding a job. The unemployed are of two types: short-term and long-term unemployed, with the latter being less advantageous in the job searching process. Long- and short-term unemployed in turn can search for a job either in the public or the private sector.

In particular, at any point in time a fraction n_t^p (n_t^g) of the representative household's members are private (public) employees, a fraction u_t^S (u_t^L) are short- (long-) term unemployed but actively searching, and a fraction l_t are out of the labor force, so that:

$$n_t^p + n_t^g + u_t^S + u_t^L + l_t = 1 \tag{1}$$

The difference between the two types of unmatched agents is that labor force non-participants are not currently looking for a job, while the unemployed are active jobseekers. In line with Quadrini and Trigari (2007) and Gomes (2012), we assume that the unemployed choose in which sector they want to search. A share s_t^S (s_t^L) of the short- (long-) term unemployed looks for a public job, while the remaining part, $1 - s_t^S$ ($1 - s_t^L$), is seeking a private job.

In each period, jobs in each sector $j = p, g$ (i.e. private/public) are destroyed at a constant fraction σ^j and a measure m^j of new matches are formed. The evolution of each type of employment is thus given by:

$$n_{t+1}^j = (1 - \sigma^j)n_t^j + m_t^j \tag{2}$$

assuming that in general $\sigma^p > \sigma^g$ in order to capture the fact that, relatively speaking, public employment is more permanent than private employment.

Workers that experience a termination of their match enter into a period of short-term unemployment and in the next period, they may either remain unemployed, find a new job match, or become long-term unemployed. Short-term unemployed become long-term unemployed with probability $\xi \in [0, 1]$. The transition equation for short-term unemployment is given by:

$$u_{t+1}^S = (1 - \xi)u_t^S + \sigma^p n_t^p + \sigma^g n_t^g - m_t^{pS} - m_t^{gS} \tag{3}$$

where m_t^{jS} denote matches for short-term unemployed in each sector $j = p, g$. The aggregate matches in each sector are given by:

$$m_t^p = \underbrace{\rho_m^{pS}(\upsilon_t^p)^\iota[(1-s_t^S)u_t^S]^{1-\iota}}_{m_t^{pS}} + \underbrace{\rho_m^{pL}(\upsilon_t^p)^\iota[(1-s_t^L)u_t^L]^{1-\iota}}_{m_t^{pL}} \tag{4}$$

$$m_t^g = \underbrace{\rho_m^{gS}(\upsilon_t^g)^\iota\left(s_t^S u_t^S\right)^{1-\iota}}_{m_t^{gS}} + \underbrace{\rho_m^{gL}(\upsilon_t^g)^\iota\left(s_t^L u_t^L\right)^{1-\iota}}_{m_t^{gL}} \tag{5}$$

where we assume that the matching efficiency is higher for the short- rather than the long-term unemployed, i.e. $\rho_m^{jS} > \rho_m^{jL}$, and υ_t^j for $j = p, g$ denotes vacancies. Notice that short-term unemployed are likely to be better off searching than non-participating since they are faced with a better matching technology. Long-term unemployed instead have to decide whether they should participate in the labor market by taking into account the fact that they are penalized in matching with firms.

From the matching functions specified above we can define the probabilities of a short- (long-) term unemployed being hired, ψ_t^{hjS} (ψ_t^{hjL}), and of a vacancy being filled, ψ_t^{fj}:

$$\begin{aligned} \psi_t^{hp} &\equiv \frac{m_t^p}{(1-s_t)u_t}, \quad \psi_t^{hg} \equiv \frac{m_t^g}{s_t u_t} \\ \psi_t^{hpS} &\equiv \frac{m_t^{pS}}{(1-s_t^S)u_t^S}, \quad \psi_t^{hgS} \equiv \frac{m_t^{gS}}{s_t^S u_t^S} \\ \psi_t^{hpL} &\equiv \frac{m_t^{pL}}{(1-s_t^L)u_t^L}, \quad \psi_t^{hgL} \equiv \frac{m_t^{gL}}{s_t^L u_t^L} \end{aligned} \tag{6}$$

$$\psi_t^{fj} \equiv \frac{m_t^j}{\upsilon_t^j} \tag{7}$$

Finally, market tightness in the two sectors is defined as:

$$\theta_t^p \equiv \frac{\upsilon_t^p}{(1-s_t^S)u_t^S + (1-s_t^L)u_t^L}, \quad \theta_t^g \equiv \frac{\upsilon_t^g}{s_t^S u_t^S + s_t^L u_t^L} \tag{8}$$

3.2 Household

The representative household is infinitely lived and derives utility from private consumption, c_t^p, the public good, y_t^g, which is supplied free of price by the government, and the fraction of members that are out of the labor force and enjoy leisure, l_t:

$$U(c_t^p, y_t^g, l_t) = \frac{(c_t^p + z y_t^g)^{1-\zeta}}{1-\zeta} + \Phi \frac{(l_t)^{1-\psi}}{1-\psi} \tag{9}$$

where $z \geq 0$ determines the size of the utility gains from the consumption of the public good, $\frac{1}{\zeta}$ is the intertemporal elasticity of substitution, $\Phi > 0$ is a preference parameter related to leisure, ψ is the inverse of the Frisch elasticity of labor supply.

The household owns the private capital stock, which evolves over time according to:

$$k_{t+1}^p = i_t^p + (1-\delta^p)k_t^p - \frac{\omega}{2}\left(\frac{k_{t+1}^p}{k_t^p} - 1\right)^2 k_t^p \tag{10}$$

where δ^p is a constant depreciation rate and $\frac{\omega}{2}\left(\frac{k_{t+1}^p}{k_t^p} - 1\right)^2 k_t^p$ are adjustment costs, paid by the household.

3.2.1 Household's intratemporal problem

The household buys a range of retail good varieties sold by domestic and foreign producers. We define x_t the composite private consumption $c^p$and investment i^p baskets which are bundles of domestically and foreign produced goods according to the CES aggregator:

$$x_t \equiv [(1-\alpha_x)^{\frac{1}{\eta}} x_{H,t}^{\frac{\eta-1}{\eta}} + \alpha_x^{\frac{1}{\eta}} x_{F,t}^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \tag{11}$$

where $x \in \{c^p, i^p\}$, α is a measure of home bias and η measures the trade openness. Notice that consumption and investment may be characterized by different home bias. The optimal allocation problem between domestically produced and foreign produced goods result to the demand functions:

$$x_{H,t} = (1-\alpha_x)\left[\frac{P_{H,t}}{P_t^x}\right]^{-\eta} x_t \tag{12}$$

$$x_{F,t} = \alpha_x \left[\frac{P_{F,t}}{P_t^x}\right]^{-\eta} x_t \tag{13}$$

where $x_{H,t}$ and $x_{F,t}$ are the demand for domestically produced goods and foreign goods respectively. $P_{H,t}$ is the home goods' price index, $P_{F,t}$ is the foreign goods' price index expressed in the home currency units and P_t^x is the composite price index:

$$P_t^x \equiv [(1-\alpha_x)P_{H,t}^{1-\eta} + \alpha_x P_{F,t}^{1-\eta}]^{\frac{1}{1-\eta}} \tag{14}$$

Foreign country's households behave in a similar way, thus resulting to symmetric demand functions:

$$x_{F,t}^* = (1-\alpha_x)\left[\frac{P_{F,t}^*}{P_t^{x*}}\right]^{-\eta} x_t^* \tag{15}$$

$$x_{H,t}^* = \alpha_x \left[\frac{P_{H,t}^*}{P_t^{x*}}\right]^{-\eta} x_t^* \tag{16}$$

where $x_{F,t}^*$ and $x_{H,t}^*$ are the foreign demand for foreign goods and the foreign demand for exports of domestically produced goods, respectively. All variables with an asterisk $*$ indicate foreign country's variables.

3.2.2 Household's intertemporal problem

The household holds its financial wealth in terms of domestic state-contingent bonds D_t and the intertemporal budget constraint is given by:

$$P_t^{cp}c_t^p + P_t^{ip}i_t^p + E\left[Q_{t,t+1}D_{t+1}\right] \leq D_t + P_{H,t}\left(w_t^p n_t^p + w_t^g n_t^g\right) + +P_{H,t}r_t k_t^p + P_t^{cp} b u_t - T_t + \Xi_t \tag{17}$$

where $P_t^{cp}$and P_t^{ip} are the private consumption and investment price indices, $P_{H,t}$ is the price index of the domestically produced good, w_t^j is the real wage of the private or public sector, r_t is the real return to private capital, R_t is the domestic gross nominal interest rate, b is the unemployment benefit, and Ξ_t are the profits of the monopolistically competitive firms owned by the households. Finally, T_t represent lump-sum taxes in nominal terms.

The optimization problem involves choosing sequences of c_t^p, s_t, l_t, k_{t+1}^p, $D_{t+1,}u_t^L$ so as to maximize its expected lifetime utility subject to (1), (2), (6), (10), and (17):

$$n_{t+1}^p = (1-\xi^p)n_t^p + \psi_t^{hp}(1-s_t)u_t \tag{18}$$

$$n^g_{t+1} = (1-\xi^g)n^g_t + \psi^{hg}_t s_t u_t \quad (19)$$

$$u^S_{t+1} = \sigma^p n^p_t + \sigma^g n^g_t + (1-\xi)u^S_t - \left[\psi^{hpS}_t(1-s^S_t) + \psi^{hgS}_t s^S_t\right] u^S_t \quad (20)$$

where (18)-(20) correspond to (2)-(3) after using (6).

The expected marginal value to the household of having an additional member employed in the private sector, $V^H_{n^p t}$, is:

$$V^H_{n^p,t} = (c^p_t + zy^g_t)^{-\varsigma} w^p_t - U_{l,t} + (1-\sigma^p)\underbrace{\beta E_t V^H_{n^p,t+1}}_{\lambda_{u^{np},t}} + \sigma^p \underbrace{\beta E_t V^H_{u^S,t+1}}_{\lambda_{u^S,t}} \quad (21)$$

According to (21), $V^H_{n^p t}$ has the following components: first, the increase in utility given by the real after-tax wage; second, the decrease in utility from lower leisure; third, the continuation utility values, which depend on the separation probability: a private employee may continue having the same job next period with probability $1-\sigma^p$ or experience a termination of his match and become a short-term unemployed with probability σ^p. $V^H_{u^S t+1}$ is the marginal value of having an extra short-term unemployed member.

3.3 International trade definitions

Bilateral terms of trade between the domestic economy and foreign country are defined as $TOT_t \equiv \frac{P_{F,t}}{P_{H,t}}$, i.e., the price of foreign country's goods in terms of home goods.

Assume that the law of one price holds for individual goods at all times (both for import and export prices), implying that $P_{H,t} = \mathcal{E}_t \; P^*_{H,t}$, so that an increase in $\mathcal{E}_t$ means a home currency depreciation.

The bilateral real exchange rate (in terms of the private consumption prices) is defined as

$$Q_t \equiv \frac{\mathcal{E}_t P^{cp*}_t}{P^{cp}_t}$$

i.e., the ratio of the two countries' CPIs, both expressed in terms of domestic currency.

3.4 International Risk Sharing

Under the assumption of complete markets for securities traded internationally, a condition analogous to the household's FOC with respect to the state-contingent bonds D_{t+1} must also hold for the representative household in the foreign country. Combining home and foreign country's FOC, assuming that both countries have symmetric initial conditions[2] and using the definition of the real exchange rate, we get the international risk sharing condition that relates home and foreign country's consumption:

$$\frac{(c_t^{p*} + z y_t^{g*})^{-\sigma}}{(c_t^p + z y_t^g)^{-\sigma}} = \mathcal{Q}_t \tag{22}$$

Taking logs on both sides of (22) and integrating over i yields

$$\hat{c}_t^p + z\hat{y}_t^g = \hat{c}_t^{p*} + z\hat{y}_t^{g*} + \frac{1}{\sigma}\hat{q}_t \tag{23}$$

where the second equality holds only up to a first-order approximation when $\eta \neq 1$. As we can see, movements of the effective consumption of households in both countries induce adjustments in the real exchange rate.

3.5 The production side

3.5.1 Intermediate goods firms

Intermediate goods are produced with a Cobb-Douglas technology:

$$y_t^p = (\varepsilon_t^A n_t^p)^{1-\varphi} (k_t^p)^{\varphi} (y_t^g)^{\nu} \tag{24}$$

where ε_t^A is an aggregate technology shock that follows an AR(1) process with persistence ρ_A, k_t^p and n_t^p are private capital and labor inputs, and y_t^g is the public good used in productive activities, taken as exogenous by the firms. The parameter ν regulates how the public input affects private production: when ν is zero, the government good is unproductive.

Since current hires give future value to intermediate firms, the optimization problem is dynamic and hence firms maximize the discounted value of future profits. The number of workers currently employed, n_t^p, is taken as given and the employment decision concerns the

[2] i.e., zero net foreign asset holdings and an ex-ante identical environment.

number of vacancies posted in the current period, υ_t^p, so as to employ the desired number of workers next period, n_{t+1}^p.[3] Firms also decide the amount of the private capital, k_t^p, needed for production. The problem of an intermediate firm with n_t^p currently employed workers consists of choosing k_t^p and υ_t^p to maximize:

$$Q^p(n_t^p, k_t^p) = \max_{k_t^p, \upsilon_t^p} \left\{ x_t(\varepsilon_t^A n_t^p)^{1-\varphi}(k_t^p)^{\varphi}(y_t^g)^{\nu} - w_t^p n_t^p - r_t^p k_t^p - \kappa \upsilon_t^p + E_t \left[\Lambda_{t,t+1} Q^p(n_{t+1}^p, k_{t+1}^p) \right] \right\} \tag{25}$$

where x_t is the relative price of intermediate goods, κ is a utility cost associated with posting a new vacancy, and $\Lambda_{t,t+1} = \frac{\beta^s U_{c_{t+s}}}{U_{c_t}}$ is a discount factor. The maximization takes place subject to the private employment transition equation:

$$n_{t+1}^p = (1 - \sigma^p) n_t^p + \psi_t^{fp} \upsilon_t^p \tag{26}$$

The first-order conditions are:

$$x_t \varphi \frac{y_t^p}{k_t^p} = r_t^p \tag{27}$$

$$\frac{\kappa}{\psi_t^{fp}} = E_t \Lambda_{t,t+1} \left[x_{t+1}(1-\varphi) \frac{y_{t+1}^p}{n_{t+1}^p} - w_{t+1}^p + \frac{(1-\sigma^p)\kappa}{\psi_{t+1}^{fp}} \right] \tag{28}$$

According to (27) and (28) the value of the marginal product of private capital should be equal to the real rental rate and the marginal cost of opening a vacancy should equal the expected marginal benefit. The latter includes the marginal productivity of labor minus the wage plus the continuation value, knowing that with probability σ^p the match can be destroyed.

The expected value of the marginal job for the intermediate firm, $V_{n^p t}^F$ is:

$$V_{n^p t}^F \equiv \frac{\partial Q^p}{\partial n_t^p} = x_t (1-\varphi) \frac{y_t^p}{n_t^p} - w_t^p + \frac{(1-\sigma^p)\kappa}{\psi_t^{fp}} \tag{29}$$

3.5.2 Retailers

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms

[3] Firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker. According to Hansen (1985), most of the employment fluctuations arise from movements in this margin.

one unit of intermediate goods into one unit of retail goods. Note that the relative price of intermediate goods, x_t, coincides with the real marginal cost faced by the retailers mc_t. Let y_{it} be the quantity of output sold by retailer i. Final goods can be expressed as:

$$y_t^p = \left[\int_0^1 (y_{it}^p)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{30}$$

where $\varepsilon > 1$ is the constant elasticity of demand for intermediate goods. The retail good is sold at its price, $p_t = \left[\int_0^1 p_{it}^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}$. The demand for each intermediate good depends on its relative price and aggregate demand:

$$y_{it}^p = \left(\frac{p_{it}}{p_t} \right)^{-\varepsilon} y_t^p \tag{31}$$

Following Calvo (1983), we assume that in any given period each retailer can reset her price with a fixed probability $1 - \chi$. Hence, the price index is:

$$p_t = \left[(1-\chi)(p_t^*)^{1-\varepsilon} + \chi (p_{t-1})^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{32}$$

The firms that are able to reset their price, p_{it}^*, choose it so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} (p_{it}^* - mc_{t+s}) y_{it+s}^p$$

The resulting expression for p_{it}^* is:

$$p_{it}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} mc_{t+s} y_{it+s}^p}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{it+s}^p} \tag{33}$$

3.5.3 Bargaining over the private wage

Wages are determined by ex post (after matching) Nash bargaining. Workers and private firms split rents and the part of the surplus they receive depends on their bargaining power. If $\vartheta \in (0,1)$ is the firm's bargaining power, the problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^p} \left\{ (1-\vartheta) \ln V_{n^p t}^H + \vartheta \ln V_{n^p t}^F \right\}$$

where $V^H_{n^pt}$ and $V^F_{n^pt}$ have been defined in (21) and (29), respectively. The optimization problem leads to:

$$(1-\vartheta)\left(c^p_t + zy^g_t\right)^{-\zeta} V^F_{n^pt} = \vartheta V^H_{n^pt} \tag{34}$$

As we show in detail in the Companion Appendix, solving (34) for w^p_t, using the household's FOC, results in:

$$w^p_t = (1-\vartheta)\left[x_t(1-\varphi)\frac{y^p_t}{n^p_t} + \frac{\kappa}{\psi^{fp}_t}\psi^{hpO}_t\right] + \vartheta\left[b - \sigma^p \frac{\beta E_t V^H_{u^S t+1}}{(c^p_t + zy^g_t)^{-\zeta}}\right] \tag{35}$$

3.6 Government

The government sector produces the public good using public capital and labor:

$$y^g_t = (\varepsilon^A_t n^g_t)^{1-\mu}(k^g_t)^{\mu} - \kappa \upsilon^g_t \tag{36}$$

where we assume that productivity shocks are not sector specific and μ is the share of public capital in the public production. The public good provides productivity- and utility-enhancing services[4]. The vacancies posted by the government are exogenous and are associated with a posting cost κ.

The government holds the public capital stock. Similar to the case of private capital, the government capital stock evolves according to:

$$k^g_{t+1} = i^g_t + (1-\delta^g)k^g_t - \frac{\omega}{2}\left(\frac{k^g_{t+1}}{k^g_t} - 1\right)^2 k^g_t \tag{37}$$

The government's budget is balanced in each period and lump-sum tax revenues equal expenditures. The latter consist of consumption and investment purchases, salaries and wages and unemployment benefits. We assume that there is full home bias in the government purchases.

$$T_t = P_{H,t}c^g_t + P_{H,t}i^g_t + P_{H,t}w^g_t n^g_t + P^{cp}_t b u_t + P^g_t \kappa \upsilon^g_t \tag{24}$$

If $\Psi^g = c^g,\ i^g,\ \upsilon^g, w^g$ denotes the different fiscal instruments, we assume fiscal rules of the

[4] As the public good is not sold, it has no actual price. However, there is an implicit relative price that is determined by the consumers demand.

form:

$$\Psi_t^g = \overline{\Psi}^g \left(\Psi_{t-1}^g\right)^{\varrho_g^\psi} \exp(\varepsilon_t^{\psi^g}) \tag{38}$$

where $\varepsilon_t^{\psi^g}$ is a zero-mean, white noise disturbance and ρ_g^ψ determines the persistence of the different government components processes.

3.7 Monetary policy

There is an independent monetary authority that sets the nominal interest rate as a function of current CPI inflation according to the rule:

$$R_t = \bar{R} \exp(\phi_\pi \pi_t^{cp} + \varepsilon_t^R) \tag{39}$$

where ϵ_t^R is a monetary policy shock and π_t^{cp} measures CPI inflation.

3.8 Closing the model

Goods market clearing in home economy requires private output to be equal to the sum of private and public demand for all retail good varieties

$$y_t^p(j) = \left[\frac{P_{H,t}(j)}{P_{H,t}}\right]^{-\varepsilon} \left[c_{H,t}^p + i_{H,t}^p + c_t^g + i_t^g + c_{H,t}^{p*} + i_{H,t}^{p*}\right] \tag{40}$$

Aggregate domestic output is defined by the aggregator

$$y_{H,t}^p = \left[\int_0^1 y_t^p(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{41}$$

Combining (40) and (41)

$$y_t^p = c_{H,t}^p + i_{H,t}^p + c_t^g + i_t^g + c_{H,t}^{p*} + i_{H,t}^{p*} \tag{42}$$

Net exports (trade balance) of retail goods is defined using the resource constraint as

$$nx_t = P_{H,t} y_t^p - P_t^{cp} c_t^p - P_t^{ip} i_t^p - P_{H,t} c_t^g - P_{H,t} i_t^g - P_{H,t} \kappa \upsilon_t^p \tag{43}$$

Total output, y_t, is given by

$$y_t = y_t^p + \frac{p_t^g}{p_{H,t}} y_t^g \tag{44}$$

where $\frac{p_t^g}{p_t}$ is the implicit relative price of public goods determined by the consumers' demand for public goods.

The model features six exogenous disturbances. The shocks to public vacancies, wages and fiscal spending components, as described by (38), the productivity and the monetary policy shocks. The vector of the last two shocks, $S_t = [\varepsilon_t^A, \varepsilon_t^R]'$, is parameterized as:

$$\log(S_t) = (I - \rho)\log(\bar{S}) + \rho \log(S_{t-1}) + V_t \tag{45}$$

where V is a (2×1) vector of innovations, I is a (2×2) identity matrix, ρ is a (2×2) diagonal matrix, and $\bar{S}$ is the mean of S. The innovation vector V is a stationary, zero-mean, white noise process, and the roots of ρ are all less than one in modulus.

We solve the model by approximating the equilibrium conditions around a non-stohastic steady state (setting all shocks equal to their mean values) in which all prices are flexible, the price of the private good is normalized to unity, and inflation is zero.

The model parameters are calibrated for the US economy. The benchmark parameterization is presented in Table 1.

4 Theoretical results

Figures 4-7 present the responses of several variables of the model after a sudden increase in public consumption, public investment, public vacancies and public wage rate, respectively. To make responses comparable, each shock is normalized to 1% of total government spending. According to figure 4, a government consumption shock induces a positive demand effect that causes private output and labor demand to increase. Also, such a shock triggers a negative wealth effect that makes household increase labor supply and cut consumption. The fall in private consumption requires a real exchange rate appreciation due to the hypothesis of full risk sharing between the two countries (equation 22). Of course, the final response of the real exchange rate will depend on the responses of both home and foreign marginal utilities of consumption. However, in our case the volume of the home marginal utility's effect is strong enough to dominate and affect the final response of the real exchange rate. Finally, there are two opposite effects on the trade balance. On the one hand, the fall in private consumption tends to cut imports and increase the trade balance (*absorption effect*). On the other hand, the increase in the relative prices of home goods makes domestic products less competitive thus inducing a switch to foreign goods, which in turn makes net exports fall (*switch effect*). The final effect on the trade balance depends on the two opposite channels, though in our benchmark parameterization the switch effect is stronger and trade balance deteriorates.

A government investment shock (figure 5) also induces the same effects as a consumption shock since both trigger a negative wealth effect that makes household cut consumption and at the same time, they induce a positive demand effect that causes private output to increase. However, the two shocks imply different dynamics on public output; a consumption shock expands private sector's demand for labor thus increasing private wage on impact and reallocating short term unemployed people from the public to the private sector. The latter induces a fall in total unemployment in the public sector and, hence, a fall in public employment and public output. However, a public investment shock raises public capital thus inducing an increase in public output. The effect on public output may bear implications for the real exchange rate responses. In particular, the increase in public output after an investment shock will make the effective private consumption ($c_t^p + zy_t^g$) fall less than after a public consumption shock, and as a result, it will induce a weaker appreciation. However, our benchmark parameterization does not make this difference across shocks apparent. As previously, the fall in private consumption is strong enough to induce a real appreciation according to the risk sharing condition. Moreover, the real appreciation is accompanied by a deterioration of the trade balance due to competitiveness losses.

A government vacancy shock (figure 6) is not of the same nature as a consumption or investment shock. The sudden increase in public vacancies, on one hand, will induce a reallocation of short-term unemployed from the private to the public sector, but on the other hand, it raises the probability of finding a job for long-term unemployed. The latter raises long-term unemployed in private sector thus leading to an increase in private employment and output. Unlike public consumption and investment shocks that exert pression on aggregate demand and reduce available resources for private consumption, the public vacancy shock implies a positive supply effect that raises output - resources for private consumption. Also, the increase in the employed household members will induce a positive wealth effect and finally private consumption increases. According to figure 6, the increase in private consumption seems to dominate and, therefore, the full risk sharing assumption requires a real depreciation in the home country, i.e.

an increase in Q. The sharp increase in terms of trade (fall in relative prices of home goods) induces a strong *switch effect* in favor of home goods and hence a trade balance improvement.

A public wage shock (figure 7) will induce different dynamics than the rest shocks. As it was discussed in the previous chapter, a sudden increase in the public wage rate will induce a reallocation of searching for a job from the private towards the public sector, since the increase in public wage raises the relative value of an extra public employee versus a private employee. Both short-term and long-term unemployment in the private sector fall and lead to a significant decline in private employment and private output. This negative effect on labor supply to the private sector also raises the private wage thus inducing upward pressures on marginal costs, inflation (due to sticky prices and monopolistic competition in retailers) and interest rates (according to the Taylor rule). According to the intertemporal equation for private consumption (Euler equation), private consumption falls. At the same time, public output increases substantially. For the first quarters the drop in private consumption dominates the increase in public output, the effective consumption falls and full risk sharing requires a real appreciation in the home country. However, after several quarters, as public output builds up and the negative intertemporal effect on private consumption weakens, effective consumption $(c_t^p + zy_t^g)$ rises and the real exchange rate starts to depreciate. The response of net exports follows accordingly; the initial appreciation at home induces trade deficit for eight quarters, and after then it decays and it may switch sign.

5 Squaring theory and facts

A direct comparison between the empirical evidence and the theoretical predictions would be useful in order to (i) make empirical responses interpretable (i.e. explain them according to mechanisms that lie behind) and (ii) evaluate how this class of dynamic general equilibrium models performs in an open economy analysis. Especially the latter could result to useful suggestions about where theory should be directed and get improved.

According to the empirical part, government employment shocks induce an increase in private consumption, a sharp real depreciation and a trade balance improvement (increase in US net exports). This pattern of responses coincide qualitatively with those that the theoretical model predicts. The same happens for public wage shocks; both the empirical and the theoretical analyses conclude that a sudden increase in the average wage will lead to a decline in private consumption, appreciation of the real exchange rate and a fall in net exports. Relating our results to the existing literature, Benetrix and Lane (2009, 2010) estimate structural VARs for Ireland and a panel of EMU countries, and they conclude that a positive shock to the government wage bill induces a real appreciation, a contraction in exports and a slight increase in imports. The two latter combined imply a fall in net exports. Those responses of the real exchange rate and net exports are similar to what we receive after government wage shocks but opposite to employment shocks' responses. As a result, disaggregating wage bill shocks further into employment and wage shocks seems really crucial for uncovering significant and distinct patterns that an aggregate analysis cannot reveal.

According to the empirical part, government consumption shocks cause private consumption to fall, the real exchange rate to depreciate and the trade balance to improve. Government investment shocks induce very similar pattern of responses, but net exports may initially fall and then increase. Those results partly contradict what theory predicts. In particular, the theoretical model predicts that both public consumption and investment shocks imply a negative wealth effect that reduces private consumption. This effect is in accordance with our evidence, though the response of private consumption after investment shocks is not significantly different from zero (only the median estimate tends to fall). However, the theory also predicts that those two shocks imply a real appreciation and a trade balance deficit while the VAR model yields the opposite. In other words, theory cannot capture the empirical correlation between consumption and exchange rate responses; it is positive in theory but negative in the VAR.

A similar discrepancy has also been noted by other researchers. In particular, in a similar empirical framework but for aggregate spending shocks Ravn, Schmidt-Grohe and Uribe (2007) and Monacelli and Perotti (2010) find that a shock to total government expenditure leads to an increase in private consumption, a real depreciation and a deterioration of the trade balance. Since their empirical correlation between the responses of private consumption and the real exchange rate after a spending shock have the same sign as the theoretical correlation, they conclude that the problematic point from which discrepancies arise is the response of private consumption itself; it rises in their VAR but it falls in theory. Accordingly, Monacelli and Perotti (2010) have tested several ways that a standard open economy New Keynesian model could generate the right response of private consumption observed in data, but their analysis has not yielded a satisfactory improvement. Yet, our work reveals something novel; when government spending is disaggregated in several components their puzzling pattern after consumption shocks does not emerge; instead, as we showed, another puzzling pattern arises for consumption shocks: *a mistaken correlation between the private consumption and exchange rate responses.* As a result, disaggregating government spending seems to be critical to make a more direct and reliable comparison between empirical shocks and theoretical counterparts.

The next step is to test whether there is any possibility to generate in the theoretical model the responses to government consumption and investment shocks that we observe in data. As discussed before, the problematic point is the correlation between the responses of private consumption and the real exchange rate, which is positive in theory and negative in the VAR. Actually, in the theoretical model what matters for the determination of the real exchange rate is the effective consumption (i.e. the weighted sum of private consumption and public output that yields utility). A significant increase in the effective consumption could generate a real depreciation as in data. However, since private consumption falls both in the VAR and the theoretical model, then the only way to replicate such an increase in the effective consumption would be through the public good which is also part of the effective consumption considered in the utility function. As we showed in the previous section, public consumption shocks reduce public output and therefore it is impossible to generate the required increase in effective consumption. For this reason, for the analysis with respect to consumption shocks that follows we use an alternative specification of the utility function where public output is replaced by government non-wage consumption. The reasoning is that if government non-wage consumption yields utility and enters the effective consumption of households, then it is more probable of generating the empirical patterns. However, for the analysis with respect to the public investment shocks the utility specification remains as in the benchmark model, i.e. public output yields utility. Finally, in a two country model both home and foreign country's consumption dynamics affect the risk sharing condition and the real exchange rate. As a result, in the analysis that follows we present responses of both home and foreign country's effective consumption.

We have conducted sensitivity analysis with respect to several parameters of the model in order to generate the empirical correlation between private consumption and real exchange rate. Figure 8a,b presents selected responses of five critical variables: private consumption, public output, effective consumption $(c_t^p + zy_t^g)$ of home and foreign country, and the real exchange rate. Left columns show responses to government consumption shocks and right columns responses to government investment shocks. In figure 8a we vary the relative weight z of public consumption/output that enters the utility function. According to the model, after a public consumption shock c_t^p falls but c_t^g rises. Similarly, after an investment shock c_t^p falls but y_t^g rises. As a result, we expect that higher weight z will induce marginally a lower decline in the sum $c_t^p + zc_t^g$ ($c_t^p + zy_t^g$) or even an increase. The latter would lead to the desired real depreciation. Indeed, a higher $z = 0.5$ makes home effective consumption not fall that much comparably to the benchmark case, and consequently the real exhange rate bearly appreciates. However, even this implausibly high value of z is not enough to make effective consumption switch sign and generate a real depreciation. For public investment shocks (right column), a higher z bearly improves responses. This happens because public output may not increase as much as public investment - it also depends on public employment - and hence the final increase in public output may not be enough to make the difference. The second alternative to improve responses would be to weaken the negative response of private consumption. It is possible if we assume quite high inertia in the interest rate setting so that the increase in the interest rates after a fiscal expansion to be low. The latter would imply a lower negative effect on private consumption through the Euler equation. However, according to figure 8a, setting both $z = 0.5$ and $\varrho_R = 0.8$ makes little difference. The same happens if we try higher price stickiness ($\chi = 0.80$) that could induce different dynamics of inflation, interest rates and private consumption.

Figure 8b presents sensitivity analysis with respect to the trade openness parameter η. Intuitively, trade openness regulates the degree of international spillover effects and hence the responses of both home and foreign effective consumption. A higher $\eta = 3$ slightly raises home effective consumption and reduces foreign effective consumption. The combined effects induce a lower decline in the real exchange rate (weaker depreciation) comparably to the benchmark scenario, but the effects are so small that bearly there is improvement. Finally, we present how the intertemporal elasticity of substitution for present and future consumption ζ affects responses. Even though a higher ζ slightly increase private consumption and the effective consumption comparably to the benchmark responses, it cannot generate the required depreciation.

To sum up, the model performs well to generate responses after government employment and wage shocks similar to the empirical ones. However, the observed correlation puzzle in the responses of private consumption and real exchange rate to government consumption and investment shocks cannot be trivially resolved by changes in the parameterization of the model. Extensions of the present model that would change some of the basic assumptions about labor market or the financial structure (e.g. incomplete markets) are priority in the research agenda.

6 Conclusion

In this paper, we estimate the effects of disaggregated fiscal policy on the trade balance and the real exchange rate. The empirical part finds that government consumption and investment shocks reduce private consumption, leads to a real exchange rate depreciation and an improvement in the US trade balance. Public employment shocks induce an increase in private consumption, a real depreciation and an increase in net exports. On the contrary, a public wage shock leads to a fall in private consumption, a real exchange rate appreciation and a deterioration of the trade balance.

A dynamic general equilibrium model that incorporates nominal rigidities, search and matching frictions, endogenous labor force participation and complete international financial markets is solved in order to get theoretical responses to the four fiscal shocks and explain the mechanisms behind the empirical facts. The model does quite well reconciling responses after public employment and wage shocks. The model can also capture the decline in private consumption, as well as the empirical correlation between the responses of the trade balance and the real exchange rate after government consumption and investment shocks. However, the present model assumptions do not help to replicate the empirical correlation between the responses of private consumption and the real exchange rate; a decline in private consumption is accompanied by a real depreciation in the VAR, while it is accompanied by a real appreciation in theory. The sensitivity analysis concludes that trivial modifications in the parameterization of the model cannot resolve the consumption - exchange rate correlation paradox.

Above all, the present analysis reveals two important issues. The first is that future research on empirical and theoretical open economy Macroeconomics and fiscal policy should focus on a disaggregated fiscal instrument analysis, since each fiscal instrument implies different transmission channels and effects on trade and the real economy. Secondly, given that a standard two country New Keynesian model with labor market frictions and complete international markets cannot generate all empirical facts satisfactorily (mainly the consumption - exchange rate correlation paradox), further research that would account for improvements in the structure of the labor market, or other structures of the financial system (e.g. incomplete markets) seems promising.

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Tables

Table 1: Parameter values

Parameters		Values	Parameters		Values
ζ	risk aversion coefficient	1.0	$\frac{\kappa}{w^p}$	vacancy cost - wage ratio	0.045
z	preference parameter for y^g	0.1	$\frac{u}{1-l}$	unemployment rate	0.065
$\frac{1}{\psi}$	Frisch elasticity	0.25	$\frac{n^g}{n}$	public employment share	0.16
ν	productivity of public goods	0.1	$\frac{u^{gL}}{u^{pL}}$	long-term unemployed allocation	0.3
η	trade openness	1.5	ψ^{fp}	priv. vacancy filling probability	0.5
$\frac{C^g}{Y}$	steady-state C^g/Y ratio	0.08	ψ^{hp}	private hiring probability	0.9
$\frac{K^g}{K^p}$	steady-state K^g/K^p ratio	0.31	$\frac{\psi^{hjS}}{\psi^{hjL}}$	short- vs. long-term unemployed	1.015
δ^j	capital depreciation rate	0.025		hiring probability	
φ, μ	productivity of capital stocks	0.36	$\frac{b}{w^p}$	replacement rates	0.4
ω	adjustment costs parameter	5.5	$\frac{w^g}{w^p}$	steady-state wage ratio	1.03
α	home bias parameter	0.1	π_ω	public wage elasticity to w^p	0.94
ζ_π	Taylor's π coefficient	1.5	$\frac{u^L}{u}$	long-term unemployment share	0.18
χ	price stickiness	0.67	ϑ	firms bargaining power	0.4
ϱ, ϱ_g^ψ	persistence of shocks	0.85	$1-l$	labor participation rate	0.65
			σ^g	public separation rate	0.04
			σ^p	private separation rate	0.05
			$\frac{\varepsilon}{\varepsilon-1}$	steady-state markup	1.1

Notes: $j = p, g$ and $\psi = c^g, i^g, \upsilon^g, w^g$

Figures

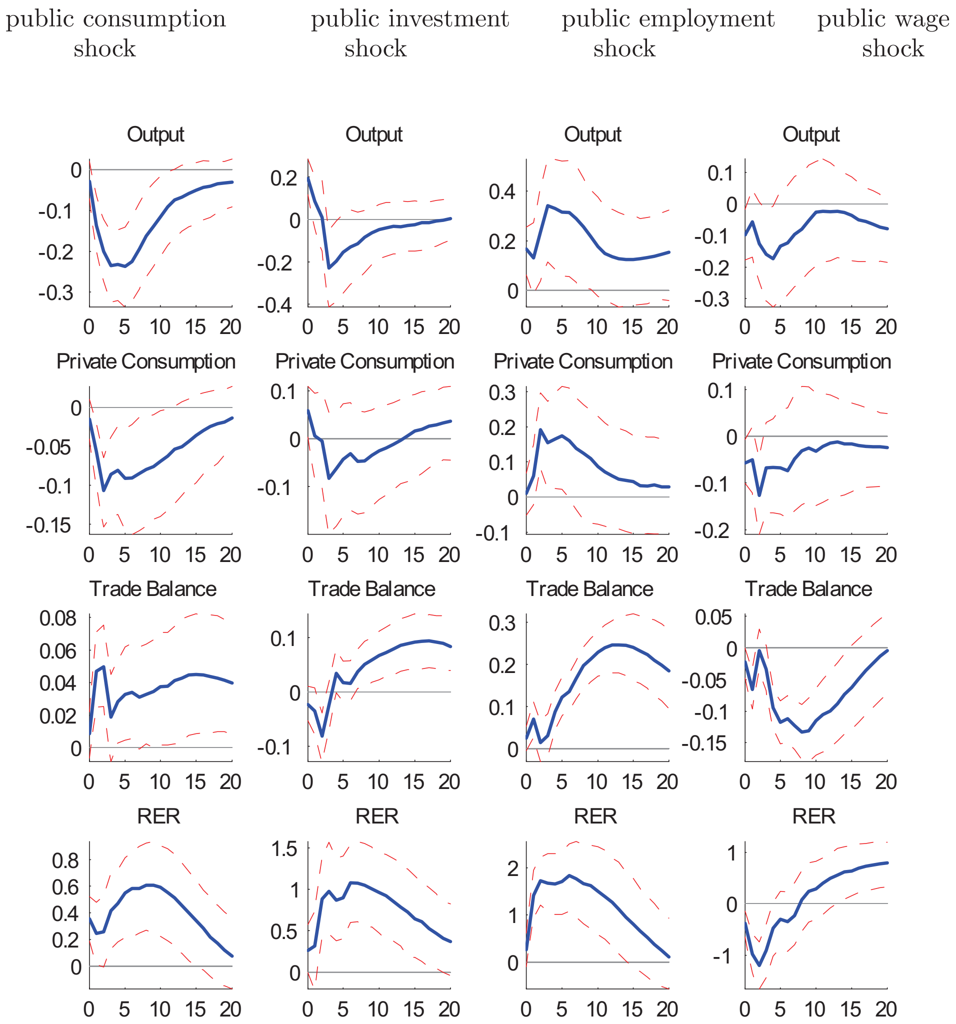

Figure 1: IRFs, Benchmark VAR

public consumption shock	public investment shock	public employment shock	public wage shock

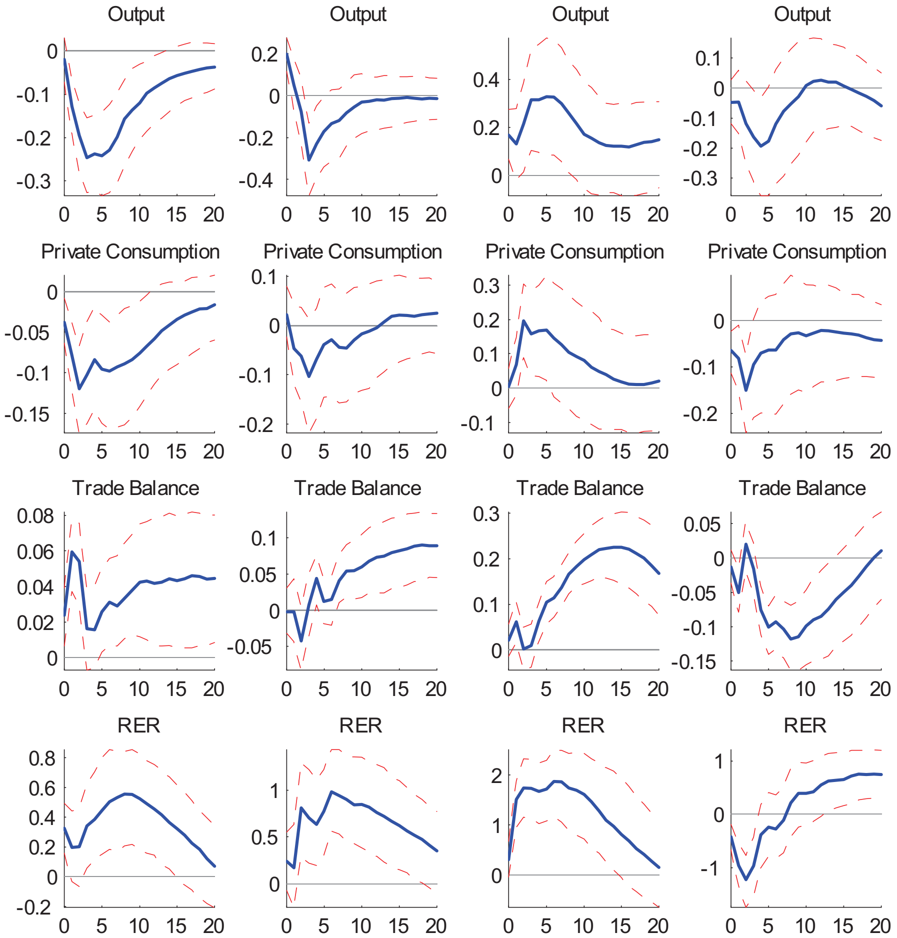

Figure 2: IRFs, Controlling for Tax and Monetary Policy

public consumption shock	public investment shock	public employment shock	public wage shock

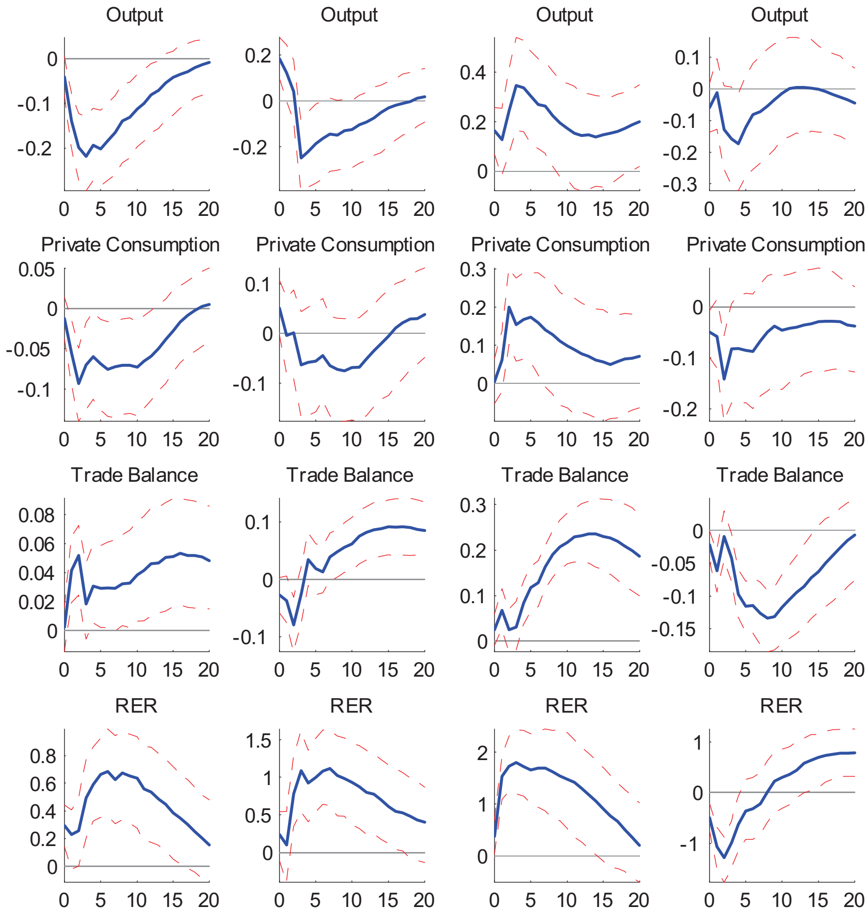

Figure 3: IRFs, Controlling for Expectations

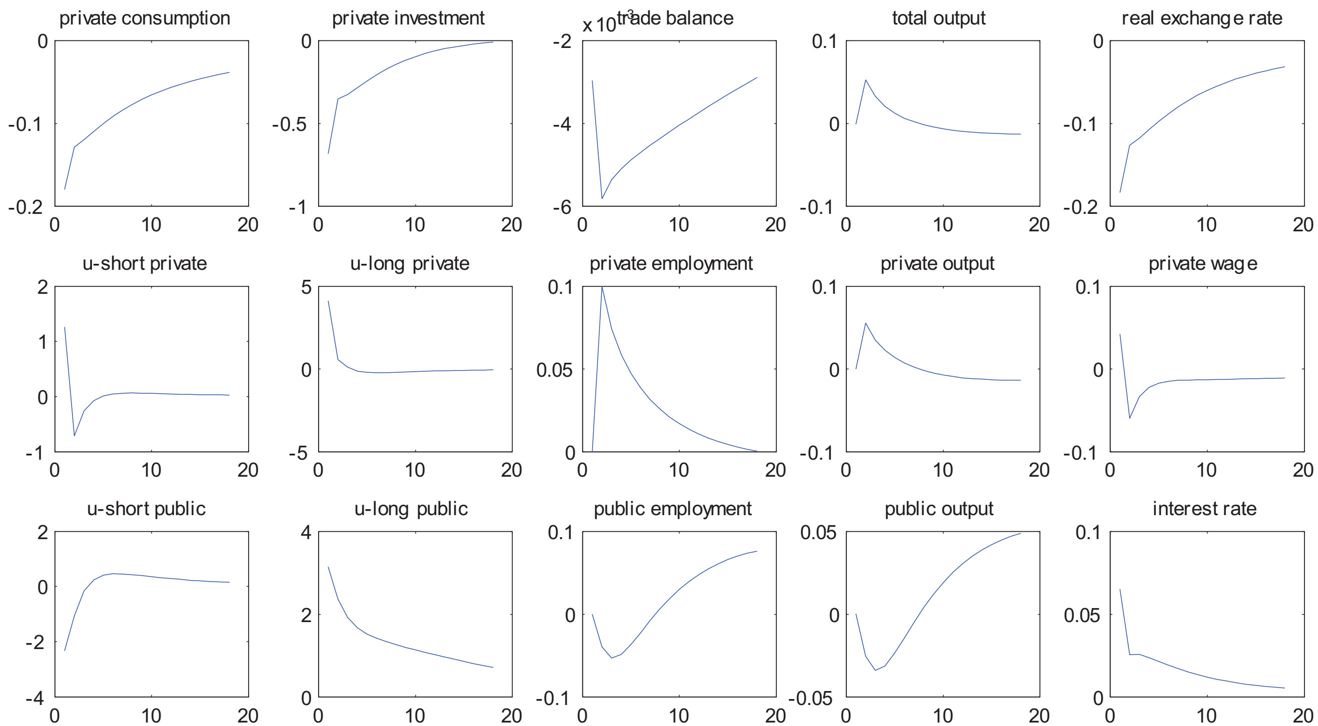

Figure 4: Theoretical responses, Government consumption shock

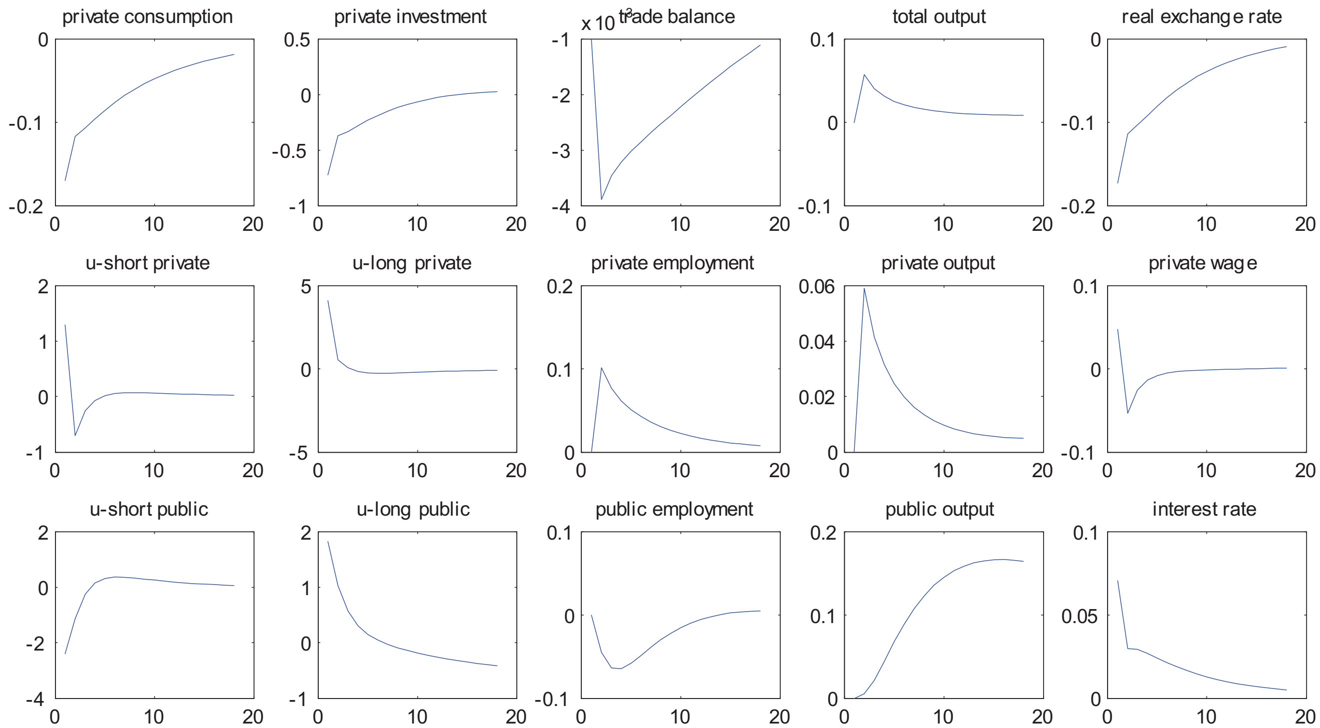

Figure 5 : Theoretical responses, Government investment shock

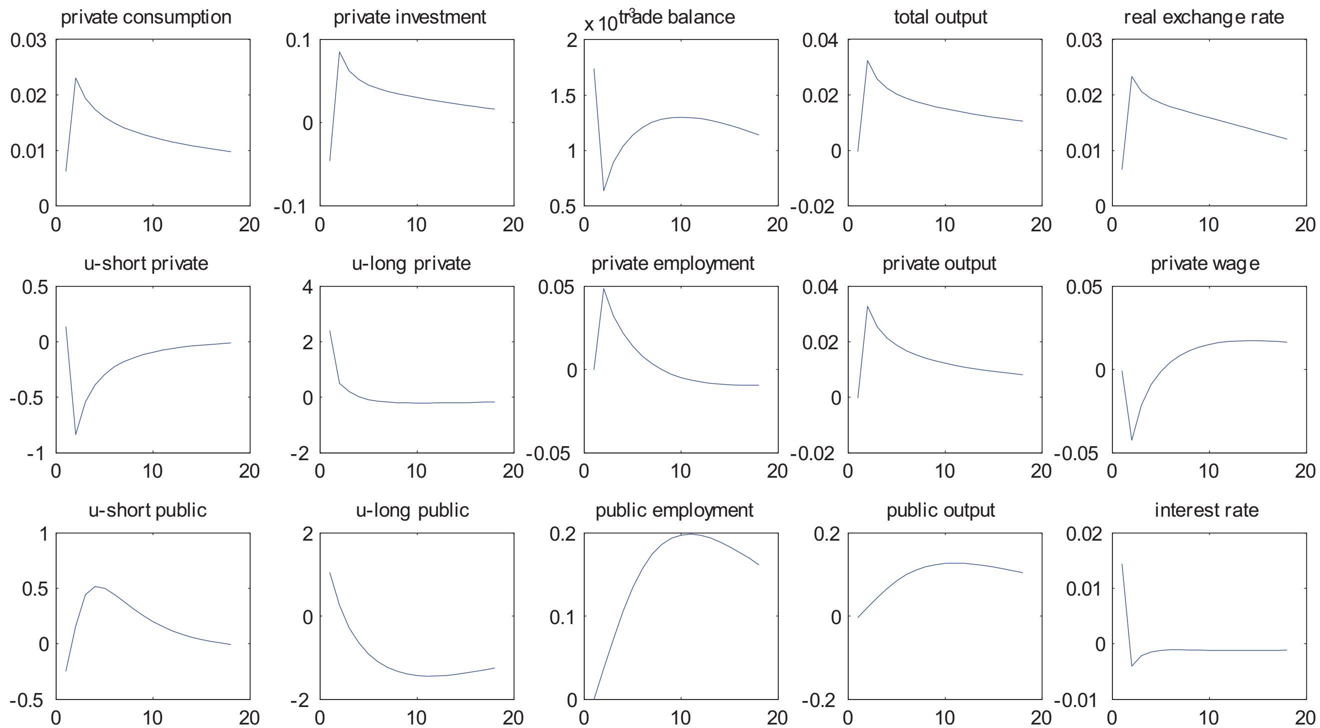

Figure 6: Theoretical responses, Government vacancy shock

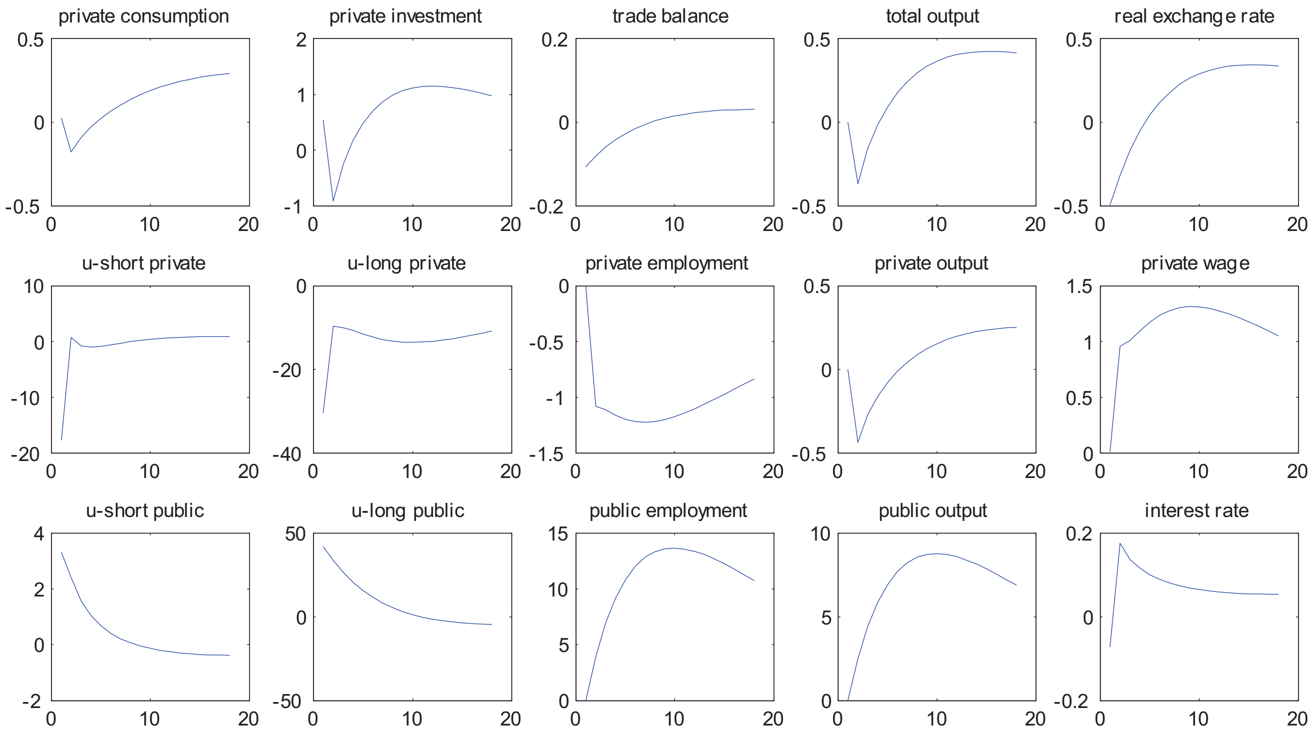

Figure 7: Theoretical responses, Government wage shock

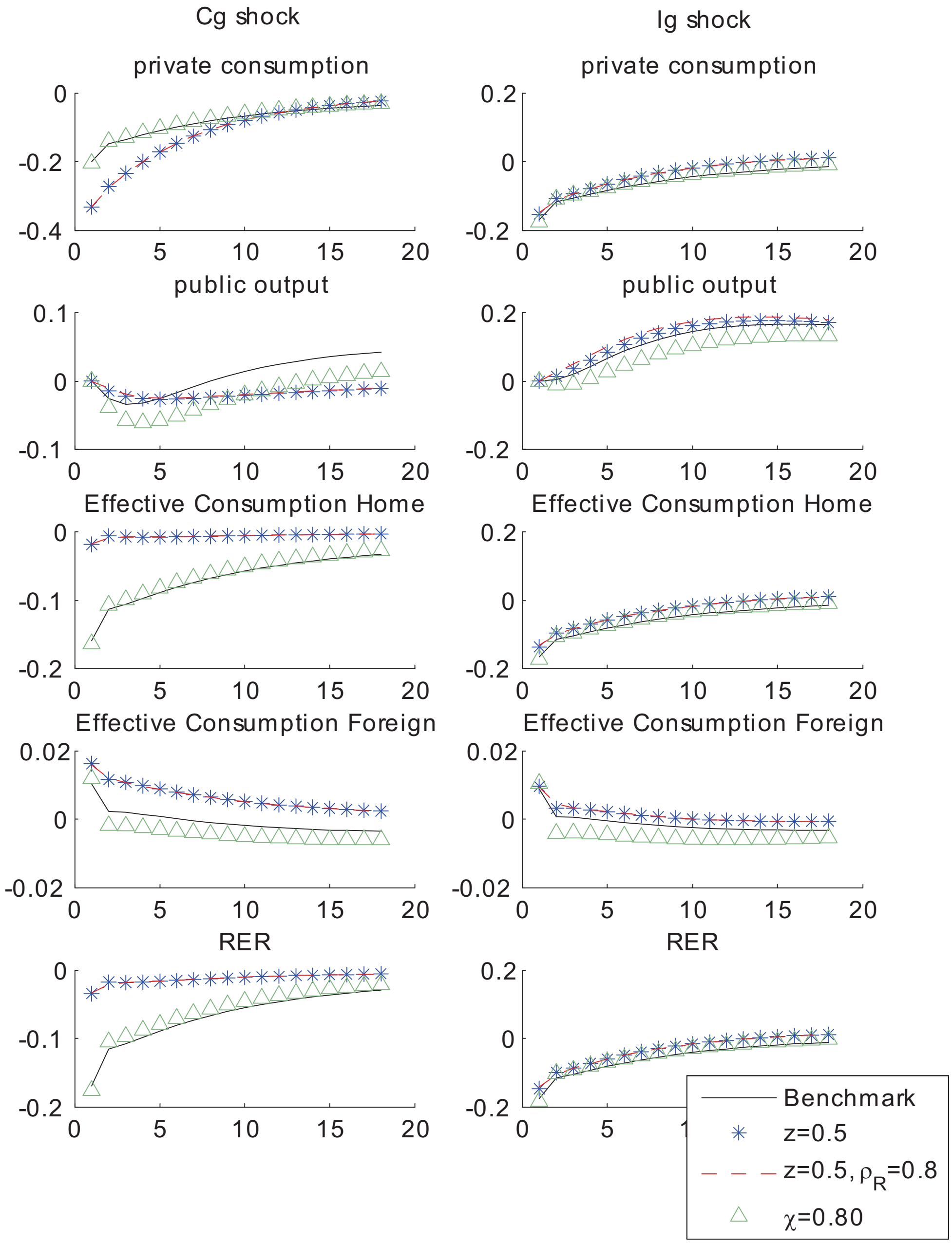

Figure 8a: Sensitivity analysis with respect to government consumption and investment shocks

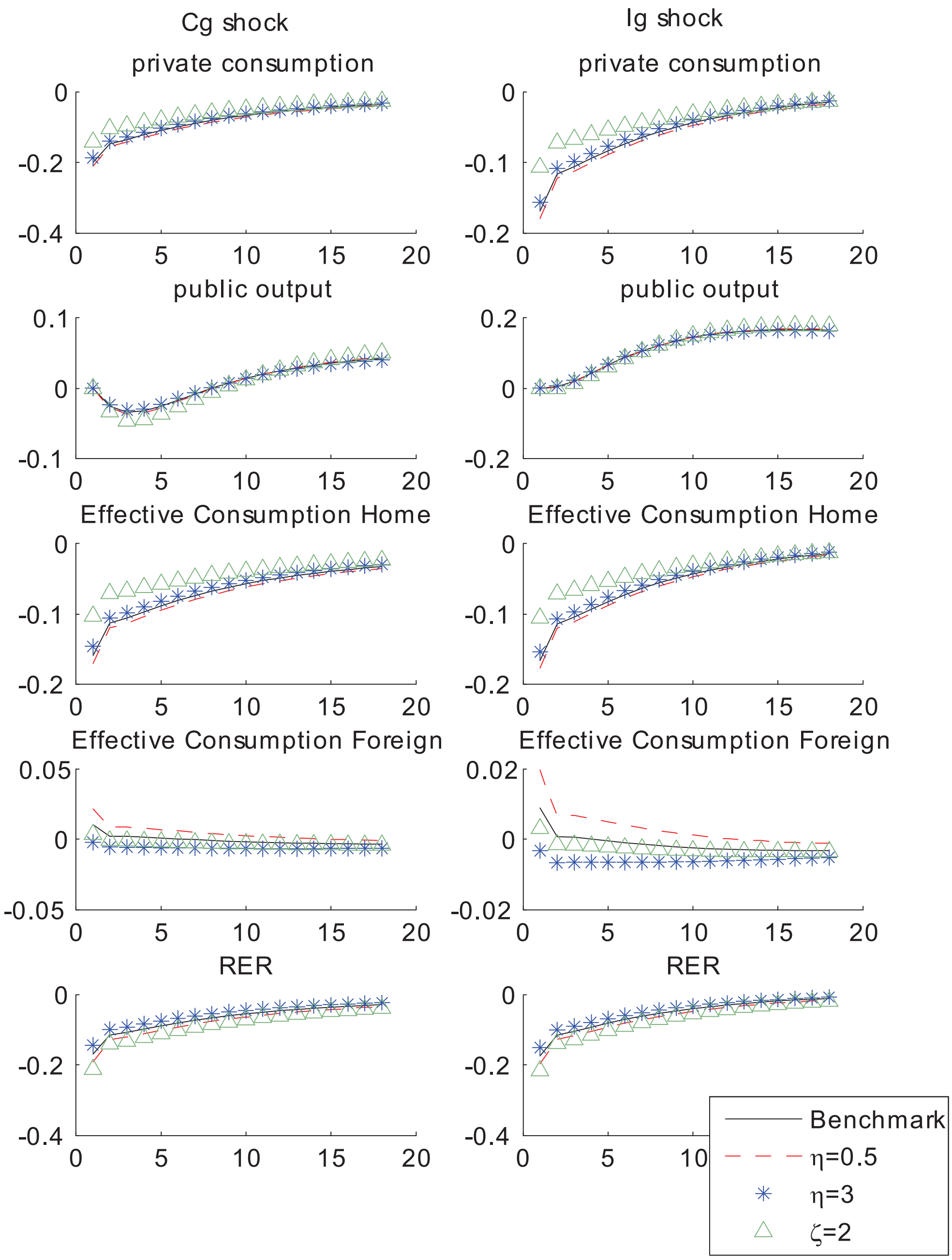

Figure 8b: Sensitivity analysis with respect to government consumption and investment shocks