Government consumption, investment, or employment to boost the economy? There is no trilemma

Dimitrios Bermperoglou * Evi Pappa† Eugenia Vella ‡

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Abstract

We compare the transmission of the three types of government spending shocks in the US and in Canada, Japan, the UK and the Euro area. Shocks are identified in a SVAR via theoretical robust sign restrictions extracted from a New-Keynesian model with matching frictions, equilibrium unemployment both public and private, endogenous labor participation and heterogeneous workers. Government employment multipliers are the highest for all countries, all samples and all identification schemes used to extract the shocks in the data. We use the model to explain the empirical results: A government employment shock generates an additional wealth effect since it induces an increase in the number of working members of the household that yields a crowding in of private consumption and investment after the shock.

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*UAB, dimitirios.bermperoglou@uab.cat
†EUI, evi.pappa@eui.eu
‡AUEB, eugvella@aueb.gr

1 Introduction

How does the economy react to fiscal shocks? This question became central in academic and policy circles over the last five years. The answer typically depends on the methodology used to extract fiscal shocks and on the identification restrictions employed. 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), Burnside et. el. (2004) and Cavallo (2005) among others), finds that a positive shock to spending for national defense makes private consumption and the real wage fall, while employment and nonresidential investments increase. The Structural Vector Autoregression (SVAR) methodology, which identifies fiscal shocks by assuming that fiscal variables do not contemporaneously react to changes in economic conditions (see, e.g., Blanchard and Perotti (2002), Fatas and Mihov (2001) and Perotti (2004)), concludes that private consumption, output, employment and the real wage positively comove with the spending shock[1]. The Dummy and the standard SVAR approaches are not the only method used to identify fiscal shocks in the empirical literature. For example, Canova and Pappa (2006) and (2007), Pappa (2009) and Mountford and Uhlig (2009) have used sign restrictions to identify fiscal shocks. Sign restrictions are preferable to those of the standard SVAR approach because they are valid with data at any frequency; because they are shared by models with different microfundations, and because they circumvent problems connected with the endogeneity and the predictability of movements in fiscal variables. The evidence that this literature produces is somewhat mixed, but, in general, shocks to government expenditure tend to increase employment and real wages.

With the exception of Pappa (2009) the focus of the analysis has been on the effects of government consumption shocks. A key issue in current research and policy is the size of fiscal multipliers and, more specifically, the stimulative effect of different fiscal packages for alleviating the economy from the negative effects of exogenous shocks. The purpose of this paper is to compare the fiscal multipliers generated by (a) a government consumption, (b) a government investment and (c) a government employment shock and examine whether the data provide us with a useful guidance on which spending component to use for fuelling the economy. We focus our analysis on the US economy but investigate the robustness of our results on other four OECD countries for which we have available data. We use quarterly data for the US from 1970 to 2007 and data for Canada, Japan, UK from 1970 until 2007, and for the Euro area

[1] Perotti (2007) reconciles the results in the two strands of literature.

since 1991. In order to account for potential structural breaks (See, Kim and Nelson (1999), McConell and Perez-Quiros (2000), and Stock and Watson (2003)), we also split the sample at the beginning of the 1980s.

We use a structural VAR and identify fiscal shocks via sign restrictions. To this end we build a comprehensive DSGE model with endogenous labor force participation, matching frictions and unemployment that can be either long or short term and specific to the private or public sector. To derive robust sign restrictions we examine the responses of macrovariables to government consumption, investment and public vacancies disturbances in the model and show that for a wide range of parameterizations the model predicts that a shock to the various components of government spending increases output for some periods after the shock and the deficit on impact, while tax revenues have a low or slightly positive correlation with the shock on impact. These restrictions distinguish fiscal shocks from other shocks such as TFP or interest rate shocks since such shocks induce a negative correlation between deficits and output on impact. To identify fiscal shocks in the data, we restrict the contemporaneous response of the deficit and the consecutive two periods' response of output to positively comove with the fiscal disturbance. Since tax cuts might also increase output and deficits, we require a zero or slightly positive correlation between the identified shock and tax revenues on impact, so as to exclude the possibility that the identified shocks are combinations of government spending and tax cut shocks. Once shocks are identified, we examine the dynamics of output and its components and the labor market variables in response to the fiscal shocks and compute fiscal multipliers.

Our findings can be summarized as follows. All spending shocks stimulate output; however, government employment shocks have the largest output multiplier, regardless of the sample, the country, or the identification method we consider to extract the shocks from the data. According to the baseline case of the US, upon a one unit increase in government consumption, investment and employment expenditures, output rises on impact by 2.24, 2.69 and 4.89 units respectively. This pattern is shared by the Euro area, Japan and the UK, while for Canada employment and investment multipliers are very close. Output multipliers are higher than unity for all shocks and all countries, while government employment multipliers are always the highest for all horizons considered and they vary on impact from 1.66 for the UK to 9 in Japan and they can reach values up to 13.5 if cumulated three years after the shock in the US and Japan.

The fact that government employment multipliers are higher than government consumption multipliers is pretty intuitive. But, how can one explain the fact that increases in government

employment can be more expansive than increases in government investment? We use the theoretical model we developed to extract sign restrictions to explain the empirical findings: In addition to the standard negative wealth effect that increases the labor supply and the labor demand effect produced by the assumption of price rigidities, government investment and employment shocks involve also a positive wealth effect since when public capital and employment are productive their accumulation increases the productivity of private inputs. This latter effect adds persistence to the responses with respect to both shocks. Yet, for government employment shocks there is an additional channel in work. Increases in public vacancies increase the number of employed members of the household and generate a positive wealth effect that stimulates demand for both consumption and investment after the shock, propagating the initial stimulus.

We believe the facts we uncover are useful to policymakers in at least two ways. First, they highlight that unexpected expansions in government employment are the most effective tool for stimulating output. Contrary to the common wisdom, increases in government investment do not generate stronger output effects at the horizons of interest. However, since they are likely to increase labor productivity and private investment more than government consumption shocks, they enjoy long run implications. Second, the facts we uncover stress that the expansionary effects of government shocks in all components considered have been significantly amplified during the last two decades in the US, while the effects of government employment shocks have been augmented for all the countries in the sample. This change provides additional support for using unexpected government employment expansions to stimulate economies in difficulties.

Finally, our model gives us some guidance for explaining the changes in the transmission of government employment shocks as it suggests that decreases in the replacement rates and in public job protection increase the size of government employment multiplier. As Gnocchi and Pappa (2012) indicate, some countries in our sample have experienced significant changes in institutions related to employment protection and non-employment benefits that can explain the increasing effectiveness of government employment shocks in the last three decades.

The rest of the paper is organized as follows: The next section describes the methodology for extracting fiscal shocks. Section 3 presents the econometric framework. Results appear in section 4, Section 5 investigates how we can reconcile the empirical evidence with our model and Section 6 concludes.

2 Identifying fiscal shocks: The methodology

We adopt the methodology used in Pappa (2009) to extract fiscal shocks in the data. The methodology involves four steps. In the first step it is established that shocks to government expenditures for consumption, investment and public vacancies increase the deficit and lagged output for a wide range of parameterizations of the model. In the second step it is established that the restrictions used to identify fiscal shocks cannot be produced by other shocks and in the third step fiscal shocks are identified in the data by imposing the model-based restrictions. The final step studies the effects of the identified fiscal shocks.

2.1 The model

We employ an extended DSGE model with search and matching frictions, endogenous labor participation choice, unemployed heterogeneity, and sticky prices. There are two types of firms in the economy: (i) competitive intermediate firms that use private and public inputs (capital and labor) to produce a final good; (ii) monopolistic competitive retailers that use all intermediate varieties to produce the final good. Price rigidities, if they exist, they 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. There are four types of unemployed workers, long and short term unemployed and unemployed that can belong to the pool of public or private unemployed[2].

2.1.1 Public employment, participation, and unemployed's heterogeneity

According to the literature on labor markets with search and matching frictions, the process through which workers and firms find each other is represented by a matching function that accounts for the imperfections and transaction costs in the labor market. These frictions prevent some unemployed from finding a job. Recently, Campolmi and Gnocchi (2011) have added a labor force participation choice and Brückner and Pappa (2012) jobseekers' heterogeneity in a New Keynesian model of equilibrium unemployment. 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 forgoing 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

[2]Notice that not all frictions are necessary for deriving our results. However, the additional features guarantee that our model is general enough to provide us with robust restrictions to extract fiscal shocks from the data.

advantageous in the job-searching process. Long and short term unemployed in turn can belong in two separate pools of unemployment: public and private unemployment.

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 remainder part, $1 - s_t^S$ ($1 - s_t^L$), are seeking a private job.

In each period, jobs of each type $j = p, g$ (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:

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

where we assume that in general $\sigma^p > \sigma^g$ in order to capture the situation of relative 'permanency' characterizing public employment, which is a feature that can make public jobs look more attractive.

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 thus 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^{pS} and m_t^{gS} denote matches for short term unemployed in the private and public sector, respectively. The aggregate matches of each type of employment are given by:

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

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

where we assume that the matching efficiency is higher for the short rather than the long term unemployed, i.e. $\rho_m^S > \rho_m^L$, and v_t^j for $j = g, p$ denotes vacancies in the two sectors. Notice that short term unemployed are more often (that is, for many parameter specifications) 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 less advantageous 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}:

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

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

Finally, market tightness for private and public unemployment 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 behaviour

The representative household is infinitely lived and derives utility from private consumption, c_t^p, public consumption, c_t^g, which is taken as exogenous, and the fraction of members that are out of the labor force and enjoy leisure, l_t:

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

where $\frac{1}{\eta}$ is the intertemporal elasticity of substitution, $z \geq 0$ and $\Phi > 0$ are preference parameters related to public consumption and leisure, and 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, beared by the household.

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

$$c_t^p + i_t^p + \frac{B_{t+1}}{p_t R_t} \leq \left[r_t^p - \tau_k(r_t^p - \delta^p)\right] k_t^p + (1-\tau_n)(w_t^p n_t^p + w_t^g n_t^g) + bu_t + \frac{B_t}{p_t} + \Pi_t^p - T_t \tag{11}$$

where p_t is the price level, w_t^j, $j = p, g$ is the real wage for the two types of employment, 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_k, τ_n and T_t represent taxes on capital income (allowing for depreciation), labor income and lump-sum taxes, respectively.

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 its expected lifetime utility subject to (1), (2), (3), (6), (10), and (11):

$$n_{t+1}^p = (1-\sigma^p)n_t^p + \psi_t^{hpS}(1-s_t^S)u_t^S + \psi_t^{hpL}(1-s_t^L)u_t^L \tag{12}$$

$$n_{t+1}^g = (1-\sigma^g)n_t^g + \psi_t^{hgS}s_t^S u_t^S + \psi_t^{hgL}s_t^L u_t^L \tag{13}$$

$$u_{t+1}^S = \sigma^p n_t^p + \sigma^g n_t^g + (1-\xi)u_t^S - \left[\psi_t^{hpS}(1-s_t^S) + \psi_t^{hgS}s_t^S\right] u_t^S \tag{14}$$

The first-order conditions from the household's maximization problem are presented in the appendix.

It is useful to derive the expected marginal value to the household of having an additional member employed privately, $V_{n^p t}^H$, as follows:

$$\begin{aligned} V_{n^p t}^H &= (c_t^p + z c_t^g)^{-\eta}(1-\tau_n)w_t^p - U_{l,t} + (1-\sigma^p)\lambda_{n^p t} + \sigma^p \lambda_{u^S t} \\ &= (c_t^p + z c_t^g)^{-\eta}(1-\tau_n)w_t^p - U_{l,t} + (1-\sigma^p)\beta E_t V_{n^p t+1}^H + \sigma^p \beta E_t V_{u^S t+1}^H \end{aligned} \tag{15}$$

According to (15), $V^H_{n^p t}$ has the following components: first, the increase in utility given by the real after-tax wage expressed in utils; 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.

2.1.3 The production side

Intermediate goods firms Intermediate goods are produced with the following Cobb-Douglas technology[3]:

$$y_t = (\varepsilon^A_t n^p_t)^{1-\varphi}(k^p_t)^{\varphi}(n^g_t)^{\mu}(k^g_t)^{\nu} \tag{16}$$

where ε^A_t is an aggregate technology shock, k^p_t and n^p_t are private capital and labor inputs, and k^g_t and n^g_t are public capital and labor inputs, taken as exogenous. The parameters μ and ν regulate how public inputs affect private production: when μ (ν) is zero, government capital (employment) is unproductive.

Since current hires give future value to intermediate firms, the optimization problem here is dynamic and hence firms maximize the discounted value of future profits. The number of workers currently employed, n^p_t, is taken as given and the employment decision concerns the number of vacancies posted in the current period, v^p_t, so as to employ the desired number of workers next period, n^p_{t+1}.[4] Firms also decide on the size of the private capital stock, k^p_t, needed for production. The problem of an intermediate firm with n^p_t currently employed workers thus consists of choosing k^p_t and v^p_t to maximize:

$$Q^p(n^p_t, k^p_t) = \max_{k^p_t, v^p_t} \left\{ x_t (A_t n^p_t)^{1-\varphi}(k^p_t)^{\varphi}(n^g_t)^{\mu}(k^g_t)^{\nu} - w^p_t n^p_t - r^p_t k^p_t - \kappa v^p_t + E_t \left[\Lambda_{t,t+1} Q^p(n^p_{t+1}, k^p_{t+1}) \right] \right\} \tag{17}$$

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

[3] This specification may seem restrictive, however Pappa (2009) shows that it provides a good approximation of a more general two-sector setup, in which one sector produces private goods and the other produces public goods.

[4] 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.

to the private employment transition equation:

$$n_{t+1}^p = (1-\sigma^p)n_t^p + \psi_t^{fp}\upsilon_t^p \tag{18}$$

The first-order conditions are:

[wrt k_t^p]

$$x_t\varphi\left(\frac{\varepsilon_t^A n_t^p}{k_t^p}\right)^{1-\varphi}(n_t^g)^{\mu}(k_t^g)^{\nu} = r_t^p \tag{19}$$

[wrt υ_t^p]

$$\frac{\kappa}{\psi_t^{fp}} = E_t\Lambda_{t,t+1}\left[x_{t+1}(1-\varphi)(\varepsilon_{t+1}^A)^{1-\varphi}\left(\frac{k_{t+1}^p}{n_{t+1}^p}\right)^{\varphi}(n_{t+1}^g)^{\mu}(k_{t+1}^g)^{\nu} - w_{t+1}^p + \frac{(1-\sigma^p)\kappa}{\psi_{t+1}^{fp}}\right] \tag{20}$$

According to (19) and (20) the value of the marginal product of private capital should equal 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.

It is useful to derive the expected value of the marginal job for the intermediate firm, $V_{n^pt}^F$:

$$V_{n^pt}^F \equiv \frac{\partial Q^p}{\partial n_t^p} = x_t(1-\varphi)\frac{y_t}{n_t^p} - w_t^p + \frac{(1-\sigma^p)\kappa}{\psi_t^{fp}} \tag{21}$$

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 the composite of individual retail goods:

$$y_t = \left[\int_0^1 (y_{it})^{\frac{\varepsilon-1}{\varepsilon}}di\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{22}$$

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 resulting demand for each intermediate good depends on

its relative price and aggregate demand:

$$y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\varepsilon} y_t \tag{23}$$

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 given by:

$$p_t = \left[(1-\chi)(p_t^*)^{1-\varepsilon} + \chi(p_{t-1})^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{24}$$

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

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

The resulting expression for p_t^* is:

$$p_{it}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} x_{t+s} y_{it+s}}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{it+s}} \tag{25}$$

2.1.4 Bargaining over the wage

Wages are determined by ex post (after matching) Nash bargaining. Workers and firms split rents and the part of the surplus they receive depends on their bargaining power. If we denote by $\vartheta \in (0,1)$ the firms' bargaining power, the bargaining 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 $V_{n^p t}^H$ and $V_{n^p t}^F$ have been defined above.

The first-order condition from the optimization problem is:

$$(1-\vartheta)(1-\tau_n)\left(c_t^p + z c_t^g\right)^{-\eta} V_{n^p t}^F = \vartheta V_{n^p t}^H \tag{26}$$

Evaluating (26) for the next period, and taking expectations given today's information set, we

get:

$$(1-\vartheta)(1-\tau_n)E_t\Lambda_{t,t+1}V^F_{n^pt+1} = \vartheta\beta E_t\left(c^p_t + zc^g_t\right)^{\eta} V^H_{n^pt+1} \tag{27}$$

which, by using the FOC of the households and (20) and (21) for the left-hand side, becomes:

$$\frac{(1-\vartheta)\kappa}{\psi^{fp}_t} = \frac{\vartheta\lambda_{n^pt}}{(1-\tau_n)\left(c_t + zy^g_t\right)^{-\eta}} \tag{28}$$

Solving (26) for w^p_t, using households FOC, and (21) , and (28), we get:

$$w^p_t = (1-\vartheta)\left[x_t(1-\varphi)\frac{y_t}{n^p_t} + \frac{\kappa}{\psi^{fp}_t}\psi^{hpO}_t\right] + \frac{\vartheta}{(1-\tau_n)}\left[b - \sigma^p\frac{\beta E_t V^H_{u^It+1}}{\left(c^p_t + zc^g_t\right)^{-\eta}}\right] \tag{29}$$

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. Note that in equilibrium, the value of working is the same for short and long term unemployed because otherwise firms could make profits by hiring less of those workers with a lower value and more of those 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 in order for there to be no 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

Similar to the case of private capital, the government capital stock evolves according to:

$$k^g_{t+1} = i^g_t + (1-\delta^g)k^g_t - \frac{\omega}{2}\left(\frac{k^g_{t+1}}{k^g_t} - 1\right)^2 k^g_t \tag{30}$$

Vacancies posted by the government are exogenous and have a utility cost κ. On average public-sector jobs enjoy a wage premium compared to private-sector ones(See Gregory and Borland (1999) for evidence on the public-sector wage premium). We allow the public wage to differ from the private wage and to be expressed as (see also Gomes (2012) and Michaillat

(2012)):

$$w_t^g = \pi_w w_t^p \tag{31}$$

where π_w is the public-wage premium.

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

$$DF_t = c_t^g + i_t^g + w_t^g n_t^g + bu_t + \kappa v_t^g - \tau_k(r_t^p - \delta^p)k_t^p - \tau_n(w_t^p n_t^p + w_t^g n_t^g) \tag{24}$$

and the government budget constraint is defined by:

$$B_t + DF_t = R_t^{-1} B_{t+1} \tag{32}$$

where B_t denotes government bonds. In order 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:

$$T_t = \overline{T} \exp(\zeta_ß(ß_t - \overline{ß})) \tag{33}$$

where $\overline{ß}$ is the steady state level of $ß_t = \frac{B_t}{y_t}$.

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

$$\Psi_t^g = \overline{\Psi}^g \left(\Psi_{t-1}^g\right)^{\boldsymbol{\rho}_g^{\psi}} \exp(\varepsilon_t^{\psi^g}) \tag{34}$$

where $\varepsilon_t^{\psi^g}$ is a zero-mean, white noise disturbance.

2.1.6 Monetary policy

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

$$R_t = \bar{R} \exp(\zeta_\pi \pi_t + \varepsilon_t^R) \tag{35}$$

where ϵ_t^R is a monetary policy shock and π_t measures inflation in deviation from the steady state.

2.1.7 Closing the model

Output must equal private and public demand. The aggregate resource constraint is given by:

$$y_t = c_t^p + i_t^p + c_t^g + i_t^g + \kappa(\upsilon_t^p + \upsilon_t^g) \tag{36}$$

The model features five exogenous disturbances. The shocks to public vacancies and fiscal spending components, as described (34), the productivity, and the monetary policy shocks. The vector of the last two shocks, $S_t = [\varepsilon_t^A,\ \epsilon_t^R]'$, is parameterized as:

$$\log(S_t) = (I - \rho)\log(\bar{S}) + \rho\log(S_{t-1}) + V_t \tag{37}$$

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 non-stohastic steady states (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. We describe the derivation of the steady state relationships in the appendix.

2.2 Robust restrictions

This step of our procedure is designed to tackle the intrinsic uncertainty implicit in calibration procedures. An implication is called robust if it holds independently of the specific parameterization and the functional forms for the primitives used. Robustness is not generic since many dynamic properties are sensitive to the exact parameterization employed and to specific features added, or subtracted to the model. What we are looking for here is to establish that there are common restrictions for the three types of shocks we study that are representative for a general DSGE model and, thus, can be used for the identification of fiscal shocks.

Formally speaking, let $h(y_t(\theta|x_t)))$ be a $J \times 1$ vector of functions of the data y_t produced by the model, when the $N \times 1$ vector of structural parameters θ is employed, conditional on the shock x_t. We let θ be uniformly distributed over Θ, where $\Theta = \prod_i \Theta_i$ is the set of admissible parameter values and Θ_i is an interval for each parameter i. We draw $\theta_i^l, i = 1, \ldots, N$ from each Θ_i, construct $h(y_t(\theta^l|x_t))$ for each draw $l = 1, \ldots, 10000$ and order them increasingly. Then

$h_j(y_t(\theta|x_t))$, $j = 1, \ldots J$ is robust if $sgn[(h_j^U(y_t(\theta|x_t))] = sgn[h_j^L(y_t(\theta|x_t))]$, where h^U and h^L are the 84 and 16 percentiles of the simulated distribution of $h(y_t(\theta|x_t))$.

Since we restrict the range of Θ_i on the basis of theoretical and practical considerations and draw uniformly, our approach is intermediate between calibrating the parameters to a point and assuming informative subjective priors. Our approach also formalizes, via Monte Carlo methods, standard sensitivity analysis conducted in calibration exercises.

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, either to avoid indeterminacies or because of steady state considerations, while θ_2 are the parameters which are allowed to vary. Table 1 gives the calibration for both parameters in θ_1 and θ_2. In the first set of parameters we have the discount factor, which is set so that the annual real interest rate equals 4%, the labor force participation rate which is set equal to 0.65, the unemployment rate equal to 6%, the share of public labor in total employment equal to 16%, the separation rates for public and private jobs, the private hiring probability rate, the ratio of short to long term unemployment hiring probability rates, and the private vacancy filling probability.

The intervals for most varying parameters are centered around calibrated values and include values that have been either estimated in the literature, or assumed in calibration exercises. 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 μ controls the interactions between public and private goods in production. Aschauer (1989) estimates the elasticity of output with respect to public capital to be in a range from 0.39 to 0.56. More recent studies, however, suggest lower values for μ (see, e.g., Garcia-Mila and McGuire (1992)). The range we choose includes both the case of unproductive government capital and most of the estimates for the elasticity of output to changes in public capital in the literature. Also, the productivity of government employment, ν, is restricted to take values in the same range. The parameter ranges for the steady state values of the fiscal variables are chosen to match the average values of their US data counterparts. Finally, for $\frac{u^S}{u} = 0$, the model reduces to a model with just two types of unemployed, i.e. private and

public jobseekers.

2.2.2 Dynamics

Figure 1 plots pointwise 68-percent probability bands for the responses of output, the deficit, the nominal interest rate and government employment to a one percent increase in government consumption (first column), government investment (second column) and public vacancies (last column) when parameters are allowed to vary over the ranges reported in Table 1.

All the fiscal shocks we consider increase deficits contemporaneously and increase output one or more periods after the shock. Also, all shocks increase the nominal interest rate on impact, while a monetary policy and a positive technology shock would move interest rates and output in the opposite direction. We have opted for not using a restriction on interest rates as the latter can be generated by the combination of a tight monetary policy response during a fiscal expansion. The responses of deficits is sufficient to distinguish monetary policy and technology from fiscal shocks since in both cases the output stimulus results in lower deficits on impact. Therefore, in order to identify a government consumption (or investment) shock we restrict the responses of government consumption (investment), output and deficit to positively correlate for two periods after the impact period of the shock and on impact, respectively. Next, the government wage bill, $w^g n^g$, robustly increases on impact after a shock in public vacancies. Accordingly, to identify such a shock we restrict the responses of the government wage bill, output and deficits to positively correlate for two periods after the impact period of the shock and on impact, respectively. Finally, since tax cuts might also increase output and deficits, we require a zero or slightly positive correlation between the identified shock and tax revenues on impact, so as to exclude the possibility that the identified shocks are combinations of government spending and tax cut shocks.

In Table 2 we report the probability that at least one of the two sign restrictions we will use to identify shocks is violated. Apart from the government vacancies shock, the probabilities we report in Table 2 are low.

3 The econometric framework

3.1 The reduced form model

We use quarterly, seasonally adjusted data for Canada and the UK from 1970 to 2007, Japan from 1962 to 2007, the US from 1960 to 2007 and data for the Euro area from 1991 to 2007, thus excluding the current financial crisis. The series come from the OECD Economic Outlook.

The reduced form model contains a constant and the following variables: The log of real per capita GDP, the log of real per capita government expenditure in (a) goods purchases, defined as government expenditures minus government wage expenditures, (b) gross fixed investment and (c) government employment, given by government wage expenditure, the log of real per-capita net tax revenues, the log of average real private wage per job, the log of total employment, the unemployment rate, the labor force participation rate and a measure of a short term interest rate. For the real wage we have used four alternative definitions: (a) wages and salaries of employees divided by the GDP deflator, (b) wages and salaries of employees divided by the CPI index, (c) gross wages received by the employee divided by the GDP deflator and (d) gross wages received by the employee divided by the CPI index. Since conclusions are similar, we present results using option (a) as a measure of the real wage.

After advising information criteria, we set the lag length of the VAR to two and only for the short Euro-area data we restrict the length of the VAR to one lag. We have also examined other variants of the model (e.g. a VAR with revenues and expenditures in percentage of GDP and a model where variables are expressed in growth rates). The results we present are unaffected by all of these changes.

Finally, we use Bayesian techniques for the estimation process and more specifically a diffuse (uninformative) prior in order to compute the point estimates and the confidence intervals.

3.2 Identifying the shocks

To identify the shocks in the data we employ the restrictions presented in Table 2; namely,upon a shock to each fiscal spending component we allow the respective fiscal variable to rise for one period, and deficits to positively comove with the fiscal variable on impact, while output is positively correlated with the government expenditure for two quarters after the shock and tax revenues are allowed to also comove or being little responsive to the shock. To account for possible correlation among the three fiscal variables we restrict the responses of the unshocked

government spending components and assume that are uncorrelated with the movements of the shocked spending variable.

Let Σ be the covariance matrix of the VAR shocks and let $PP' = \Sigma$ an orthogonal decomposition of Σ. Then, structural shocks ε_t are constructed as $\varepsilon_t = P^{-1}u_t$, where u_t are reduced form shocks and, for each element of ε_t, we check if the required restrictions are satisfied. If no structural shock produces the required comovements in the variables, the orthogonal decomposition is rotated by an orthonormal matrix $H(\lambda)$, with $H(\lambda)H(\lambda)' = I$, where λ measures the angle of rotation, and the comovements in response to the new set of shocks is examined (see Canova (2007)). This search process continues, randomly varying λ in the range $(0, \pi)$, and randomly rotating the columns of $H(\lambda)$. Since many $H(\lambda)'s$ can in principle produce the required pattern, the error bands we report reflect not only the uncertainty in Σ and the reduced form parameter estimates but also how responses vary with different $\lambda's$ and $H's$.

Besides making the link between the model and the data tighter, the use of robust sign restrictions avoids, in principle, typical problems associated with the identification of economically meaningful fiscal shocks. In particular, problems concerning the endogeneity of fiscal variables, the delays between planning, approval and implementation of fiscal policies, which may give rise to predictability problems and the scarceness of reasonable zero-identifying restrictions are to a large extent solved. In fact, all relevant variables are endogenous here and since we control for the state of the business cycle, there is no need to produce cyclically adjusted estimates of fiscal variables. Furthermore, since theory defines the features of the fiscal disturbances we are looking for and the timing of the responses of the endogenous variables is largely unrestricted, the other two problems are also considerably eased. Sign restrictions resolve to some extent the problem of predictability of fiscal shocks since identification does not rely on delay restrictions. Finally, since monetary policy and fiscal shocks move deficits in opposite directions the question of fiscal and monetary policy interaction does not arise when identifying fiscal disturbances.

4 Empirical results

4.1 Full sample evidence

Starting with the baseline VAR for the US, we present the responses of output, real wage, employment, the unemployment rate and the labor force participation rate to a 1% increase in

government spending on consumption, investment and employment in Figure 2. Each graph presents median estimates (solid line) and pointwise 68-percent probability bands (shadowed area). First we can observe a fixed pattern for all shocks; output and employment significantly increase for some periods after the three shocks, while the unemployment rate falls. On the other hand, the labor force participation rate seems to respond in the case of a consumption and employment shocks while the real wage responds positively and significantly to a government investment shock. Although responses are comparable qualitatively they convey a striking quantitative difference: output is highly stimulated after a public employment shock in constrast with the low output responses after a government consumption or investment shock. Specifically, a 1% increase in government employment induces a 0.5% increase in output on impact, while a consumption and investment shock drive output up by 0.14 and 0.10% respectively. Similar patterns arise from the VAR analysis of other OECD countries. In Figure 3 we present the output responses after a government consumption (first column), investment (second column) and employment (third column) in Canada, the Euro area, Japan, and the UK. All three fiscal spending shocks are expansionary with respect to output, but the most expansionary one is always the public employment spending shock.[5]

This is also true in terms of output multipliers. Table 3 presents the impact output multiplier and the annualized cumulative multipliers one and three years after the shock for the sample countries.[6] Statistical significant multipliers at 68% probability are indicated with an asterix. Regarding the US, government employment shocks have the highest output multipliers for all horizons. Specifically, an one unit increase in government consumption, investment and employment expenditures implies an increase in output on impact by 2.24, 2.69 and 4.89 units respectively. Three years after the shock the cumulative effect on output is significantly risen by 7.39, 8.29 and 13.2 units respectively. For the other four countries results are similar; upon a government employment shock output multipliers are always higher, except for the impact multiplier for Canada which is slightly smaller than that of an investment shock.

[5]The complete set of impulse response functions are provided in a supplementary appendix available at www.eui.eu/Personal/Pappa/research.html.

[6]Impact output multipliers are computed by dividing the response of output by the sample mean of the share of each fiscal component in GDP. Annualized cumulative multipliers are computed by dividing the response of output by the sample mean of the share of each fiscal component in GDP, then dividing by four and finally cumulating up to the required horizon.

4.2 Subsample analysis

There are several reasons to believe that the sample of data we consider is not homogeneous. For example, it is well known that the volatility and the persistence of US real and nominal variables has fallen after 1980 (see e.g. Stock and Watson (2003)). To take into account sample heterogeneity we split the sample into two subsamples, from the starting date up to 1979 and from 1982 to the end of the sample.

In Table 4 we present impact and annualized cumulative output multipliers one and three years after the shock for each of the two sub-periods, as well as the difference in the multipliers between the two sub-periods[7]. The structural change of the 1980s has changed significantly the transmission of government spending shocks. The effect of government consumption shock is enhanced in the post 80s for the US, while it is weakened for Canada and Japan. Similarly, the effects of investment shocks have weakened for the UK, while they were enhanced for Canada, Japan and the US. Surprisingly, the effects of government employment shocks have substantially increased in the second subsample for all countries and all horizons, which implies that any structural change in the 1980s was in favor of public employment shocks.

4.3 An alternative identification scheme

To examine the robustness of our results we employ a simple recursive (Choleski) identification to extract the fiscal shocks from the data. We repeat three different VAR specifications where we order each government spending variable first in the VAR, and the rest of the variables variables are included in the following order: real per capital GDP, total employment, real wage, labor force participation rate and unemployment rate.

Impulse responses of the VAR variables for the US are presented in Figure 4. A 1% increase in government spending for consumption, investment and employment results to a 0.11, 0.09 and 0.41% increase in output respectively. The public employment shock becomes even more expansionary in the fourth quarter, while the other two fiscal shocks weaken in time. Furthermore, public employment shocks are more effective concerning the labor market. Total employment reaches a peak response of 0.13% at the sixth quarter and the real wage modestly increase on impact after an employment shock, while consumption and investment shocks cannot stimulate enough these variables and total employment even falls on impact after a consumption shock.

[7] In the online appendix we present the relevant impulse responses of the variables of interest for the three spending shocks for the US economy. They are qualitatively similar across the two sub-samples and also in accordance with the full sample analysis.

The unemployment rate seems to increase contemporaneously upon a public consumption and employment shock but then starts falling below steady state. However, the public employment shock is the one that produces the highest responses since the unemployment rate falls by 0.1% five quarters after the shock. Multipliers are smaller for this identification scheme (see last column of Table 3), yet government employment multipliers are the highest and significant for all the horizons considered.

5 Why is government employment the most effective?

The empirical results of the previous section establish an important stylized fact: shocks to government employment are the most effective in stimulating the economy independently of the way used to identify fiscal shocks and the time period considered.

It is pretty intuitive to infer that government employment is successful in stimulating output relative to government consumption if it is productive, but it is difficult to understand what makes government employment more effective relative to government investment. In this section we show that the theoretical model presented in section 2 can reconcile the empirical findings and the assumptions that are crucial for replicating the empirical results.

5.1 Fiscal multipliers: public spending as a waste

We start by assuming that both public inputs are unproductive and that government consumption yields no utility to private agents. The calibration for the other parameters of the model is based on US data and is presented in Table 5.

The continuous lines in Figure 5 describe the responses of the economy to a government consumption shock when public inputs are unproductive and government spending yields no utility to households. The shock to government consumption induces a negative wealth effect that increases labor participation and decreases private consumption. The latter effect is combined with a positive demand effect stemming from the assumption of price rigidities which in turn increases labor demand generating an increase in private vacancies and consequently in private employment. The combine shifts of labor supply and demand result in an increase in the private wage which leads subsequently to an increase in the public wage as well. Output increases and private investment is crowded out by the shock. The increase in labor demand decreases short term unemployment, while the increase in labor force participation increases

long term unemployment, depending on the share of long term unemployed to total unemployment, total unemployment can go up or down after the shock. In our benchmark calibration unemployment increases initially and falls when the new vacancies are filled by short term unemployed in the subsequent period of the shock. Public employment decreases as a result of the increase in the tightness of the public jobs market. Finally the increase in labor force participation increases labor supply and the fraction of private jobseekers, while the shift of labor supply to private employment decreases the fraction of public jobseekers both in the case of short and long term unemployed.

The continuous lines in Figure 6 depict the responses of the economy to a government investment shock when public inputs are unproductive and government spending yields no utility to households. Responses in this case are identical to the case of public consumption shocks, since the two shocks represent increases in the government's absorption and have no specific feature to tell them apart.

The continuous lines of Figure 7 describe the impulse responses of the economy to a shock in public vacancies. This shock is different from the other two since it distorts the labor market conditions for both types of employment. Similarly to the case of the previous shocks, the increase in government's absorption increases labor participation due to the negative wealth effect and the labor demand effect is still at play increasing private vacancies and private employment. Nevertheless, the increase in public vacancies alters the dynamics of the other variables substantially: the increase in public employment moderates the crowding out of consumption and investment, since with the increased number of working members the households can actually afford an increase in consumption and investment the moment that more household members become employed, that is a period after the initial shock.

This property of the public vacancies shock is crucial for understanding the empirical results. In Figure 8 we plot the output multipliers generated by the 3 types of shocks when government spending is a waste (continuous lines). The multiplier associated with the government vacancies shock is the largest and larger than one, since it involves a crowding in of consumption and investment after the shock. However, the stimulative effect is short lived and is not comparable with the responses we observe in the data. In what follows we allow for productive public inputs and we show that this is a crucial feature to match the empirical evidence with the theoretical predictions.

5.2 Fiscal multipliers: productive public inputs

The dashed lines in Figure 5 represent the responses of the macro variables to a government consumption in an economy in which public inputs are productive ($\mu = \nu = 0.2$) and government consumption spending yields utility to the households ($z = 0.2$). The fact that government spending yields utility to the household decreases the size of the negative wealth effect, while the fact that government inputs are productive decreases the labor demand effect from, and, as a result, output multipliers for government consumption shocks are smaller in this case (see dashed line of first panel of Figure 8). Private consumption is more crowded out in this case because the increase in public consumption allows households to substitute private for public goods. Private vacancies increase less, since with productive public inputs there is less of a need for an increase in private inputs and private investment is less crowded out than in the previous case. Hence, the private and public wages increase by less. The smaller labor demand effect leads to higher drops in unemployment and consequently to public employment.

On the other hand, the assumption on the productivity of public inputs makes a big difference for the responses of the economy to a government investment shock. The impulse responses in this case are depicted as dashed lines in Figure 6. The wealth and demand effects in this case are combined with a positive effect of the shock on future production, since a higher i_t^g increases public capital and, thus, enhances the productivity of private factors. The contemporaneous responses induced by government investment shocks are qualitatively similar to the ones produced by a government consumption shock, however, the lagged effects are quite different. Output increases persistently after a shock to government investment, generating a persistent positive effect on wealth that reduces long term unemployment and public employment. The crowding out of private consumption is smaller and short lived and the increases in the marginal product of labor increase both private and public wages persistently.

However, the size of the impact multiplier does not change significantly in Figure 8, although cumulative multipliers for government investment shocks increase when government capital is assumed to be productive. Of course a rise in μ, the productivity of public capital, would improve further the size of the multiplier both at subsequent periods and on impact, but would not change its size relative to public vacancies shocks.

Finally, the productive nature of government employment also generates a persistent wealth effect originating from the increase in the productive capacity of private inputs similar to the one generated by government investment shocks (See dashed line in Figure 7). Output, consumption and investment increase more and more persistently after the shock, increasing further the size

of the multiplier both on impact and with several lags. Again, the multiplier is an increasing function of ν, the productivity of public employment. However, the important message to take out of this analysis is the fact that government employment gives the highest multipliers not because it is assumed to be productive, but because it induces an extra positive wealth effect that the other two shocks do not share, by increasing the number of working members in the household and allowing for crowding in of private consumption and investment. Of course the size of this effect depends on various parameters of the model. In what follows we try to identify the features of the model that determine its size.

5.3 Sensitivity analysis

Public vacancies shocks generate relatively higher multipliers since they induce a positive wealth effect by increasing the number of employed members of the households that the other two shocks do not generate. In this section we investigate the parameters that influence crucially this effect.

Apparently, there are some obvious candidates that determine this effect such as the size of replacement rates, since they affect directly the value to the household of having an additional member working. The dashed lines in Figure 9 demonstrate indeed that high replacement rates ($b/w^p = 0.5$) decrease substantially the wealth effect originating from government vacancies shocks, since with high unemployment benefits households do not experience a substantial increase in income when a member of the household gets a public job relative to remaining unemployed in the coming period.

Also, the public job destruction rate should affect the continuation value of the household for having an additional public employee among its members. The dotted lines in Figure 9 depict output multipliers in the case that $\sigma^g = 0.01$. One should expect that making public jobs more secure would increase the wealth effect associated with an increase in public vacancies, but this is not the case. Actually, a reduction in the public job separation rate has exactly the opposite effect; it reduces substantially the multiplier of government vacancies shocks. Making public jobs less permanent increases the government employment multiplier simply because it creates fewer queues for public jobs. To be more specific, when households perceive that a public job lasts longer after a shock in public vacancies they increase their relative labor supply for public employment by more than in the case when public jobs are less permanent. Given the low destruction rate of the public jobs the fraction of long-term unemployed that

are public jobseekers is persistently higher increasing persistently total unemployment. On the other hand, the pool of private jobseekers of both short and long term nature is lower and this dampens the evolution of private employment. With less private employment there is no need for extra investment and private investment responses are also dampened. As a result, output increases by less and consumption as well. Hence, the reallocation of unemployed jobseekers towards public employment, provoked by the increase in public vacancies, results in a lower stimulus from the shock.

Moreover, there are several parameters that do not affect directly the wealth effect from the fall in the unemployment rate after a public vacancy shock, but might affect the multiplier for the other two shocks considered. For example, the size of capital adjustment costs, or the flexibility in prices might influence the effectiveness of government investment shocks in stimulating the economy. As it is clear from Figure 9, such changes do affect the size of the multipliers for the three shocks considered, but do not alter towards public employment their relative ranking in terms of their effectiveness in accelerating the economy.

Finally, the model presented in Section 2 is very general and incorporates features that are not necessary for explaining the empirical findings. For example, the heterogeneity in unemployment is not necessary. In Figure 9 we plot multipliers generated by models in which the share of long term to total unemployed is set to zero. As it is clear from the picture, the assumption of heterogeneous unemployment is not crucial for the ranking of different fiscal instruments, since for this ranking the most important element is the presence of unemployment itself independently of whether this is labelled short or long term.

6 Conclusions

This paper analyzes the dynamics of transmission of different types of government expenditure shocks financed through deficit increases in the US and other four OECD countries. We restrict attention to expenditure shocks for two reasons. First, while the effects of expenditure shocks in the literature are controversial, there is somewhat more agreement on the dynamic effects induced by tax shocks. Second, although not often appreciated in the empirical literature, the qualitative features of the dynamics in response to government shocks crucially depend on the way expenditure is financed (see, e.g., Baxter and King (1993)). Since the implications produced by deficit financed expenditure increases are relatively robust across model specifications and across different components of expenditures, while this is not the case for tax financed ex-

penditure increases, and since robustness gives credibility to our identification methodology, we consider only deficit financed expenditure shocks in our exercises. A cross country perspective can help us to understand whether our findings are solely a US phenomenon, or if instead are shared in a number of developed economies. The countries we have chosen differ in size, degree of openness, size of the government sector, monetary policy regime and degree of flexibility of the labor market relative to the US, but we fail to explain differences in the responses to fiscal shocks across countries using these features.

To identify deficit financed expenditure shocks we use constraints on the sign of output and deficit responses. In particular, the identification scheme we employ requires that government spending shocks raise output persistently with a lag and the deficit contemporaneously. Our identification restrictions come from a very general DSGE model with real and nominal frictions and hold from many variants and parameterizations of the model. All spending shocks are effective in stimulating output; however, for government employment shocks multipliers are larger and larger than one for all countries and all horizons. There are substantial differences in the transmission of fiscal shocks pre and after the beginning of the 80s. Government employment has significantly stronger effects in the last two decades.

Determining whether these facts have a common underlying explanation is a challenging task. We employ the model used for the derivation of restrictions to highlight which features are necessary to justify the empirical responses: government employment is most effective in fuelling the economy because apart from generating the standard wealth and demand effects after increases in government absorption it has an additional positive effect, since it reduces unemployment and induces a positive wealth effect that incentivize households to consume and invest relatively more. This latter effect depends crucially on the size of replacement rates and on the job destruction rate of public jobs. High replacement rates and public job security decrease the effectiveness of government employment shocks. Hence the reforms in employment protection and unemployment benefits in many of the OECD countries in our sample may explain the increased effectiveness of government employment shocks in the last three decades.

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8 Tables

Table 1: Parameter ranges				
Varying parameters			Fixed parameters	
η	risk aversion coefficient	[0.5,6]	$\beta = 0.99$	discount factor
z	utility from public consumption	[0.0,0.5]	$1 - l = 0.64$	participation rate
$\frac{1}{\psi}$	Frisch elasticity	[0.1,10]	$\frac{u}{1-l} = 0.06$	unemployment rate
$\frac{u^S}{u}$	short term unemployment share	[0.0,0.2]	$\frac{n^g}{n} = 0.16$	share of public employment
ω	adjustment costs parameter	[0,5]	$\sigma^p = 0.025$	private separation rate
δ^p, δ^g	capital depreciation rates	[0.02,0.03]	$\sigma^g = 0.018$	public separation rate
φ	private capital share	[0.3,0.4]	$\psi^{hp} = 0.83$	private hiring probability
μ	productivity of public capital	[0,0.5]	$\frac{\psi^{hpS}}{\psi^{hpL}} = 1.015$	short vs.long hiring prob
ν	productivity of public employment	[0,0.5]	$\psi^{fp} = 0.54$	prob.filling private vacancy
τ^l	average labor tax rate	[0,0.5]	$\frac{\kappa}{w^p} = 0.045$	vacancy cost - wage ratio
τ^k	average capital tax rate	[0,0.4]		
$\frac{b}{w^p}$	replacement rates	[0.0,0.4]		
$\frac{\varepsilon}{\varepsilon - 1}$	steady state markup	[1.09, 1.16]		
$1 - \chi$	probability of price change	[0.0,0.85]		
ϑ	firms bargaining power	[0.4,0.6]		
$\frac{C^g}{Y}$	steady state C^g/Y ratio	[0.1,0.2]		
$\frac{K^g}{K^p}$	steady state K^g/K^p ratio	[0.25,0.35]		
π_ω	public wage premium	[0.95,1.25]		
ζ_π	Taylor's coefficient	[1,2.5]		
$\zeta_ß$	debt coefficient	[0,1.5]		
ϱ_g^ψ, $\psi = c^g, i^g, v^g$	persistence of fiscal shock	[0.0,0.95]		
ϱ	persistence of non-fiscal shocks	[0.0,0.95]		

Table 2: Identifying Restrictions							
Shock/Variables	Y_k, $k=2,3$	DF	c^g	$w^g n_k^g$, $k=2,3$	i^g	tax revenues	Probability of false restriction (%)
$\varepsilon_t^{c^g}$	>0	>0	>0	-	-	≥ 0	3.3
$\varepsilon_t^{i^g}$	>0	>0	-	-	>0	≥ 0	9.4
$\varepsilon_t^{v^g}$	>0	>0	-	>0	-	≥ 0	18
ε_t^{A}	>0	<0	-	-	-	≤ 0	14
ε_t^{R}	>0	<0	-	-	-	≤ 0	5

	Canada			EU			Japan			UK			US			US Choleski		
	1	4	12	1	4	12	1	4	12	1	4	12	1	4	12	1	4	12
Cg	1.56*	1.48*	1.86	1.73*	1.02*	2.00	2.31*	2.50*	7.38*	1.26*	1.32*	4.88*	2.24*	2.95*	7.39*	1.89*	0.56	2.61
Ig	3.09*	3.10*	6.37	1.89*	1.39*	1.80	1.19*	1.32*	2.42	1.45*	1.19*	2.19	2.69*	3.34*	8.29*	2.72	1.86*	3.08
Ng	3.07*	3.15*	3.88	3.65*	2.41*	2.27	9.00*	7.84*	13.50*	1.66*	1.87*	5.98*	4.89*	5.40*	13.20*	3.44*	2.29*	6.10

Table 3: Output multipliers

		Canada			Japan			UK			US		
		1	4	12	1	4	12	1	4	12	1	4	12
Cg	pre80's	2.12*	1.07	1.65	2.98*	2.08*	4.16	2.39	1.13	0.23	1.00	1.10*	1.97
	post80's	1.60*	1.53*	5.28	1.98*	2.05*	4.22*	1.30*	1.94*	8.11*	3.73*	3.89*	8.13
	Difference	-0.52*	0.46	3.63	-1.00*	-0.03	0.06	-1.08	0.81	7.88	2.74	2.79*	6.16
Ig	pre80's	3.53*	2.40*	3.49	1.64*	1.34*	2.58*	1.66*	1.03	-1.47	0.99*	1.15*	2.39
	post80's	3.01*	5.48*	8.43	2.26*	2.11*	4.48	1.10*	1.74*	3.14	3.96*	5.10*	17.04*
	Difference	-0.52*	3.07*	4.94	0.62*	0.77*	1.90	-0.56*	0.71	4.61	2.97*	3.94*	14.66
Ng	pre80's	1.75*	1.75*	3.78	2.90*	4.05*	12.29*	1.77*	1.62*	2.42	3.47*	2.53*	2.82
	post80's	5.18*	5.22*	8.79	13.46*	12.25*	19.55*	1.93*	3.10*	9.65*	7.57*	8.61*	24.27*
	Difference	3.43*	3.47*	5.01	10.56*	8.20*	7.26*	0.15*	1.48*	7.24	4.10*	6.08*	21.45

Table 4: Output multipliers, subsample analysis

Table 5: Baseline calibration	
Description	Values
participation rate	$1 - l = 0.65$
unemployment rate	$\frac{u}{1-l} = 0.06$
share of public employment	$\frac{n^g}{n} = 0.16$
short-term unemployment share	$\frac{u^S}{u} = 0.16$
private separation rate	$\sigma^p = 0.025$
public separation rate	$\sigma^g = 0.018$
private hiring probability	$\psi^{hp} = 0.83$
hiring prob short- vs.long-term unemployed	$\frac{\psi^{hpS}}{\psi^{hpL}}, \frac{\psi^{hgS}}{\psi^{hgL}} = 1.015$
prob.filling private vacancy	$\psi^{fp} = 0.54$
replacement rate	$\frac{b}{w^p} = 0.3$
vacancy cost as a share of the private wage	$\frac{\kappa}{w^p} = 0.045$
public wage premium	$\pi_\omega = 1.16$
matching elasticity, firm's bargaining power	$\alpha, \vartheta = 0.6$
average capital tax rate	$\tau^k = 0.4$
average labor tax rate	$\tau^l = 0.27$
discount factor	$\beta = 0.99$
risk aversion coefficient	$\eta = 1$
utility from public consumption	$z = 0.2$
inverse of Frisch elasticity	$\psi = 4$
capital depreciation rates	$\delta^p, \delta^g = 0.025$
steady state $\frac{k^g}{k^p}$ ratio	$\frac{k^g}{k^p} = 0.31$
steady state $\frac{c^g}{y}$ ratio	$\frac{c^g}{y} = 0.165$
private capital share	$\varphi = 0.36$
productivity of public capital/employment	$\mu, \nu = 0.2$
demand elasticity for intermediate goods	$\varepsilon = 11$
price stickiness parameter	$\chi = 0.75$
adjustment costs parameter	$\omega = 2$
Taylor's and debt coefficients	$\zeta_\pi = 1.5, \zeta_ß = 0.5$
persistence of fiscal shock	$\varrho_g^\psi = 0.85$, $\psi = c^g, i^g, v^g$
persistence of non-fiscal shocks	$\varrho^A = 0.95$, $\varrho^{\epsilon^R} = 0.65$

public consumption shock | public investment shock | public vacancies shock

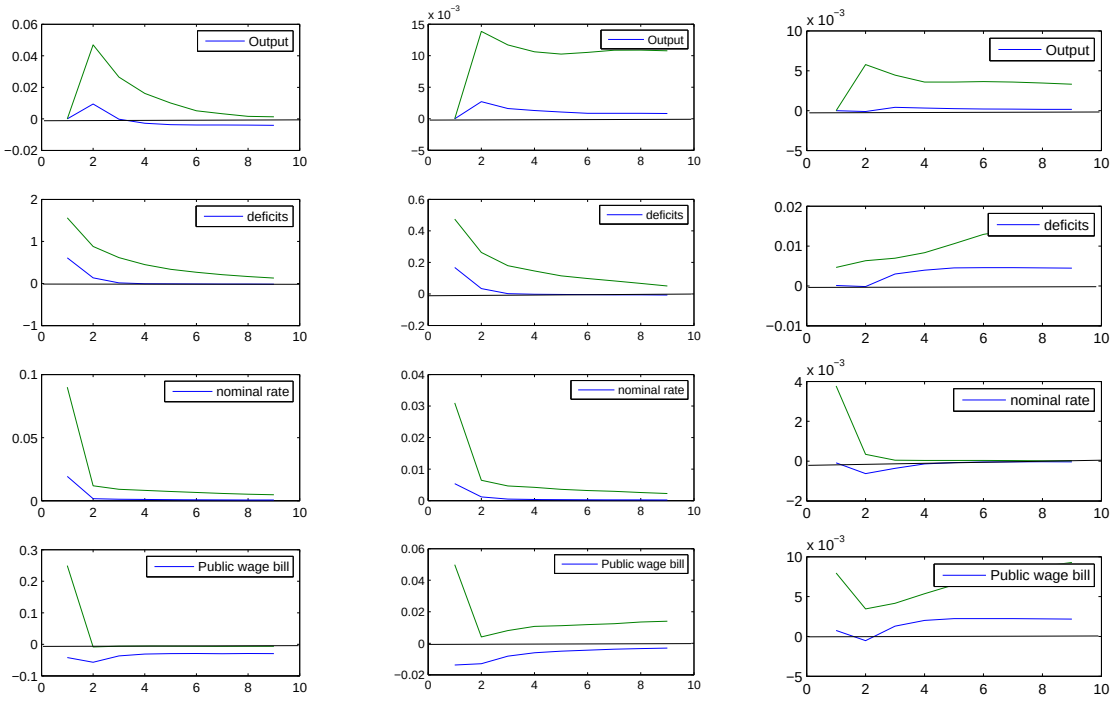


Figure 1: Robust sign restrictions, theoretical responses to fiscal shocks

public consumption shock public investment shock public vacancies shock

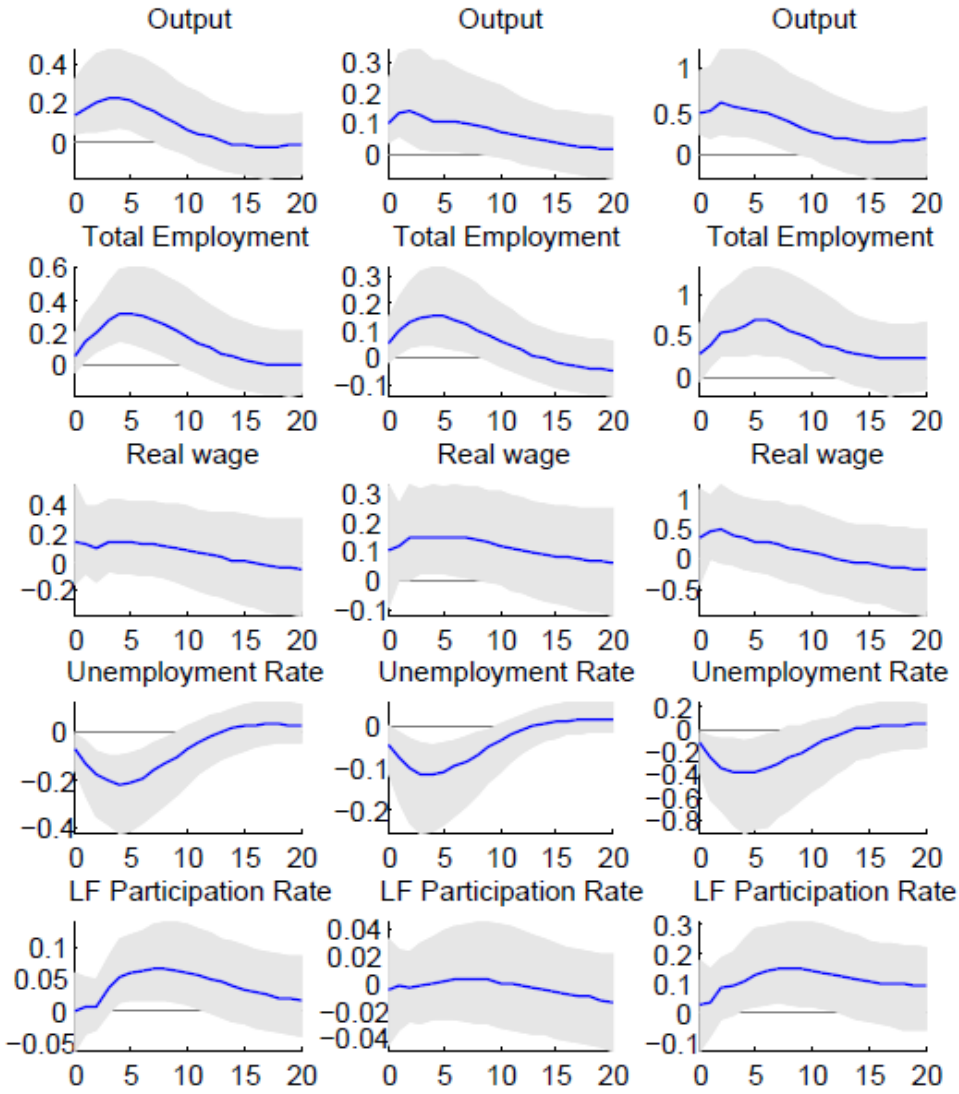


Figure 2: IRFs to government spending shocks, US data

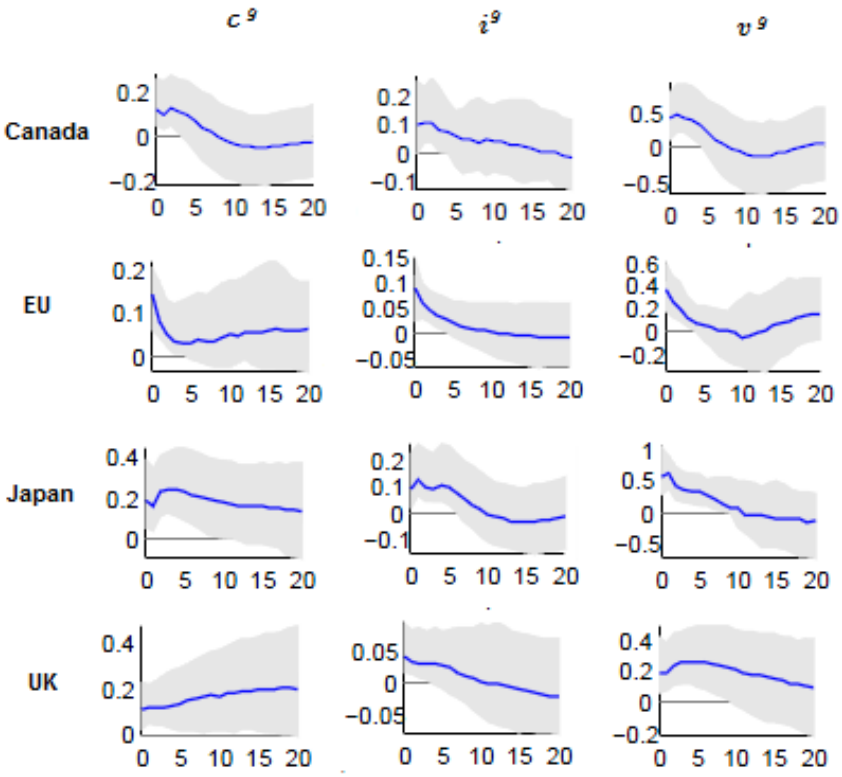


Figure 3: Output responses in other OECD countries

public consumption shock public investment shock public vacancies shock

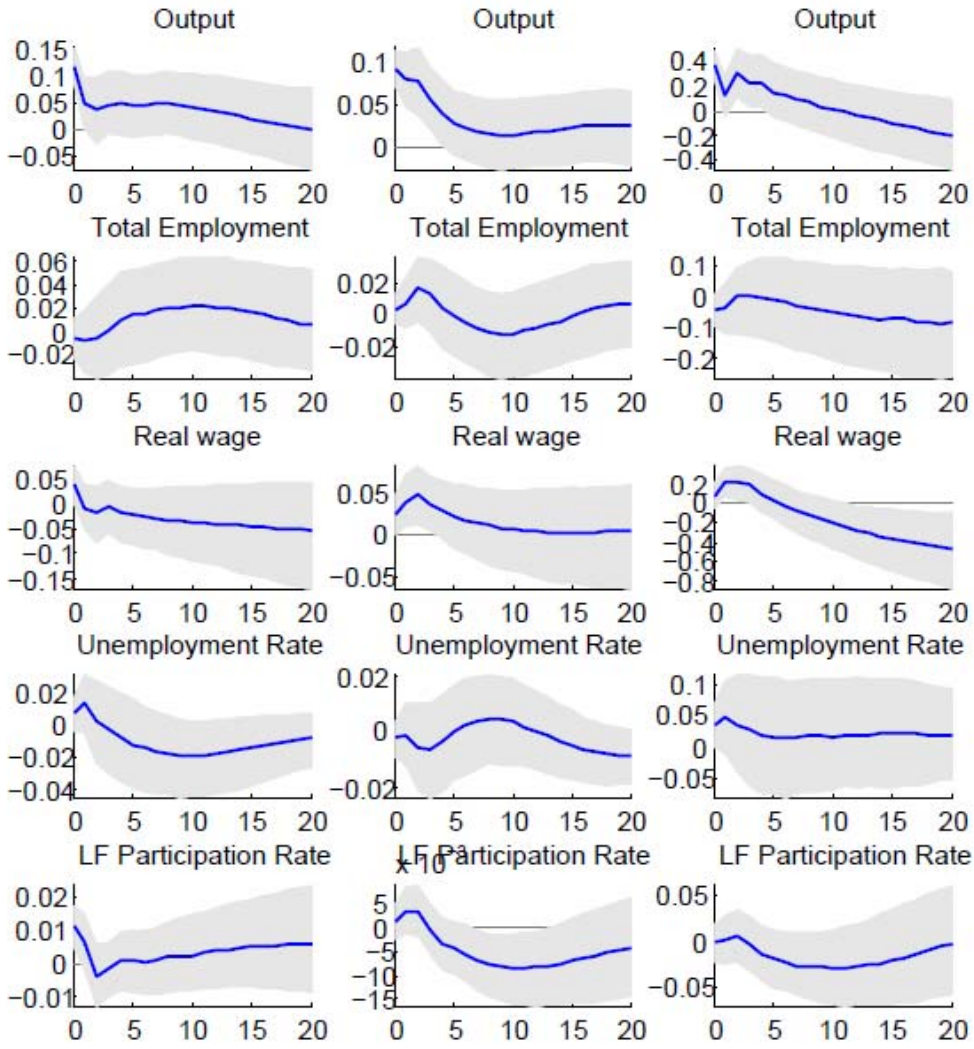


Figure 4: IRFs to goverment spending shocks, US data, Choleski

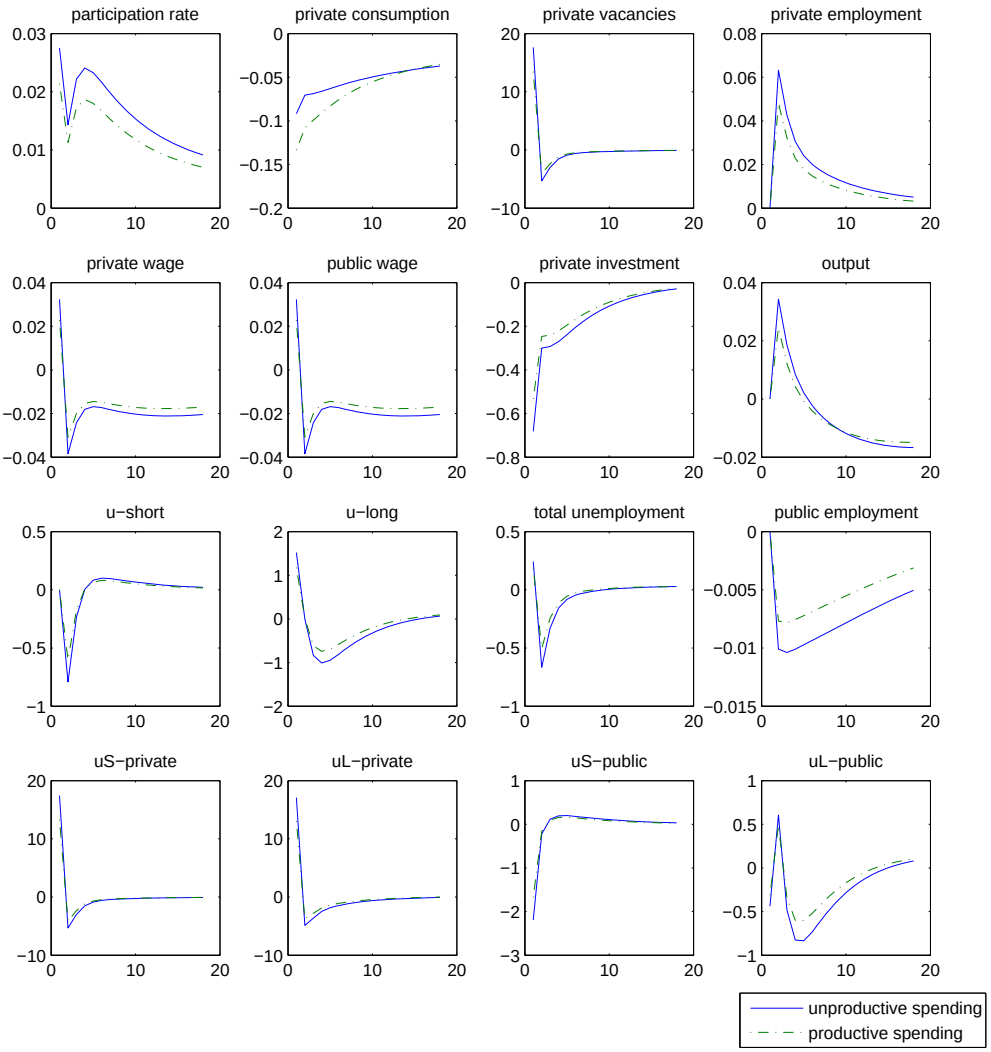


Figure 5: Responses to a public consumption shock

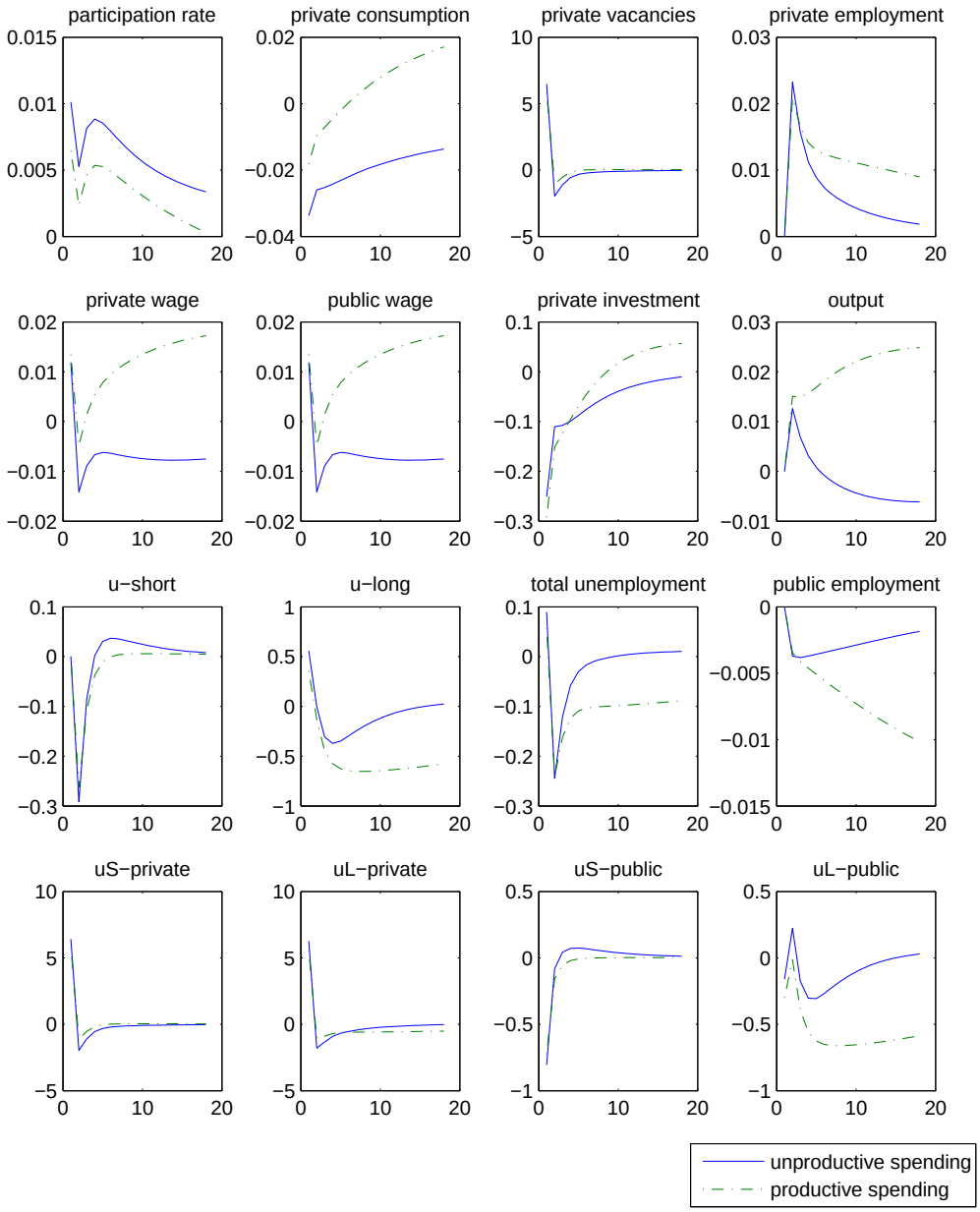


Figure 6: Responses to a public investment shock

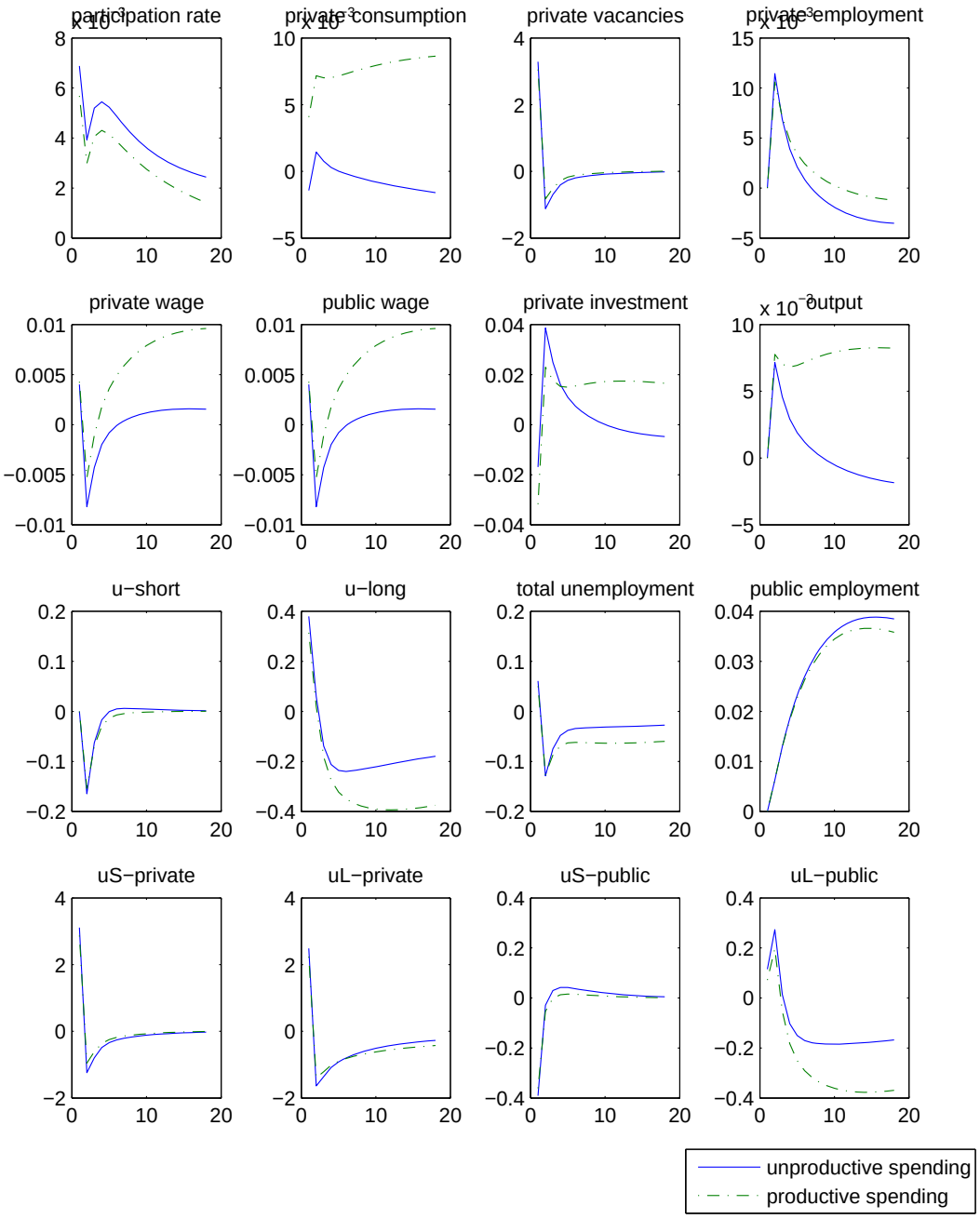


Figure 7: Responses to a public vacancies shock

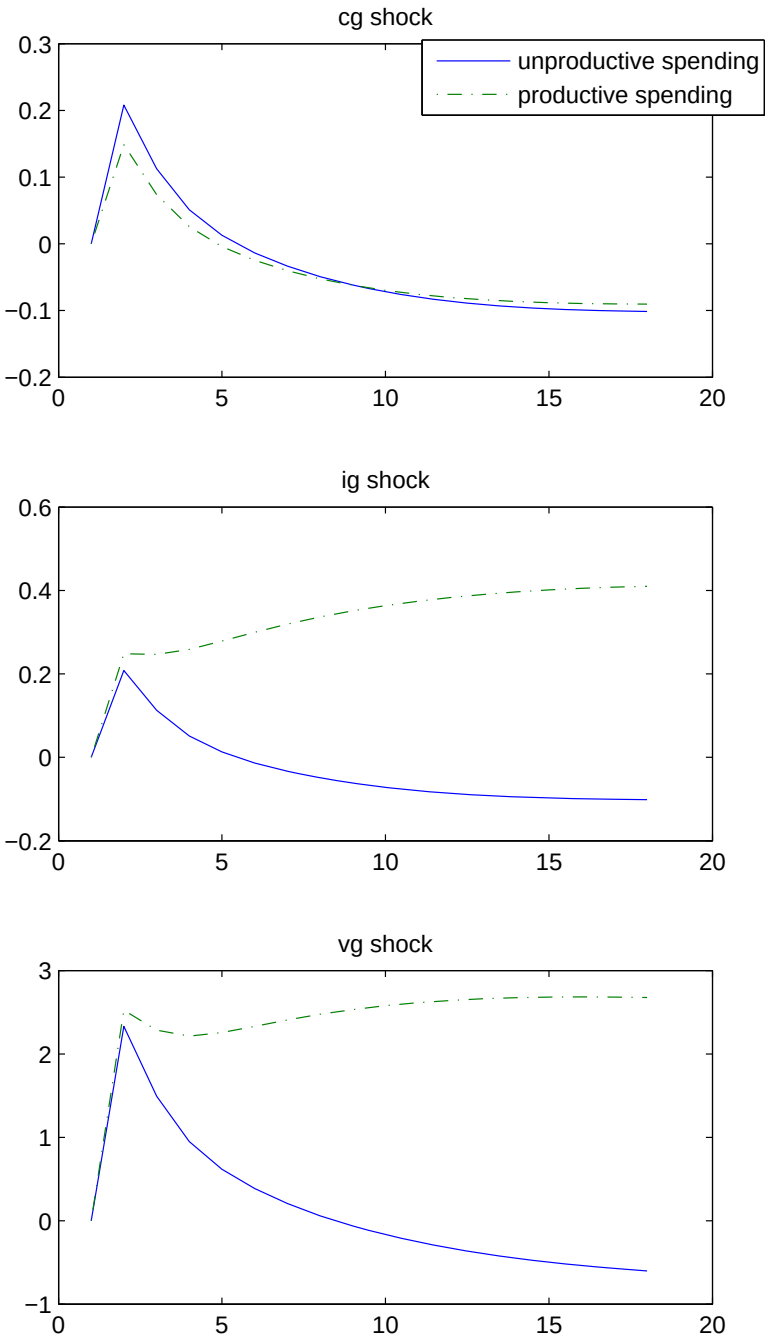


Figure 8: Comparison of output mulipliers

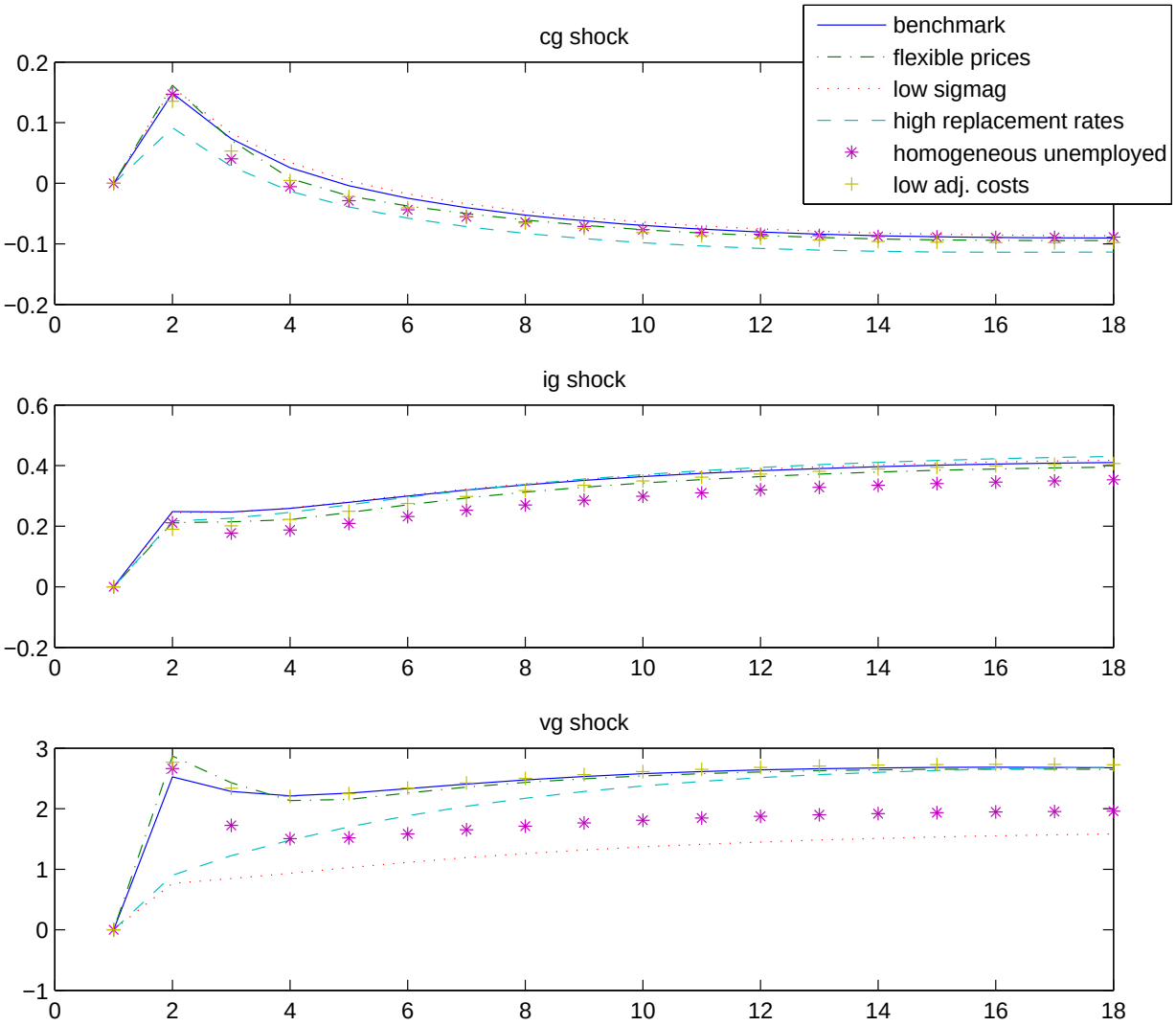


Figure 9: Sensitivity analysis

A Appendix: F.O.C. from the household's problem

Equations (2), (3), (6), can be summarized as:

$$n^p_{t+1} = (1-\sigma^p)n^p_t + \psi^{hpS}_t(1-s^S_t)u^S_t + \psi^{hpL}_t(1-s^L_t)u^L_t \tag{A1}$$

$$n^g_{t+1} = (1-\sigma^g)n^g_t + \psi^{hgS}_t s^S_t u^S_t + \psi^{hgL}_t s^L_t u^L_t \tag{A2}$$

$$u^S_{t+1} = \sigma^p n^p_t + \sigma^g n^g_t + (1-\xi)u^S_t - \left[\psi^{hpS}_t(1-s^S_t) + \psi^{hgS}_t s^S_t\right] u^S_t \tag{A3}$$

The problem of the household is to maximize (9) subject to (10)-(11) and the three equations above. If we denote by λ_{ct}, λ_{n^pt}, λ_{n^gt}, λ_{u^St} the multipliers in front of equations (11), (A1)-(A3), the first-order conditions from the optimization problem are:

[wrt c^p_t]

$$(c^p_t + z c^g_t)^{-\eta} = \lambda_{ct} \tag{A4}$$

[wrt K^p_{t+1}]

$$\lambda_{ct}\left[1+\omega\left(\frac{K^p_{t+1}}{K^p_t}-1\right)\right] = \beta E_t \lambda_{ct+1}\left\{1-\delta^p + [r^p_{t+1} - \tau_k(r^p_{t+1}-\delta^p)] + \frac{\omega}{2}\left[\left(\frac{K^p_{t+2}}{K^p_{t+1}}\right)^2 - 1\right]\right\} \tag{A5}$$

[wrt B_{t+1}]

$$\lambda_{ct}\pi_{t+1} = \beta E_t \lambda_{ct+1} R_t \tag{A6}$$

[wrt n^j_{t+1}]

$$\lambda_{n^jt} = \beta E_t\left[\lambda_{ct+1}(1-\tau_n)w^j_{t+1} + \lambda_{n^jt+1}(1-\sigma^j) + \lambda_{u^St+1}\sigma^j - U_{l,t+1}\right] \text{ for } j = p, g \tag{A7}$$

[wrt u^S_{t+1}]

$$\begin{aligned}\lambda_{u^St} = \beta E_t\{&\lambda_{ct+1}b + \lambda_{n^pt+1}\psi^{hpS}_{t+1}(1-s^S_{t+1}) + \lambda_{n^gt+1}\psi^{hgS}_{t+1}s^S_{t+1} \\ &+ \lambda_{u^St+1}\left[1-\xi-\psi^{hpS}_{t+1}(1-s^S_{t+1}) - \psi^{hgS}_{t+1}s^S_{t+1}\right] - U_{l,t+1}\}\end{aligned} \tag{A8}$$

[wrt u^L_t]

$$\lambda_{n^pt}\psi^{hpL}_t(1-s^L_t) + \lambda_{n^gt}\psi^{hgL}_t s^L_t + \lambda_{ct}b = U_{l,t} \tag{A9}$$

[wrt s_t^S]

$$(\lambda_{n^p t} - \lambda_{u^S t})\,\psi_t^{hpS} = (\lambda_{n^g t} - \lambda_{u^S t})\,\psi_t^{hgS} \tag{A10}$$

[wrt s_t^L]

$$\lambda_{n^p t}\psi_t^{hpL} = \lambda_{n^g t}\psi_t^{hgL} \tag{A11}$$

where $U_{l,t} \equiv \Phi l_t^{-\psi}$ is the marginal utility from leisure (labor market non-participation). Equations (A4)-(A6) are standard and include the arbitrage conditions for the returns to private consumption, private capital and bonds. Equation (A7) relates the expected marginal value from being employed to the after-tax wage, the utility loss from the reduction in leisure, and the continuation value, which depends on the separation probability. Equation (A8) associates the expected marginal value from being short term unemployed with the expected marginal values of being search active (rather than non-participating), $\lambda_{ct+1}b$, of being employed, $\lambda_{n^j t+1}$, weighted by the job finding probabilities, ψ_{t+1}^{hjS}, of being short term unemployed weighted by the respective probability, $\left[1-\xi-\psi_{t+1}^{hpS}(1-s_{t+1}^S)-\psi_{t+1}^{hgS}s_{t+1}^S\right]$, and finally to utility loss from the reduction in leisure. Equation (A9) states that the value of being search active (rather than non-participating), $\lambda_{ct}b$, plus the expected marginal values of being employed, $\lambda_{n^j t}$, weighted by the job finding probabilities, ψ_t^{hjL}, and the respective share of outside jobseekers should equal the marginal utility from leisure, $U_{l,t}$. Equations (A10)-(A11) are arbitrage conditions according to which the choice of shares s_t^S and s_t^L, is such that the expected marginal values of being employed, weighted by the job finding probabilities, are equal across the two types of employment. Notice that in the case of the share of short term unemployed seeking public employment the expected marginal values of being employed are net of the expected marginal value of being short term unemployed.

B Appendix: Derivation of the private wage

Substituting (15) and (21) in (26) we get:

$$(1-\vartheta)\frac{(1-\tau_n)}{(c_t^p+zc_t^g)^\eta}\left[x_t(1-\varphi)\frac{y_t}{n_t^p}-w_t^p+\frac{(1-\sigma^p)\kappa}{\psi_t^{fp}}\right]=\vartheta\left[\frac{(1-\tau_n)}{(c_t^p+zc_t^g)^\eta}w_t^p-U_{l,t}+(1-\sigma^p)\lambda_{n^p t}+\sigma^p\lambda_{u^I t}\right]$$

$$\Rightarrow w_t^p=(1-\vartheta)\left[x_t(1-\varphi)\frac{y_t}{n_t^p}+\frac{(1-\sigma^p)\kappa}{\psi_t^{fp}}\right]-\frac{\vartheta\,(c_t^p+zc_t^g)^\eta}{(1-\tau_n)}\left[-U_{l,t}+(1-\sigma^p)\lambda_{n^p t}+\sigma^p\lambda_{u^I t}\right]$$

Using (28) we get:

$$\Rightarrow w_t^p = (1-\vartheta)\left[x_t(1-\varphi)\frac{y_t}{n_t^p} + \frac{(1-\sigma^p)\kappa}{\psi_t^{fp}}\right] - (1-\sigma^p)\frac{(1-\vartheta)\kappa}{\psi_t^{fp}} - \frac{\vartheta\left(c_t^p + zc_t^g\right)^{\eta}\left[-U_{l,t} + +\sigma^p\lambda_{u^I t}\right]}{(1-\tau_n)}$$

$$\Rightarrow w_t^p = (1-\vartheta)x_t(1-\varphi)\frac{y_t}{n_t^p} - \frac{\vartheta\left(c_t^p + zc_t^g\right)^{\eta}\left[-U_{l,t} + +\sigma^p\lambda_{u^I t}\right]}{(1-\tau_n)}$$

Using (A9) it follows:

$$\Rightarrow w_t^p = (1-\vartheta)x_t(1-\varphi)\frac{y_t}{n_t^p} - \frac{\vartheta\left(c_t^p + zc_t^g\right)^{\eta}}{(1-\tau_n)}\left[-\left(\lambda_{n^p t}\psi_t^{hpO}(1-s_t^O) + \lambda_{n^g t}\psi_t^{hgO}s_t^O + \lambda_{ct}b\right) + \sigma^p\lambda_{u^I t}\right]$$

Using (A11) we get:

$$\Rightarrow w_t^p = (1-\vartheta)x_t(1-\varphi)\frac{y_t}{n_t^p} - \frac{\vartheta\left(c_t^p + zc_t^g\right)^{\eta}}{(1-\tau_n)}\left(-\lambda_{n^p t}\psi_t^{hpO} - \lambda_{ct}b + \sigma^p\lambda_{u^I t}\right)$$

Using (A4) we get:

$$\Rightarrow w_t^p = (1-\vartheta)x_t(1-\varphi)\frac{y_t}{n_t^p} + \frac{\vartheta b}{(1-\tau_n)} + \frac{\vartheta\lambda_{n^p t}\psi_t^{hpO}}{(1-\tau_n)\left(c_t^p + zc_t^g\right)^{-\eta}} - \frac{\vartheta\sigma^p\lambda_{u^I t}}{(1-\tau_n)\left(c_t^p + zc_t^g\right)^{-\eta}}$$

Using (28) we get:

$$\Rightarrow w_t^p = (1-\vartheta)x_t(1-\varphi)\frac{y_t}{n_t^p} + \frac{\vartheta b}{(1-\tau_n)} + \frac{(1-\vartheta)\kappa}{\psi_t^{fp}}\psi_t^{hpO} - \frac{\vartheta\sigma^p\lambda_{u^I t}}{(1-\tau_n)\left(c_t^p + zc_t^g\right)^{-\eta}}$$

$$\Rightarrow w_t^p = (1-\vartheta)\left[x_t(1-\varphi)\frac{y_t}{n_t^p} + \frac{\kappa}{\psi_t^{fp}}\psi_t^{hpO}\right] + \frac{\vartheta b}{(1-\tau_n)} - \frac{\vartheta\sigma^p\left(c_t^p + zc_t^g\right)^{\eta}\beta E_t V_{u^I t+1}^H}{(1-\tau_n)}$$

C Appendix: Steady state calculations and calibration

C.1 Labor market variables

We calibrate the labor-force participation rate, the unemployment rate, and the share of public employment in total employment to match the observed average values from the data for the

US ($1-l=0.65$, $\frac{u}{n+u}=0.06$, $\frac{n^g}{n}=0.16$). Then we get u, n, $\frac{n^p}{n}$, n^p, n^g as follows:

$$u=\frac{u}{n+u}(n+u)\overset{(1)}{=}\frac{u}{n+u}(1-l)$$

$$n=1-l-u$$

$$\frac{n^p}{n}=1-\frac{n^g}{n}$$

$$n^j=\frac{n^j}{n}n$$

We set the following values for the separation rates, $\sigma^p=0.025$ and $\sigma^g=0.018$. Then we get m^j from:

$$m^j=\sigma^j n^j$$

Following Shimer (2010), we calibrate the private job finding rate, ψ^{hp} to be equal to 0.83. According to Barnichon and Figura (2011) having an unemployment spell lasting six months reduces ψ^{hp} by $1-1.5\%$ points. Hence assuming that the long-term unemployed have a 1.5% lower job finding probability than the short-term unemployed, i.e. $\frac{\psi^{hpS}}{\psi^{hpL}}=1.015$ and the definition of the aggregate private job finding rate we get:

$$\psi^{hp}=\psi^{hpL}+\psi^{hpS}\Rightarrow\psi^{hpL}=\frac{\psi^{hp}}{1+\frac{\psi^{hpS}}{\psi^{hpL}}}\quad\text{and}\quad\psi^{hpS}=\frac{\psi^{hpS}}{\psi^{hpL}}\psi^{hpL}$$

Also by definition:

$$u^p=\frac{\psi^{hp}}{m^p}$$

$$u^g=u-u^p$$

$$\psi^{hg}=\frac{m^g}{u^g}$$

Assuming that $\frac{\psi^{hgS}}{\psi^{hgL}}=\frac{\psi^{hpS}}{\psi^{hpL}}$ and the definition of the aggregate public job finding rate we get:

$$\psi^{hg}=\psi^{hgL}+\psi^{hgS}\Rightarrow\psi^{hgL}=\frac{\psi^{hg}}{1+\frac{\psi^{hgS}}{\psi^{hgL}}}\quad\text{and}\quad\psi^{hgS}=\frac{\psi^{hgS}}{\psi^{hgL}}\psi^{hgL}$$

Since there is no exact estimate for the value of the private vacancy-filling probability, ψ^{fp}, in the literature, we use what is considered as standard by setting it equal to 0.54 and then we

assume that $\psi^{fp} = \psi^{fg}$. Hence,, we get θ^j, υ^p:

$$\theta^j = \frac{\psi^{hj}}{\psi^{fj}} \quad \text{[see (6) after using (4)-(5)]}$$

$$\upsilon^j = \theta^j u^j$$

Long-term unemployment, defined as the share of unemployed with a spell lasting longer than 27 weeks, represents 16% of total unemployment according to CPS data, i.e. $\frac{u^L}{u} = 0.16$, so we get:

$$\frac{u^S}{u} = 1 - \frac{u^L}{u}$$

$$u^L = \frac{u^L}{u} u \quad \text{and} \quad u^S = \frac{u^S}{u} u$$

The matching elasticity, α, is set, by the Hosios condition, equal to the bargaining power, ϑ, which takes the value 0.6. Divinding m_t^{pS} by m_t^{gS} implies:

$$\frac{u^{gS}}{u^{pS}} = \frac{\upsilon^p}{\upsilon^g}\left(\frac{\psi^{hgS}}{\psi^{hpS}}\right)^{1/\alpha} \quad \text{and} \quad \frac{u^{gL}}{u^{pL}} = \frac{\upsilon^p}{\upsilon^g}\left(\frac{\psi^{hgL}}{\psi^{hpL}}\right)^{1/\alpha} \quad \text{see (4)-(5) after using (6)}$$

$$u^S = u^{pS} + u^{gS} \Rightarrow u^{pS} = \frac{u^S}{1 + \frac{u^{gS}}{u^{pS}}} \quad \text{and} \quad u^L = u^{pL} + u^{gL} \Rightarrow u^{pL} = \frac{u^L}{1 + \frac{u^{gL}}{u^{pL}}}$$

$$u^{gS} = u^S - u^{pS} \quad \text{and} \quad u^{gL} = u^L - u^{pL}$$

Then the matching efficiencies are given by:

$$\rho_m^S = \psi^{hpS}\left(\frac{u^{pS}}{\upsilon^p}\right)^{\alpha} \quad \text{and} \quad \rho_m^L = \psi^{hpL}\left(\frac{u^{pL}}{\upsilon^p}\right)^{\alpha} \quad \text{[see (4) after using (6)]}$$

The probability of a short-term unemployed becoming in the next period long-term unemployed, ξ, is determined by (3) in the steady state:

$$\xi = \psi^{hp}\frac{u^p}{u^S} + \psi^{hg}\frac{u^g}{u^S} - \psi^{hpS}\frac{u^{pS}}{u^S} - \psi^{hgS}\frac{u^{gS}}{u^S} \quad \text{[see (3) after using (2) and (6)]}$$

C.2 Other Parameters and Steady State Relations

We set the capital depreciation rates, δ^j, equal to 0.025. Then we derive $\frac{i^p}{k^p}$, $\frac{i^g}{k^g}$:

$$\frac{i^j}{k^j} = \delta^j \quad \text{[see (10) and (30)]}$$

Following the literature, we set the discount factor, β, equal to 0.99. The initial tax rates are calibrated to match the actual tax rates in the U.S. Using the method outlined in Mendoza, Razin and Tesar (1994) we calculate average tax rates for the United States using OECD data. For the period 1990-96, the capital income tax rate averaged 40%, while the labor income tax rate averaged 27%. Next, we get r^p and R from:

$$r^p = \frac{1}{(1-\tau_k)}\left(\frac{1}{\beta} - 1\right) + \delta^p \quad \text{[see (A5)]}$$

$$R = \frac{1}{\beta} \quad \text{[see (A6)]}$$

The elasticity of demand for intermediate goods, ε, is set equal to 6, which implies a gross steady-state markup, $\frac{\varepsilon}{\varepsilon-1}$, equal to 1.1, and the price of the final good is normalized to one. Then x is determined by:

$$x = \frac{\varepsilon - 1}{\varepsilon} \quad \text{[see (25)]}$$

We set the private capital share in the production function equal to 0.36, and the shares of public employment and public capital, μ and ν, equal to 0.2. Then we obtain $\frac{y^p}{k^p}$ by:

$$\frac{y}{k^p} = \frac{r^p}{\varphi x} \quad \text{[see (19)]}$$

Using data from Kamps (2006), available at http://www.ifw-kiel.de/forschung/datenbanken/netcap, we set $\frac{k^g}{k^p} = 0.31$ equal to the mean value for 1970-2002. Since we restrict our case to a deterministic steady state, we normalize the productivity shock to one. Then k^p is determined by:

$$k^p = \left[\frac{y}{k^p}\left(n^p\right)^{-(1-\varphi)}\left(n^g\right)^{-\mu}\left(\frac{k^g}{k^p}\right)^{-\nu}\right]^{\frac{1}{\varphi+\nu-1}} \quad \text{[see (16)]}$$

and so we get i^p, y, k^g, and i^g:

$$i^p = \frac{i^p}{k^p}k^p, \quad y = \frac{y}{k^p}k^p \quad \text{and} \quad k^g = \frac{k^g}{k^p}k^p$$

$$i^g = \frac{i^g}{k^g}k^g$$

Following Hagedorn and Manovskii (2008), Gali (2011), and Brückner and Pappa (2012), we calibrate the cost of posting a vacancy, κ, by targeting vacancy costs per filled job as a fraction of the real private wage, $\frac{\kappa}{w^p}$, choosing 0.045 as a target as in Gali (2011). Also, we set the replacement rate, $\frac{b}{w^p}$, equal to 0.3 (in accordance with the range [0.2, 0.4] in Petrongolo and

Pissarides, 2001). Then, we can get w^p:

$$w^p = x(1-\varphi)\frac{y}{n^p}\left(1+\frac{\sigma^p}{\psi^{fp}}\frac{\kappa}{w^p}\right)^{-1} \quad \text{[see (20)]}$$

and it follows that κ and b are given by:

$$\kappa = \frac{\kappa}{w^p}w^p$$

$$b = \frac{b}{w^p}w^p$$

We set the public-wage premium and the output share of public consumption spending equal to the observed average values from the data, $\pi^w = 1.16$ and $\frac{c^g}{y} = 0.165$. It follows that:

$$w^g = \pi^w w^p$$

$$c^g = \frac{c^g}{y}y$$

$$c^p = y - i^p - c^g - i^g - \kappa(v^p + v^g) \quad \text{[see (36)]}$$

From the government budget constraint we can compute the lump-sum taxes and so the government deficit:

$$T = c^g + i^g + w^g n^g + bu + \kappa v^g - \tau_k(r^p - \delta^p)k^p - \tau_n(w^p n^p + w^g n^g) \quad \text{[see (24)]}$$

$$\Rightarrow DF = c^g + i^g + w^g n^g + bu + \kappa v^g - T - \tau_k(r^p - \delta^p)k^p - \tau_n(w^p n^p + w^g n^g)$$

We set the intertemporal elasticity of substitution, $\frac{1}{\eta}$, equal to 1, the Frisch elasticity of labor supply, $\frac{1}{\psi}$, equal to 0.25 (in the range of Domeij and Floden, 2006). Then we get:

$$\frac{\lambda_{n^p}}{\lambda_c} = \frac{(1-\vartheta)\kappa(1-\tau_n)}{\vartheta\psi^{fp}} \quad \text{[see (28)]}$$

$$\frac{\lambda_{u^S}}{\lambda_c} = \frac{1}{\sigma^p}\left\{\frac{(1-\tau_n)}{\vartheta}\left[-w^p + (1-\vartheta)\left(x(1-\varphi)\frac{y}{n^p} + \frac{\kappa}{\psi^{fp}}\psi^{hpL}\right)\right] + b\right\} \quad \text{[see (29)]}$$

and then from the household's FOCs at the steady state:

$$\frac{\lambda_{u^S}}{\lambda_{n^p}} = \frac{\psi^{hpS}(1-s^S) - \psi^{hpL} + \frac{\psi^{hpL}}{\psi^{hgL}}\psi^{hgS}s^S}{\frac{1}{\beta} - 1 + \xi + \psi^{hpS}(1-s^S) + \psi^{hgS}s^S} \quad \text{[see (A8) after using (A9), (A11)]}$$

$$\lambda_{n^p} = \frac{\lambda_{n^p}}{\lambda_{u^S}}\lambda_{u^S}$$

$$\lambda_c = \frac{\lambda_c}{\lambda_{n^p}} \lambda_{n^p}$$

$$z = \left[\frac{1}{(\lambda_c)^{1/\eta}} - c^p \right] \frac{1}{c^g} \quad \text{[see (A4)]}$$

$$\Phi = \left(\lambda_{n^p} \psi^{hpL} + \lambda_c b \right) l^{\psi} \quad \text{[see (A9) after using (A11)]}$$

Finally, the model's steady state is independent of the degree of price rigidities, the monetary policy rule, and the size of the capital adjustment costs. We set the probability that a firm does not change its price within a given period, χ, equal to 0.75, the Taylor rule coefficient, ζ_π, equal to 1.5 and the adjustment costs parameter, ω, equal to 2.