Spending-based fiscal consolidations and their effects on output and unemployment

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Abstract

We compare the output and unemployment effects of four types of government spending cuts in the US, Canada, Japan, the UK and the Euro area. Shocks are identified in a SVAR using sign restrictions extracted from a New-Keynesian model with matching frictions in the public and private sector, endogenous labor force participation and heterogeneous unemployed jobseekers. Government employment cuts are associated with the highest output losses for all countries, all samples and all identification schemes. This is because a government employment shock generates an additional wealth effect: it induces a fall in the number of working members of the household that yields a crowding out of private consumption and investment. Government wage cuts are the least destructive mean for fiscal adjustments that typically reduces unemployment.

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Key Words: Search and matching frictions, Government vacancies, Government wages, Fiscal shocks, Labor force participation, VARs, Sign restrictions.

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1 Introduction

How does an economy react to a fiscal consolidation? This question has become central in academic and policy circles over the last three years. The recovery from the financial crisis has been rather slow and fragile in many regions of the world economy. Growth in the industrial countries was throttled by the excessive government debt and the financial crisis transformed into a fiscal crisis, particularly in the euro area. The rise in government debt and the higher risk perception by financial markets have triggered a crisis of public budgets. The increase was linked to the financial crisis that led to a decrease in public revenues. In addition, fiscal stimulation measures during the offset of the crisis have raised government debt and many countries were obliged to cut spending items from their budget and increase the tax rates so as to decrease government deficits.

Fiscal consolidations are usually expected to imply short-term contractionary effects on output, given the Keynesian positive fiscal spending multiplier. In the empirical literature the effects of fiscal shocks typically depend on the methodology used to extract them from the data 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), and Burnside et al. (2004) 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, generating multipliers lower than one. 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), Perotti (2002), Fatás and Mihov (2001), Galí et al. (2007) among others), concludes that private consumption, output, employment and the real wage positively comove with the spending shock and estimated multipliers usually vary in the range of (0.8, 1.2)\(^1\). 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. The evidence that this literature produces is somewhat mixed, but a reconciliation offered by Caldara and Kamps (2008) suggests that shocks to government expenditure tend to increase employment and real wages and to generate output multipliers higher than one, while tax shocks are associated with higher tax multipliers.

Theoretical models have hard time to generate significant aggregate demand effects af-

\(^1\)Perotti (2007) reconciles the results in the two strands of literature.
ter government spending expansions. Hall (2009) and Woodford (2011) use simple analytical frameworks within the mainstream New Keynesian paradigm to understand the effects of government spending and the assumptions necessary to generate high output multipliers. Coenen et al. (2012) perform similar exercises in seven large-scale models used by policy institutions in the developed world. Finally, Christiano et al. (2009) focus on the interactions between expansionary fiscal policy and the zero bound constraint on monetary policy as a mechanism for producing considerable demand effects from government spending shocks.

Recently, Alesina et al. (2012) suggest that the output effects of fiscal adjustments depend on how the consolidation occurs. They show that fiscal adjustments based upon spending cuts are much less costly in terms of output losses than tax based ones. Using multi-year fiscal consolidation data collected by Devries at al (2011) for the period 1980-2005 they show that spending-based adjustments have been associated with mild and short-lived recessions and, in many cases with no recession at all, while tax-based adjustments have been followed but prolonged and deep recessions. On the other hand, Erceg and Linde (2012) focus on the interactions between fiscal consolidation and monetary policy and using a two-country DSGE model of a monetary union show that the effects of tax-based versus expenditure-based consolidations depend on the degree of monetary accommodation.

All the existing analysis considers general cuts in government expenditures. But, are all components equally harmful in reducing demand, or is there a lever which is stronger for a given amount spent by the government? With the exception of Pappa (2009), the focus of the analysis has been on the effects of government expenditure shocks.² Moreover, most of the existing analysis concentrates on the output losses from fiscal adjustments and neglects the effects of fiscal consolidations on unemployment. Given the rise in unemployment after the crisis in both the US and Europe studying the effects of such cuts on unemployment is fundamental. The purpose of this paper is to compare the output and unemployment losses generated by a government (a) consumption, (b) investment, (c) employment and (d) government wage shock in order to assess which spending component is the most painless to cut. The analysis focuses on the US but to robustly infer we also look at other four OECD countries for which we have data (Canada, Japan, UK and Euro area). 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 when relevant.

In the empirical analysis we use a structural VAR and identify fiscal shocks via sign re-

²Auerbach and Gorodnichenko (2012) also distinguish between different types of government spending, but do not consider government employment and wage shocks.
restrictions derived from theory. To this end we build a general Dynamic Stochastic General Equilibrium (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 the public sector. We examine the responses of macrovariables to government consumption, investment, vacancies and wages disturbances in the model and show that for a wide range of parameterizations a negative shock to the various components of government spending decreases total output for some periods after the shock and the deficit on impact, while tax revenues have a low or slightly negative correlation with the shock on impact. These restrictions distinguish fiscal shocks from other shocks, such as TFP or interest rate shocks, since those induce a negative correlation between deficits and output on impact. On the other hand, public wage cuts robustly decrease the deficit and the wage bill on impact, but increase output with a lag, while TFP and interest rate shocks increase deficits and decrease both output and the government wage bill. Hence, to identify fiscal shocks in the data, we restrict the contemporaneous response of the deficit and the lagged response of output to positively comove with the fiscal disturbance for government consumption, investment and employment shocks and we restrict the contemporaneous responses of the deficit and the wage bill to negatively comove with the lagged output response for government wage shocks. Since tax hikes might also reduce output and deficits, we require a zero or slightly positive correlation between the identified shock and tax revenues on impact. Once shocks are identified, we compute output and unemployment multipliers to quantify the losses associated with the different spending cuts.

Our methodology gives similar results with the existing literature when we identify government spending shocks as shocks to total government expenditure. Yet, when we split government spending into different components we find that multipliers differ for different items of the government’s budget: government employment shocks generate the largest output and unemployment losses, regardless of the sample and the country and government wage cuts have expansionary effects. In the US, upon a one dollar fall in total government expenditure output falls by 1.97 dollars and unemployment rises by 0.2 percentage points, while a one dollar reduction in government consumption, investment, and wage bill expenditures coming from a decrease in public employment, decreases output on impact by 1.59, 2.58, and 4.47, and increases unemployment by 0.30, 0.26 and 0.30 percentage points, respectively; while a one dollar fall in wage bill expenditure stemming from a cut in public wages increases output on impact by 1.10 dollars and reduces unemployment by 2.06 percentage points.

The fact that cuts in government employment are more harmful than cuts in government
consumption is intuitive. But, how can one explain the fact that government employment cuts can be more contractionary than cuts in government investment? The theoretical model we developed suggests that in addition to the standard wealth effect that decreases the labor supply and the labor demand effect produced by the assumption of price rigidities, government investment and employment cuts also produce a negative wealth effect since they may decrease the productivity of private inputs. This latter effect adds persistence to the responses with respect to both shocks. Furthermore, there is an additional channel at work for government employment shocks: Decreases in public vacancies decrease the number of employed members of the household and generate a negative wealth effect that suppresses demand for both consumption and investment with a delay, propagating the initial restraint. Our model also predicts that wage cuts are expansionary since they reallocate labor supply from the public to the private sector. As a result, the private real wage falls and private employment increases generating increases in private output and reducing unemployment. The data confirm our theoretical predictions as the identified shocks to the government wage reduce the real wage and increase private employment, reducing substantially the unemployment rate.

We have examined the sensitivity of our results to different identification schemes, different sample periods, and the inclusion of different variables in the VAR and the conclusions hold unchanged. The facts we uncover are useful to policymakers in a number of ways. First, estimating the output losses of total government spending cuts might be misleading since, the analysis of specific government spending components cuts reveals that different items of the budget affect differently the macroeconomy. Second, results highlight that unexpected contractions in government employment are the most harmful tool for cutting the budget in terms of output losses. Contrary to the common wisdom, government investment cuts do not generate stronger output effects at the horizons of interest. However, since they are likely to decrease labor productivity and private investment more than government consumption shocks, they enjoy important long run implications. Third, while the evidence is mixed concerning consumption and investment cuts, the contractionary effects of government employment shocks have been significantly amplified during the last two decades in all countries. Thus, even from a historical perspective, using unexpected government employment cuts to balance the budget can generate deep and prolonged recessions. Fourth, our model gives some guidance in explaining changes in the transmission of government employment and wage shocks: decreases in the replacement rates and in public job protection increase the size of the government employment multiplier and make government employment cuts more destructive. Also, decreases in replace-
death rates reduce the expansionary effects of government wage cuts. As Gnocchi and Pappa (2012) indicate, some countries we consider have experienced significant changes in employment protection and non-employment benefits that can explain the increasing importance of government employment on output fluctuations over the last three decades. Fifth, government wage cuts is the least destructive instrument a government has for reducing the budget since through workers reallocation between sectors it increases employment and production. Finally, in terms of unemployment increases cutting public wages is much more preferable than cutting any other item of the government’s budget, since the combination of the negative wealth effect that reduces labor force participation and the relative increase in private labor supply reduces substantially the unemployment rate of the economy.

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 and Section 5 studies their robustness. Section 6 investigates how we can reconcile the empirical evidence with our model and Section 7 concludes.

2 Identifying fiscal shocks: The methodology

The methodology to extract fiscal shocks in the data involves four steps. In the first step, we establish that in theory shocks to government expenditures for consumption, investment and public vacancies induce comovements of the deficit and lagged output for a wide range of parameterizations of the model. In the second step, we show that the restrictions used to identify fiscal shocks cannot be produced by other shocks and in the third step how model-based restrictions can be used to identify fiscal shocks in the data. In the final step we compute the magnitude of the output 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 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 final good; (iii) 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.\footnote{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 in the data.}

2.1.1 Public employment, participation, and heterogeneity of unemployment

The process through which workers and firms find each other in the labor market is represented by a matching function that accounts for imperfections and transaction costs. 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 advantageous in the job-searching process. Long and short term unemployed in turn can belong in two separate pools: public and private unemployment.

In particular, at any point in time a fraction \( n^p_t \) (\( n^g_t \)) of the representative household’s members are private (public) employees, a fraction \( u^S_t \) (\( u^L_t \)) are short (long) term unemployed but actively searching, and a fraction \( l_t \) are out of the labor force, so that:

\[
n^p_t + n^g_t + u^S_t + u^L_t + l_t = 1
\]  

(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 \( s^S_t \) (\( s^L_t \)) of the short (long) term unemployed looks for a public job, while the remainder part, \( 1 - s^S_t \) (\( 1 - s^L_t \)), 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 \( \sigma^j \) and a measure \( m^j \) of new matches are formed. The evolution of each type of employment is thus given by:

\[
n^j_{t+1} = (1 - \sigma^j) n^j_t + m^j_t
\]

(2)

where we assume that in general \( \sigma^p > \sigma^g \) in order to capture the fact that, relatively speaking, public employment is more permanent than private employment, which is a feature that makes...
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:

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

where $m_t^j$ denote matches for short term unemployed in each sector. The aggregate matches of each type of employment are given by:

$$m_t^p = \rho^p_m (v_t^p)^{\alpha} \left[ (1 - s_t^S) u_t^S \right]^{1-\alpha} \left( m_t^S \right)$$

$$m_t^g = \rho^g_m (v_t^g)^{\alpha} \left[ s_t^S u_t^S \right]^{1-\alpha} \left( m_t^S \right)$$ \hspace{1cm} (4)$$

$$m_t^p = \rho^p_m (v_t^p)^{\alpha} \left[ (1 - s_t^L) u_t^L \right]^{1-\alpha} \left( m_t^L \right)$$

$$m_t^g = \rho^g_m (v_t^g)^{\alpha} \left[ s_t^L u_t^L \right]^{1-\alpha} \left( m_t^L \right)$$ \hspace{1cm} (5)$$

where we assume that the matching efficiency is higher for the short rather than the long term unemployed, i.e. $\rho^S_m > \rho^L_m$, and $v_t^j$ for $j = g, p$ denotes vacancies in the two sectors. 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, $\psi_t^{hp}$ ($\psi_t^{hpL}$), and of a vacancy being filled, $\psi_t^{fj}$:

$$\psi_t^{hp} = \frac{m_t^p}{(1 - s_t) u_t^s}, \quad \psi_t^{hpS} = \frac{m_t^p}{s_t u_t^s}$$

$$\psi_t^{hpL} = \frac{m_t^p}{(1 - s_t^L) u_t^L}, \quad \psi_t^{fj} = \frac{m_t^j}{v_t^j}$$ \hspace{1cm} (6)$$

$$\psi_t^{hp} = \frac{m_t^p}{s_t u_t^s}, \quad \psi_t^{hpS} = \frac{m_t^p}{s_t^S u_t^S}$$

$$\psi_t^{hpL} = \frac{m_t^p}{s_t^L u_t^L}, \quad \psi_t^{fj} = \frac{m_t^j}{v_t^j}$$ \hspace{1cm} (7)$$
Finally, market tightness for each sector is defined as:

\begin{equation}
\theta^p_t \equiv \frac{\nu^p_t}{(1 - s^p_t)u^p_t + (1 - s^L_t)u^L_t}, \quad \theta^g_t \equiv \frac{\nu^g_t}{s^p_t u^p_t + s^L_t u^L_t}.
\end{equation}

### 2.1.2 Household’s behavior

The representative household is infinitely lived and derives utility from private consumption, $c^p_t$, the public good, $y^g_t$, which is taken as exogenous, and the fraction of members that are out of the labor force and enjoy leisure, $l_t$:

\begin{equation}
U(c^p_t, y^g_t, l_t) = \left( \frac{c^p_t + z^p y^g_t}{1 - \eta} \right)^{1-\eta} + \Phi \left( \frac{1}{1 - \psi} \right)
\end{equation}

where $\frac{1}{\eta}$ is the intertemporal elasticity of substitution, $\Phi > 0$ is a preference parameter related to leisure, $z \geq 0$ determines the size of the utility gains from the consumption of the public good and $\psi$ is the inverse of the Frisch elasticity of labor supply, while $\gamma$ denotes the proportion of the public good that is dedicated to utility enhancing purposes.

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

\begin{equation}
k^p_{t+1} = i^p_t + (1 - \delta^p)k^p_t - \frac{\omega}{2} \left( \frac{k^p_{t+1}}{k^p_t} - 1 \right)^2 k^p_t
\end{equation}

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

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

\begin{equation}
c^p_t + i^p_t + \frac{p^g_t}{p_t} y^g_t + \frac{B_{t+1}}{p_t R_t} \leq [r^p_t - \tau_k(r^p_t - \delta^p)] k^p_t + (1 - \tau_n)(w^p_t n^p_t + w^g_t n^g_t) + bu_t + \frac{B_t}{p_t} + \Pi^p_t - T_t
\end{equation}

where $p_t$ is the price level, $p^g_t$ is the price of the public good, $w^j_t$, $j = p,g$ is the real wage for the two types of employment, $r^p_t$ is the real return to private capital, $b$ denotes unemployment benefits, $R_t$ is the gross nominal interest rate, and $\Pi^p_t$ are the profits of the monopolistically competitive firms (see below). Finally, $\tau_k, \tau_n$ 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 $c^p_t, y^g_t, u^L_t, s^L_t, s^S_t, u^S_t, n^p_{t+1}, n^g_{t+1}$,
$k_{t+1}$, $B_{t+1}$ so as to maximize its expected lifetime utility subject to (1), (2), (3), (6), (10), and (11):

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

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

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

The first-order conditions from the household’s maximization problem are in the Appendix.

The expected marginal value to the household of having an additional member privately employed, $V_{n_{t+1}}^H$, is:

$$V_{n_{t+1}}^H = (c_t^p + z \gamma y_t^g)^{-\eta} (1 - \tau_n) u_{t,t}^p - U_{t,t} + (1 - \sigma^p) \lambda_{w_{t,t}} + \sigma^p \lambda_{u_{t,t}}$$

According to (15), $V_{n_{t+1}}^H$ 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 $\sigma^p$.

### 2.1.3 The production side

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

$$y_t^p = (\varepsilon_t^A n_t^p)^{1-\phi} (k_t^p)^\phi [(1 - \gamma) y_t^g]^{\nu} \tag{16}$$

where $\varepsilon_t^A$ is an aggregate technology shock, $k_t^p$ and $n_t^p$ are private capital and labor inputs, and $(1 - \gamma) y_t^g$ is the proportion of the public good used in productive activities, taken as exogenous by the firms. The parameter $\nu$ regulates how the public input affects private production: when $\nu$ 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, $v_t^p$, so as to employ the desired number of
workers next period, \( n_{t+1}^{p} \). 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 \( \nu_{t}^{p} \) to maximize:

\[
Q^{p}(n_{t}^{p}, k_{t}^{p}) = \max_{k_{t}^{p}, \nu_{t}^{p}} \left\{ x_{t}(A_{t}n_{t}^{p})^{1-\varphi}(k_{t}^{p})^{\varphi}((1-\gamma)g_{t}^{p})^{\nu} - w_{t}^{p}n_{t}^{p} - r_{t}^{p}k_{t}^{p} - \kappa \nu_{t}^{p} + E_{t} [\Lambda_{t,t+1}Q^{p}(n_{t+1}^{p}, k_{t+1}^{p})] \right\}
\]

(17)

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

\[
n_{t+1}^{p} = (1-\sigma_{p})n_{t}^{p} + \psi_{t}^{fp} \nu_{t}^{p}
\]

(18)

The first-order conditions are:

\[
x_{t}\varphi \left( \frac{e_{t}^{A}n_{t}^{p}}{k_{t}^{p}} \right)^{1-\varphi} [(1-\gamma)g_{t}^{p}]^{\nu} = r_{t}^{p}
\]

(19)

\[
\frac{\kappa}{\psi_{t}^{fp}} = E_{t} \Lambda_{t,t+1} \left[ x_{t+1}(1-\varphi)(e_{t+1}^{A})^{1-\varphi} \left( \frac{h_{t+1}^{p}}{n_{t+1}^{p}} \right)^{\varphi} [(1-\gamma)g_{t+1}^{p}]^{\nu} - w_{t+1}^{p} + \frac{(1-\sigma_{p})\kappa}{\psi_{t+1}^{fp}} \right]
\]

(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 \( \sigma_{p} \) the match can be destroyed.

The expected value of the marginal job for the intermediate firm, \( V_{n_{it}}^{F} \) is:

\[
V_{n_{it}}^{F} = \frac{\partial Q^{p}}{\partial n_{t}^{p}} = x_{t}(1-\varphi)\frac{y_{t}^{p}}{n_{t}^{p}} - w_{t}^{p} + \frac{(1-\sigma_{p})\kappa}{\psi_{t}^{fp}}
\]

(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

\footnote{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.}
$y_{it}$ be the quantity of output sold by retailer $i$. Final goods can be expressed as:

$$y_i^p = \left[ \int_0^1 (y_{it}^p)^{\frac{1}{\varepsilon - 1}} \, dt \right]^{\frac{\varepsilon - 1}{\varepsilon}}$$  \hspace{1cm} (22)

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

$$y_{it}^p = \left( \frac{p_t}{p_i} \right)^{-\varepsilon} y_t^p$$  \hspace{1cm} (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:

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

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

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

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

$$p_{it}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} x_{t+s} y_{it+s}^p}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t+s} y_{it+s}^p}$$  \hspace{1cm} (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 $\vartheta \in (0, 1)$ is the firms’ bargaining power, the problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^i} \left\{ \max \left\{ (1 - \vartheta) \ln V_{nH}^t + \vartheta \ln V_{nF}^t \right\} \right.$$
where $V_{n^p t}^H$ and $V_{n^p t}^F$ have been defined above. The optimization problem leads to:

$$(1 - \vartheta)(1 - \tau_n) (\epsilon_t^p + z\gamma y_t^g)^{-\eta} V_{n^p t}^F = \vartheta V_{n^p t}^H$$

(26)

Solving (26) for $w_t^p$, using the households FOC results in:

$$w_t^p = (1 - \vartheta) \left[ x_t (1 - \varphi) \frac{y_t^p}{n_t^p} + \frac{k}{\psi_t^p} S_p \phi \right] + \frac{\vartheta}{(1 - \tau_n)} \left[ b - \sigma \beta E_{t+1} V_{n^p t+1}^H \right]$$

(27)

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 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 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 the public good using public capital and labor:

$$y_t^g = (\xi_t^A m_t^g)^{1-\mu} (k_t^g)^\mu$$

(28)

where we assume that productivity shocks are not sector specific and where $\mu$ is the share of public capital in the public production. The production of the public good is split between productive and utility enhancing activities and we denote by $\gamma$ the share of public good dedicated to utility enhancing activities. The price of the public good, $p_t^g$, is flexible and determined by its demand.

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

\footnote{The derivation is presented in Appendix B.}
government capital stock evolves according to:

$$k_{t+1}^g = \delta_k^g + (1 - \delta^g)k_t^g - \frac{\omega}{2} \left( \frac{k_{t+1}^g}{k_t^g} - 1 \right)^2 k_t^g \tag{29}$$

Vacancies posted by the government are exogenous and are associated with a vacancy cost $\kappa$. 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 we assume that is set according to (see also Gomes (2012) and Michaillat (2012)):

$$w_t^g = \pi_w w_t^p + \varepsilon_t^{w_g} \tag{30}$$

where $\pi_w$ is the public-wage premium and $\varepsilon_t^{w_g}$ is a shock in the public wage.

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

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

and the government budget constraint is defined by:

$$B_t + P_t DF_t = R_t^{-1} B_{t+1} \tag{31}$$

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:

$$T_t = \overline{T} \exp(\zeta_T (B_t - \overline{B})) \tag{32}$$

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

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

$$\Psi_t^g = \overline{\Psi} \left( \Psi_{t-1}^g \right)^{\theta_g^\Psi} \exp(\theta_g^{\psi_g} \Delta y_t - \varepsilon_t^{\psi_g}) \tag{33}$$

where $\Delta y_t$ is output growth and $\varepsilon_t^{\psi_g}$ 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:

$$ R_t = \bar{R} \exp(\zeta \pi_t + \epsilon^R_t) $$

(34)

where $\epsilon^R_t$ is a monetary policy shock and $\pi_t$ measures inflation in deviation from the steady state.

2.1.7 Closing the model

Private output must equal private and public demand. The resource constraint is given by:

$$ y^p_t = c^p_t + i^p_t + c^g_t + i^g_t + \kappa(\upsilon^p_t + \upsilon^g_t) $$

(35)

Total output, $y_t$, is given by

$$ y_t = y^p_t + p^g_t y^g_t $$

(36)

The model features six exogenous disturbances. The shocks to public vacancies and fiscal spending components, as described, the productivity, the public wage and the monetary policy shocks. The vector of the last three shocks, $S_t = [\epsilon^A_t, \epsilon^w_t, \epsilon^R_t]'$, is parameterized as:

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

(37)

where $V$ is a $(3 \times 1)$ vector of innovations, $I$ is a $(3 \times 3)$ identity matrix, $\rho$ is a $(3 \times 3)$ 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 $\rho$ are all less than one in modulus.

We solve the model by approximating the equilibrium conditions around non-stochastic 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. The derivation of the steady state relationships is in the appendix.

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2.2 Robust restrictions

This step 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 of interest that are representative of 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 \( \theta \) is employed, conditional on the shock \( x_t \). We let \( \theta \) be uniformly distributed over \( \Theta \), where \( \Theta = \prod_i \Theta_i \) is the set of (a-priori) admissible parameter values and \( \Theta_i \) is an interval for each parameter \( i \). We draw \( \theta_i^l, i = 1, \ldots, N \) from each \( \Theta_i \), 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 \( \text{sgn}(h_U^j(y_t(\theta|x_t))) = \text{sgn}(h_L^j(y_t(\theta|x_t))) \), where \( h_U^j \) and \( h_L^j \) are the 84 and 16 percentiles of the simulated distribution of \( h(y_t(\theta|x_t)) \).

Since we restrict the range of \( \Theta_i \) on the basis of theoretical and practical considerations and draw uniformly, our approach is intermediate between calib rating 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 (see also Canova and Paustian (2011)).

2.2.1 Parameter ranges

The model period is a quarter. We let \( \theta = (\theta_1, \theta_2) \), where \( \theta_1 \) represents the parameters which are fixed to a particular value, either to avoid indeterminacies or because of steady state considerations, while \( \theta_2 \) are the parameters which are allowed to vary. 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 0.64, the unemployment rate set equal to 6%, the share of public labor in total employment set 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 (See Table 1).

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.
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. For the share of public goods used for productive activities, \((1 - \gamma)\), we have allowed for specifications in which the public good is very productive to cases in which most of the government goods are utility enhancing.

The parameter \( \nu \) 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. 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-percent probability bands for the responses of the output, the deficit and the government wage bill to a one percent decrease in government consumption (first row), government investment (second row) public vacancies (third row), public wages (forth row), TFP (fifth row) and interest rate (last row) when parameters vary over the ranges reported in Table 1.

All the fiscal shocks, except for government wage shocks, robustly decrease total output one or more periods after the shock and the deficit on impact. A contractionary monetary policy and a negative technology shock move deficits in the opposite direction relative to the four fiscal disturbances. Hence, the deficit responses can be used to distinguish monetary policy and technology from shocks to government consumption, investment and employment since in both cases the output contraction results in higher deficits on impact. Therefore, in order to identify a shock in those components we restrict the responses of each component, total output and deficit to positively correlate for two periods after the shock and on impact, respectively. Next, the government wage bill, \( w_n^g \), robustly decreases on impact after a shock in public vacancies and wages. To distinguish the two types of shocks to the government wage bill it is enough to impose that output and the government wage bill move in the same direction for government vacancy shocks and in the opposite direction for government wage shocks. Notice that by adopting those restrictions the shock in government wages cannot be confused with a productivity or an interest rates shock, since for these shocks output and the wage bill comove.
Finally, since tax hikes might also contract 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 cuts and tax hike shocks.

In Table 2 we report the probability that at least one of the three sign restrictions we used to identify shocks is violated for the six shocks considered. Obviously, the probability of adopting false restrictions is very low for all identified fiscal shocks. Instead, for the other shocks the probability of identifying a false shock using the same restrictions is very high.

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) the government wage bill expenditure, the log of real per-capita net tax revenues, the log of average real private wage per job\(^6\), the log of total employment, the unemployment rate, the labor force participation rate and a measure of a short term interest rate. Ideally we should use series for government employment instead of the government wage bill in our VAR exercise in order to be consistent with the theoretical vacancy shocks. We do run our VAR exercise using series for government employment in the section of robustness analysis, but to facilitate comparisons we use the VAR with the government wage bill as a benchmark.

We set the lag length of the VAR to two for the first three countries and to one for the short Euro data. 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 are unaffected by all of these changes. Finally, we use flat prior Bayesian techniques for the responses to compute the point estimates and the credible intervals.

\(^6\)For the real wage we have used wages and salaries of employees divided by the GDP deflator. Results are robust if we use wages and salaries of employees divided by the CPI index as an alternative real wage measure.
3.2 Identifying the shocks

To identify the shocks we employ the restrictions presented in Table 2; namely, after 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 lagged total output positively comoves with the government expenditure for two quarters. Tax revenues are also allowed to positively comove or being little responsive to the shock. To account for possible correlation among the three fiscal components, we shut the responses of the unshocked government spending variables on impact.

Let $\Sigma$ be the covariance matrix of the VAR shocks and let $PP = \Sigma$ an orthogonal decomposition of $\Sigma$. Then, structural shocks $\varepsilon_t$ are constructed as $\varepsilon_t = P^{-1}u_t$, where $u_t$ are reduced form shocks and, for each element of $\varepsilon_t$, 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 $\lambda$ 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 $\lambda$ 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 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 avoided. 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 it is possible to design restrictions which will capture it. 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

We present in Figure 2 the responses of output, employment, the real wage, the unemployment rate and the labor force participation rate to a 1% decrease in government spending on consumption, investment, employment and wages in the US. Each graph presents median estimates (solid line) and pointwise 68-percent probability bands (shaded area). According to the results, output and employment significantly decrease for some periods after the first three shocks, but the responses are more pronounced after a public employment shock. On the other hand, as was imposed by our restrictions, output increases significantly and persistently with respect to government wage cuts. Total employment decreases significantly in responses to consumption and employment shocks, but increases according to our theoretical predictions with respect to government wage cuts (recall that the responses of employment were not restricted when identifying the shock). The real wage responses are not significant for any of the shocks considered. The unemployment rate increases significantly with some delay for government consumption and employment shocks and it falls significantly after a public wage cut. Finally, the labor force participation rate responds negatively and significantly to consumption and employment shocks, with the fall being persistent and stronger for the latter shock. Although responses are similar qualitatively, there are striking quantitative differences: output is largely reduced after a public employment shock, but not after a government consumption or investment shock. Specifically, a 1% decrease in the government wage bill induced by cuts in public employment induces a 0.5% fall in output on impact, while a consumption and investment cut drive output down by 0.20% and 0.10%, respectively. Instead, a 1% cut in the public wage bill originating from government wage cuts increases output by 0.5%. Similar patterns arise in other OECD countries. In Figure 3 we present the output responses after a government consumption (first column), investment (second column), employment (third column) and wage (last column) shock in Canada, the Euro area, Japan, and the UK. The first three fiscal spending cuts contract significantly output, and the most contractionary adjustment is always the public employment reductions, while cuts in the government wage increase output significantly.7

This instantaneous difference translates in differences in the output multipliers and, hence, losses. Table 3 presents point estimates of the impact output and unemployment multiplier and the long-run cumulative multipliers one and three years after the shock for the sample countries. Impact output multipliers are computed by dividing the output response by the sample mean

7The complete set of impulse response functions for all countries are provided in a supplementary appendix available at www.eui.eu/Personal/Pappa/research.html.
of the GDP share of each fiscal component. Long-run multipliers are computed by dividing the cumulative sum of the output response by the product of the cumulative sum of the government spending response and the sample mean of the GDP share of government spending. Similarly, unemployment multipliers measure what is the percentage change in unemployment when government spending decreases by one percent of GDP. Values for which corresponding 68% intervals do not include zero are indicated with an asterisk. For the US, shocks to the government wage bill originating from changes in public employment have the highest output multipliers at all horizons. A one unit decrease in government consumption, investment and wage bill expenditures implies a decrease in output on impact by 1.59, 2.58 and 4.47 units, respectively. Three years after the government investment and employment shock the cumulative effect on output is 5.26 and 6.18 units, respectively. The results for the other four countries are similar; the output multipliers of the government employment shocks are always higher in absolute value. In contrast, government wage cuts generate positive, considerable, and, often, significant output effects in all countries in the sample.

The size of the output multipliers for the different government spending components reported in Table 3 is much higher than the estimates reported in the existing SVAR literature. Typically, the output multiplier for total government expenditures in the US in normal times varies between 0.6 in Barro and Redlick (2011) to 2.20 in Canova and Pappa (2011). To understand whether the size of our estimated multipliers is driven by the specification we adopted, or the data we used, we have identified a shock to total government expenditures by using our theoretical restrictions for the first three components of spending. Results from this exercise appear in the seventh column of Table 3. The multipliers we generate are comparable with the ones of the existing literature and are always lower than the ones in the previous columns of the table and for Canada, Japan and the UK even lower than the multipliers from government consumption shocks. We conjecture that this is due to aggregation, since the correlation of the series for the different government components is moderate and by summing up the different series a lot of useful information is lost. The results in Table 3 give an additional motivation for investigating separately the effects of different spending components.

Unemployment multipliers in the US are moderate on impact for all shocks but for wage cuts, where they are estimated to be negative, significant and considerable both on impact and one year after the shock. Instead, government consumption and employment cuts generate positive sizeable and significant cumulative unemployment multipliers one and three years after the shock. Again, four years after the shock, government employment cuts generate the highest
positive unemployment multiplier. Unemployment multipliers for the other OECD countries we consider are not significant except for government wage cuts in Canada, the Euro Area and Japan where estimates are negative and significant. Government investment unemployment multipliers are never significant while government consumption ones are significant and positive for Canada and Euro Area, while government employment ones are negative and significant for Canada on impact and after three years in the Euro Area.

5 Robustness

5.1 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 has fallen after 1980 (see, e.g., Stock and Watson (2003)). There is some evidence that the dynamics effects of fiscal shocks have changed over time (see, e.g., Perotti (2002)). To take into account sample heterogeneity we repeat the analysis for 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 cumulative output and unemployment multipliers one and three years after the shock for each of the two sub-periods, as well as the difference between the two sub-periods. The results indicate that the structural change of the 1980s has changed significantly the transmission of government spending shocks. The effect of government consumption shocks on output is weakened in the post 80s for the Canada, Japan and the UK, while it is reinforced for the US. Similarly, the output effects of investment shocks have weakened for Japan, while they became stronger for the US and Canada. The effects of government employment shocks on output have substantially increased in the second subsample for all countries and all horizons, while the output effects of government wage cuts have weakened for most countries and time horizons considered.

However, unemployment effects of government spending disturbances changes in the two sub-periods do not have a uniform pattern. They do not seem to have changed significantly in the two sub-periods in the US, apart from a significant decrease in the negative multiplier for government wage cuts and a fall in the unemployment multiplier for government invest-

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8In the online supplementary appendix we present the relevant impulse responses of the variables of interest for the four spending shocks for the US economy. They are qualitatively similar across the two sub-samples and also in accordance with the full sample analysis.
ment. Government consumption multipliers increase for all countries in the second subsample, and government investment multipliers also increase for all countries, but the US. In the UK government employment multipliers change significantly, they become positive in the post 80s periods and in Canada and Japan they become negative. Finally, in Canada and Japan government wage multipliers increase significantly in absolute value and in the UK and the US they decrease.

5.2 Government employment and wage series

Due to data availability for the Euro area we have decided to run the VAR in the benchmark model using the government wage bill in the VAR and sign restrictions on output and the wage bill to distinguish government wage from government employment cuts. In this subsection we investigate the validity of our results when we include government employment and wage series to extract the shock in government employment in the VAR. The identifying restriction is that a shock to government employment increases deficits on impact and the government wage bill and output with a lag. Instead, we identify a shock to the government wage by imposing that an increase in the government wage increases the government wage bill and deficits contemporaneously, without restricting the output response. Data for public employment are available for Canada, Japan, the UK and the US, and results are reported in Table 5.

Responses are similar to the benchmark model. Shocks to government employment are still the most harmful in terms of output losses and shocks to the government wage affect output positively and significantly in all countries. Recall that for this identification responses of output after the wage cut have not be restricted and Table 5 confirms the estimates of the sign restrictions approach to recover the government wage cut. Unemployment multipliers are larger and more significant for government employment shocks, while they are negative and significant for Canada and the US. Hence, the main message of the analysis remains unchanged: government employment cuts are the most harmful and government wage cuts the least harmful tool for making fiscal adjustments.

5.3 An alternative identification scheme

For readers who prefer a simple recursive (Choleski) identification to extract the fiscal shocks from the data to sign restrictions, we have also run four different VARs with each government spending variable ordered first and the rest of the variables included in the following order: real
per capita GDP, total employment, real wage, labor force participation rate and unemployment rate.

Impulse responses of the VAR for the US variables are presented in Figure 4. The public employment cut leads to a persistent and pronounced recession, while the effects of the other two contractionary fiscal shocks die out quicker. Public employment shocks are also more contractionary in the labor market. Total employment is significantly and persistently decreased and unemployment increases significantly after a public employment cut. Consumption shocks also increase unemployment but by much less and investment cuts seem to have no effects on unemployment. The wage cut results to significant and persistent positive output effects and, confirming theoretical predictions, decrease the real wage and increase employment significantly, leading to significant reductions in the unemployment rate.

For this identification scheme, multipliers are similar with the ones obtained by sign restrictions (see Table 6) with government employment cuts generating the biggest output losses for all the horizons considered and government wage generating positive responses of output.

5.4 Controlling for expectations

Ramey (2011) argues that 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 the US government spending and output from the Survey of Professional Forecasters (SPF) of the Federal Reserve Bank of Philadelphia. The VAR we consider includes 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, the log of real per-capita net tax revenues, the log of average real private wage per job, the log of total employment, the total public spending and the output forecasts, and a measure of a short-term interest rate. We use the same sign restrictions as in the benchmark model to identify the fiscal shocks. The responses of the macro variables for the US are depicted in Figure 5. The ordering of multipliers is unchanged (see second row of Table 6). We do not find significant changes because both the public spending and the output forecast do not react significantly on impact after the identified shocks.
6 Reconciling the evidence with the theory

The data strongly suggests that government employment cuts are the most destructive mean of fiscal adjustment. Although it is pretty simple to explain why government investment cuts, if government output is productive, can be more harmful relative to government consumption cuts, it is difficult to understand what makes government employment cuts more damaging relative to government investment cuts. In this section, we use the theoretical model of Section 2 to explain this outcome and reconcile the empirical evidence with the predictions of our model.

6.1 Fiscal multipliers: public spending as a waste

We start by assuming that the public good is unproductive ($\nu = 0$) and yields no utility to households ($z = 0.2$). The values for the other parameters of the model appear in Table 1.

In Figure 6 we plot with continuous lines the responses of the economy to a government consumption shock.$^9$ As it is well known, a government consumption induces a wealth effect that decreases labor participation and increases private consumption. The presence of long-term unemployed magnifies the size of the negative wealth effect, since for those agents looking for a job when the economy is contracting has a lower payoff since during such times it is difficult to find a job that would help them move away from long-term unemployment and increase their matching efficiency. This effect 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. Output decreases but private investment is crowded in by the negative shock. The combined shifts of labor supply and demand produce a decrease in the private wage, which leads subsequently to a fall in the public wage. The decrease in labor demand increases short-term unemployment, while the decrease in labor force participation decreases long-term unemployment, and depending on the share of the latter in total unemployment, total unemployment can go down or up. In our benchmark parameterization unemployment decreases initially and raises when firms reduce employment decreasing vacancies and increasing short-term unemployment in the periods after the shock. Public employment increases because the decrease in demand in the private sector is large so that the tightness of the public jobs market decreases. As a result, public output slightly increases.

The continuous lines in Figure 7 depict the responses of the economy to a government

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$^9$Dashed lines correspond to the case in which the public good is useful (see next subsection). Since, the properties of the public good affect marginally the responses of the economy to a government consumption shock, the continuous and the dashed lines coincide for most variables.
investment cut when the public good is unproductive and yields no utility to households. Responses in this case are identical to the case of public consumption shocks, since the two shocks represent decreases in the government’s absorption and have no specific feature to distinguish them.

The continuous lines of Figure 8 describe the responses to a negative shock in public vacancies. This shock is different since it directly affects the labor market outcomes in both the private and the public sector. As with the previous shocks, the decrease in government’s absorption decreases labor participation, due to the wealth effect, and the labor demand effect is still relevant decreasing private vacancies and private employment. However, the fall in public vacancies alters the dynamics of the other variables substantially. In fact, the supply of labor in both labor markets decreases. The fall in the labor supply for private employers comes from the fact that agents have a lower probability to find a job when private demand falls. The fall in the labor supply of public employees comes instead from the tightening of the public labor market. Hence, a shock in public vacancies will decrease the probability of the household to employ an additional member in either the private or the public sector. This is why the fall in public vacancies exacerbates the crowding out of consumption and investment: with the reduced number of working members, the households cannot afford an increase in consumption and investment when more household members become unemployed, that is, a period after the initial shock.

This property of the public vacancies shock is crucial for understanding the empirical results. In Figure 10 we plot the output and unemployment losses generated by the different types of cuts when government spending is a waste (continuous lines)\textsuperscript{10}. The losses associated with government vacancies shocks are the largest and larger than one in absolute value, since they generate a crowding out of consumption and investment. However, the effect is short lived and is not comparable with the responses we observe in the data. Next, we allow for productive public inputs and show that this feature is crucial to understand the results we obtain.

In Figure 9 we plot the impulse responses of the economy to a cut in public wages. Again as a reduction in government’s absorption this policy is associated with a positive wealth effect that decreases labor force participation and increases consumption and investment. At the same time, the shock reallocates jobseekers from looking for a job in the public to the private sector since wage rates in the public sector become lower. The increase in demand for consumption and

\textsuperscript{10}The output losses measure how much output decreases when a fiscal component is undergoing a 1% of output cut. Similarly, unemployment losses are computed as the increases in unemployment when a fiscal components is reduced by 1% of output.
investment coupled with 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 increases in private output. On the other hand, the reduction in labor force participation and the increase in employment in the private sector reduce unemployment. As a result, the initial negative shock results to be expansionary, increasing slightly output and reducing substantially unemployment. This might not be surprising if government output is assumed to be unproductive. In the next section we study the sensitivity of our results when we dismiss this assumption.

6.2 Fiscal multipliers: productivity- and utility-enhancing public good

The dashed lines in Figure 7 represent the responses of the macro variables to a government investment cut when the public good is productive for the private sector ($\nu = 0.2$) and utility enhancing ($z = 0.2$). The assumption on the productivity of the public good makes a difference for the responses of the economy to a government investment shock. The wealth and demand effects in this case are combined with a negative effect that the shock has on future production, since a lower $i^g_t$ reduces, through public capital accumulation, future government production, which enhances future private productivity. The contemporaneous responses induced by government investment shocks are qualitatively similar to the ones produced by a government consumption shock, but the lagged effects are quite different. Private and, hence, total output persistently fall after a government investment shock, generating a persistent negative effect on wealth that increases long-term unemployment and public employment. The crowding in of private consumption is smaller and the fall in the marginal product of labor decreases both private and public wages on impact. The size of the impact multiplier does not change significantly, although cumulative multipliers for government investment shocks decrease when government output is productive (see Figure 10). Of course a rise in $\nu$, the productivity of public good, would reduce further the size of the output losses, both on impact and in subsequent periods (but would not change the ranking relative to the output and unemployment losses related to public vacancies cuts).

The productive nature of government output also generates a persistent negative wealth effect when we examine the responses of the economy to a government vacancies shock (see dashed lines in Figure 8). This effect is similar in nature with the one generated by government investment shocks, but the transmission of the two shocks is very different. Consumption
decreases more and more persistently after the shock. Private investment reacts less on impact but its response is more persistent. Hence, the size of the multiplier does not change much on impact, but the effects of the shocks are amplified. Again, output losses are an increasing function of $\nu$, while unemployment losses do not seem to relate strongly to the productive nature of public goods. It is important to note that government employment shocks give the highest output losses not because government employment is productive, but because it induces the additional negative wealth effect that the other two shocks do not generate. That is, the shock induces a fall in the number of working members in the household inducing a crowding out of private consumption and investment. Clearly, the size of this effect depends on various parameters of the model. In the next session we try to identify which parameters are crucial for determining its size.

Finally, a public wage cut can have more expansionary output effects and reduce further unemployment when the public good is assumed to be productive (See Figure 9). The reason behind this result is very simple. Since a wage cut decreases labor force participation and, in particular, crowds out the public sector labor supply, public employment increases less decreasing the productive capacity of the economy. On the other hand, the increase in private consumption and investment has to be met with increases in labor demand, which imply higher employment in the private sector and a higher total output and lower unemployment in equilibrium. Hence, public wage cuts can result even more effective when public goods are productive (See last row of Figure 10).

### 6.3 Sensitivity analysis

Shocks related to the government wage bill are associated with very distinct effects on output and unemployment. Government employment cuts generate the highest output losses and increases in unemployment, while on the other hand, government wage cuts have expansionary effects. Government consumption and investment imply smaller output and unemployment losses. Nevertheless, it is important to study the sensitivity of our conclusions to changes in the parameterization of the model. This will also help us understand which features are crucial for mapping model and empirical responses.

For example, there are some obvious candidates that determine the magnitude of government employment multipliers 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
11 demonstrate that indeed high replacement rates \((b/w^u = 0.5)\) decrease substantially the wealth effect originating from government vacancies shocks. In fact, with high unemployment benefits, households do not experience a substantial fall in income when a member of the household loses a public job relative to remaining employed in the coming period. High replacement rates also reduce the output and unemployment losses associated with government consumption and investment cuts, since with high replacement rates the positive wealth effects associated with the government contraction is reduced. On the other hand, in an economy with high replacement rates the expansionary effects of government wage cuts become larger, since a cut in public wages with high replacement rates implies a higher increase in consumption and investment demand and a further increase in private employment. However, the public wage cuts discourage the participation of long-term unemployed in the labor market and the effects in terms of reductions in the unemployment rate are smaller relative to the benchmark case.

A change in the job destruction rate of public jobs does not change the dynamics with respect to government consumption and investment cuts, but it affects significantly the output losses associated with government employment and wages shocks. The public job destruction rate should also affect the continuation value of the household of having one less public employee among its members. The dashed-dotted lines in Figure 11 depict output losses and unemployment multipliers when \(\sigma^g = 0.01\). One should expect that making public jobs more secure would increase the size of the wealth effect associated with a decrease in public vacancies, but this is not the case. A reduction in the public job separation rate has exactly the opposite effect; it reduces substantially output and unemployment losses from government employment cuts. This occurs because more permanent public jobs imply longer queues for public jobs. Hence, the reallocation of unemployed jobseekers towards private employment, caused by the decrease in public vacancies, results in a lower recession after the shock and a fall of unemployment on impact. When public jobs are more permanent, government wage cuts are still expansionary and they reduce unemployment but by less than in the case of more temporary public jobs. The longer life of a public job implies that reallocation of jobseekers is more sticky when the government turns to wage cuts for decreasing the government deficits, as a result, the increase in employment in the private sector is lower and output expands less resulting in lower reductions in unemployment.

There are several parameters that do not affect directly the wealth effect due to the fall in the unemployment rate after a public vacancy or wage shock, but might affect the output multiplier for the other two government spending shocks. For example, the size of capital
adjustment costs or the flexibility in prices might influence the output losses from government
investment cuts. As it is clear from Figure 11, such changes do affect the size of the losses for
the four shocks, but do not alter their relative ranking in terms of the recessionary effects that
they imply for the economy.

Finally, we investigate how the assumption on workers’ heterogeneity affects our results. In
Figure 11 we plot losses generated by the model with homogeneous unemployed jobseekers. As
it is clear from the picture, the ranking of the different fiscal instruments is independent of
the presence of heterogeneous unemployed. However, in the homogeneous agents’ model the
absence of long-term unemployed implies that, other things being equal, the fall in labor force
participation is smaller after a shock in public vacancies and the wealth effect associated with
having one more member of the household unemployed is stronger leading to further decreases
in consumption and investment demand and, hence higher output and unemployment losses.
On the other hand, with no heterogenous agents there is no change in labor participation after
a wage cut in the public sector, as a result the reallocation of jobseekers from the public to the
private sector results in no changes in total unemployment. Also, the fall in productive public
employment cancels out with the increase in private employment and output is hardly affected
by the public wage cut.

In sum, all the parameter changes we have considered do not change the ranking of the
different spending cuts: cutting government wages to decrease debt is always ranked as the
best policy response in terms of both output and unemployment losses, while cutting public
jobs is the worst policy a government can adopt especially when replacements rate are low and
public jobs are of more temporary nature.

7 Conclusions

This paper analyzes the dynamics of transmission of different types of government expenditure
cuts engineered to decrease deficits 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 cuts are relatively robust across model specifications and across
different components of expenditures, while this is not the case for tax financed expenditure 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 total output and deficit responses. In particular, the identification scheme we employ requires that government consumption, investment and employment shocks decrease total output persistently with a lag and the deficit contemporaneously, while government wage shocks increase total output with a lag and decrease deficits and the government wage bill contemporaneously. Our identification restrictions come from a very general DSGE model with real and nominal frictions and hold for many variants and parameterizations of the model. Government spending cuts in consumption, investment and employment are all associated with output losses and increases in unemployment; however, for government employment cuts output and unemployment losses are larger and larger than one for all countries and all horizons. Cuts in government wages do not imply output losses, instead, they can be expansionary and reduce unemployment. There are substantial differences in the transmission of fiscal shocks before 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 spending is the most effective in fueling the economy because, apart from generating the standard wealth and demand effects after decreases in government absorption, it has an additional negative effect, since it increases unemployment and induces a negative wealth effect that incentivizes households to consume and invest relatively less. This latter effect depends crucially on the size of the replacement rates and the destruction rate of public jobs. High replacement rates and public job security decrease the output and unemployment losses associated with government employment cuts. Hence, the reforms in employment protection and unemployment benefits in many of the OECD countries in our sample may explain the increased influence of government employment shocks in the last three decades.
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### Table 1: Parameter ranges and values

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<th>Varying parameters</th>
<th>Ranges</th>
<th>Values</th>
<th>Fixed parameters</th>
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<td>Frisch elasticity</td>
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<td>private separation rate</td>
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<td>public separation rate</td>
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<td>adjustment costs parameter</td>
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Notes: $j = p, g$ and $\psi = \epsilon^p, \epsilon^g, \epsilon^g$
Table 2: Identifying restrictions

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<th>$\varepsilon^{g, k}_i$</th>
<th>$\varepsilon^{g, k}_w$</th>
<th>$\varepsilon^{g, n_k}_k$</th>
<th>Tax revenues</th>
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<td>$\varepsilon^{w_g}_t$</td>
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<td>-</td>
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<td>16%</td>
</tr>
<tr>
<td>$\varepsilon^{A}_t$</td>
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<td>6%</td>
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<tr>
<td>$\varepsilon^{R}_t$</td>
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<td>+</td>
<td>-</td>
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Table 3: Full sample

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<th>unemployment multipliers</th>
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<td>1</td>
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<tr>
<td>4</td>
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Note: $G = c_g + i_g + w_g n_g$
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<tr>
<td>post-80s</td>
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<td>0.90</td>
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<td>0.79</td>
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<td>4.26*</td>
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### Table 5: Government employment and wage series

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<td>$i_g$</td>
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<td>-2.01*</td>
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### Table 6: Robustness checks for the US

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</tr>
<tr>
<td>12</td>
<td>-5.25</td>
<td>-6.44*</td>
</tr>
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Figure 1: Robust sign restrictions, theoretical responses to public spending shocks
Figure 2: VAR impulse responses to fiscal shocks in the US
Figure 3: Output responses in other OECD countries
Figure 4: VAR impulse responses to fiscal shocks in the US, Choleski.
public consumption shock  
public investment shock  
public employment shock  
public wage shock  

Figure 5: IRFs to fiscal shocks, US data, control for expectations
Figure 6: Theoretical responses to a public consumption cut
Figure 7: Theoretical responses to a public investment cut
Figure 8: Theoretical responses to a public vacancies cut
Figure 9: Theoretical responses to a public wage cut
Figure 10: Comparison of output and unemployment losses
Figure 11: Sensitivity analysis
A Appendix: F.O.C. from the household’s problem

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

\[ n_{t+1}^p = (1 - \sigma^p) n_t^p + \psi_{ht}^p (1 - s_t^S) u_t^S + \psi_{ht}^p (1 - s_t^L) u_t^L \] (A1)

\[ n_{t+1}^g = (1 - \sigma^g) n_t^g + \psi_{ht}^g s_t^S u_t^S + \psi_{ht}^g s_t^L u_t^L \] (A2)

\[ u_{t+1}^S = \sigma^p n_t^p + \sigma^g n_t^g + (1 - \xi) u_t^S - \left[ \psi_{ht}^p (1 - s_t^S) + \psi_{ht}^g s_t^S u_t^S \right] u_t^S \] (A3)

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

[wrt \( c^p_t \)]

\[ (c^p_t + z \gamma y_t^p)^{-\eta} = \lambda_{ct} \] (A4)

[wrt \( y_t^q \)]

\[ z \gamma (c^p_t + z \gamma y_t^q)^{-\eta} = \lambda_{ct} \frac{p_t^q}{p_t} \] (A5)

[wrt \( K_{t+1}^p \)]

\[ \lambda_{ct} \left[ 1 + \omega \left( \frac{K_{t+1}^p}{K_t^p} - 1 \right) \right] = \beta E_t \lambda_{ct+1} \left\{ 1 - \delta^p + [r_{t+1}^p - \tau_k (r_{t+1}^p - \delta^p)] + \omega \left[ \frac{K_{t+2}^p}{K_{t+1}^p} \right]^2 - 1 \right\} \] (A6)

[wrt \( B_{t+1} \)]

\[ \lambda_{ct} \pi_{t+1} = \beta E_t \lambda_{ct+1} R_t \] (A7)

[wrt \( n_{t+1}^j \)]

\[ \lambda_{nt} = \beta E_t \left[ \lambda_{ct+1} (1 - \tau_n) w_{t+1}^j + \lambda_{n^t+1} (1 - \sigma^j) + \lambda_{u^S_t+1} \sigma^j - U_{t+1} \right] \text{ for } j = p, g \] (A8)

[wrt \( u_{t+1}^S \)]

\[ \lambda_{u^S_t} = \beta E_t \left\{ \lambda_{ct+1} b + \lambda_{n^p t+1} \psi_{ht}^p (1 - s_t^S) + \lambda_{n^g t+1} \psi_{ht}^g s_t^S \right. \\
+ \lambda_{u^S_t+1} \left[ 1 - \xi - \psi_{ht}^p (1 - s_t^S) - \psi_{ht}^g s_t^S \right] - U_{t+1} \} \] (A9)
\[ \text{wrt } u_t^L \]
\[ \lambda_{npt} \psi_t^{hpL} (1 - s_t^L) + \lambda_{npt} \psi_t^{hgL} s_t^L + \lambda_{ct} b = U_{lt} \tag{A10} \]

\[ \text{wrt } s_t^S \]
\[ (\lambda_{npt} - \lambda_{wst}) \psi_t^{hpS} = (\lambda_{npt} - \lambda_{wst}) \psi_t^{hgS} \tag{A11} \]

\[ \text{wrt } s_t^L \]
\[ \lambda_{npt} \psi_t^{hpL} = \lambda_{npt} \psi_t^{hgL} \tag{A12} \]

where \( U_{lt} \equiv \Phi_l - \psi_t \) is the marginal utility from leisure (labor market non-participation). Equations (A4)-(A7) are standard and include the arbitrage conditions for the returns to private consumption, the public good, private capital and bonds. Notice that (A4)-(A5) imply that \( \frac{p_t^g}{p_t} = \gamma z \). Equation (A8) 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 (A9) 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, \( \lambda_{njt+1} \), weighted by the job finding probabilities, \( \psi_{t+1}^{bjL} \), of being short-term unemployed weighted by the respective probability, \( 1 - \xi - \psi_{t+1}^{hpS}(1 - s_{t+1}^S) - \psi_{t+1}^{hgS} s_{t+1}^S \), and finally with the utility loss from the reduction in leisure. Equation (A10) states that the value of being search active (rather than non-participating), \( \lambda_{ct} b \), plus the expected marginal values of being employed, \( \lambda_{njt} \), weighted by the job finding probabilities, \( \psi_{t}^{bjL} \), and the respective share of outside jobseekers should equal the marginal utility from leisure, \( U_{lt} \). Equations (A11)-(A12) 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 sectors. Notice that in the case of the share of short-term unemployed seeking a public-sector job the expected marginal values of being employed are net of the expected marginal value of being short-term unemployed.

\section*{B Appendix: Derivation of the private wage}

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

\[
(1-\vartheta) \left( \frac{1 - \tau_n}{c_t^p + z \gamma g_t^p} \right) \left[ x_t (1 - \varphi) \frac{w_t^p}{n_t} - w_t^p + \frac{(1 - \sigma^p) \kappa}{\psi_t^{hp}} \right] = \vartheta \left( \frac{1 - \tau_n}{c_t^p + z \gamma g_t^p} \right) w_t^p - U_{lt} + (1 - \sigma^p) \lambda_{npt} + \sigma^p \lambda_{utl} \]

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\[ \Rightarrow w^p_t = (1 - \vartheta) \left[ x_t(1 - \varphi) \frac{y^p_t}{n^p_t} + \frac{(1 - \sigma^p) \kappa}{\psi^f_t} \right] - \frac{\vartheta (c^p_t + z \gamma y^p_t)^\eta}{(1 - \tau_n)} \left[-U_{l,t} + (1 - \sigma^p) \lambda_{n \mu t} + \sigma^p \lambda_{u \mu t} \right] \]

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

\[(1 - \vartheta)(1 - \tau_n) E_t \Lambda_{t,t+1} V_{n \mu t+1}^F = \vartheta \beta E_t (c^p_t + z \gamma y^p_t)^\eta V_{n \mu t+1}^H \]

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

\[
\frac{(1 - \vartheta) \kappa}{\psi^f_t} = \frac{\vartheta \lambda_{n \mu t}}{(1 - \tau_n) (c_t + z \gamma y^p_t)^{-\eta}} \tag{B1} \]

Using (B1) we get:

\[ w^p_t = (1 - \vartheta) \left[ x_t(1 - \varphi) \frac{y^p_t}{n^p_t} + \frac{(1 - \sigma^p) \kappa}{\psi^f_t} \right] - (1 - \sigma^p) \frac{(1 - \vartheta) \kappa}{\psi^f_t} - \frac{\vartheta (c^p_t + z \gamma y^p_t)^\eta}{(1 - \tau_n)} \left[-U_{l,t} + \sigma^p \lambda_{u \mu t} \right] \]

\[ \Rightarrow w^p_t = (1 - \vartheta) x_t(1 - \varphi) \frac{y^p_t}{n^p_t} - \frac{\vartheta (c^p_t + z \gamma y^p_t)^\eta}{(1 - \tau_n)} \left[-U_{l,t} + \sigma^p \lambda_{u \mu t} \right] \]

Using (A10) it follows:

\[ w^p_t = (1 - \vartheta) x_t(1 - \varphi) \frac{y^p_t}{n^p_t} - \frac{\vartheta (c^p_t + z \gamma y^p_t)^\eta}{(1 - \tau_n)} \left[- \lambda_{n \mu t} \psi^{h \mu O}_t (1 - s^O_t) + \lambda_{n \mu t} \psi^{h \mu O}_t s^O_t + \lambda_{\mu b} + \sigma^p \lambda_{u \mu t} \right] \]

Using (A12) we get:

\[ w^p_t = (1 - \vartheta) x_t(1 - \varphi) \frac{y^p_t}{n^p_t} - \frac{\vartheta (c^p_t + z \gamma y^p_t)^\eta}{(1 - \tau_n)} \left[- \lambda_{n \mu t} \psi^{h \mu O}_t - \lambda_{\mu b} + \sigma^p \lambda_{u \mu t} \right] \]

Using (A4) we get:

\[ w^p_t = (1 - \vartheta) x_t(1 - \varphi) \frac{y^p_t}{n^p_t} + \frac{\vartheta b}{(1 - \tau_n)} + \frac{\vartheta \lambda_{n \mu t} \psi^{h \mu O}_t}{(1 - \tau_n) (c^p_t + z \gamma y^p_t)^{-\eta}} - \frac{\vartheta \sigma^p \lambda_{u \mu t}}{(1 - \tau_n) (c^p_t + z \gamma y^p_t)^{-\eta}} \]

Using (B1) we get:

\[ w^p_t = (1 - \vartheta) x_t(1 - \varphi) \frac{y^p_t}{n^p_t} + \frac{\vartheta b}{(1 - \tau_n)} + \frac{(1 - \vartheta) \kappa}{\psi^f_t} \psi^{h \mu O}_t - \frac{\vartheta \sigma^p \lambda_{u \mu t}}{(1 - \tau_n) (c^p_t + z \gamma y^p_t)^{-\eta}} \]
\[ w_t^p = (1 - \vartheta) \left[ x_t (1 - \varphi) \frac{y_t^P}{n_t^L} + \kappa \frac{\psi_t^{hpO}}{\psi_t^{hpL}} \right] + \vartheta b \left( 1 - \tau_n \right) - \vartheta \sigma (c_t^P + z \gamma y_t^P)^n \beta E_t V^H_{u_{t+1}} \]

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

\[
\begin{align*}
  u &= \frac{u}{n+u} (n + u) \frac{1}{n+u} (1 - l) \\
  n &= 1 - l - u \\
  \frac{n^p}{n} &= 1 - \frac{n^g}{n} \\
  n^j &= \frac{n^j}{n}
\end{align*}
\]

We set the following values for the separation rates, \(\sigma^P = 0.025\) and \(\sigma^g = 0.018\). Then we get \(m^j\) from (2) at the steady state:

\[ m^j = \sigma^j n^j \]

Following Shimer (2010), we calibrate the private job finding rate, \(\psi^{hp}\), to equal to 0.83. According to Barnichon and Figura (2011) having an unemployment spell lasting six months reduces \(\psi^{hp}\) by 1-1.5 percentage points. Hence assuming that \(\frac{\psi^{hpS}}{\psi^{hpL}} = 1.015\) 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:

\[
\begin{align*}
  u^P &= \frac{\psi^{hp}}{m^P} \\
  u^g &= u - u^P \\
  \psi^{hg} &= \frac{m^g}{u^g}
\end{align*}
\]
Assuming that $\psi_{hg} = \psi_{hg}^{L} + \psi_{hg}^{S}$ and the definition of the aggregate public job finding rate we get:

$$\psi_{hg} = \frac{\psi_{hg}^{L} + \psi_{hg}^{S}}{1 + \frac{\psi_{hg}^{S}}{\psi_{hg}^{L}}} \quad \text{and} \quad \psi_{hg}^{S} = \frac{\psi_{hg}^{S}}{\psi_{hg}^{L} \psi_{hg}^{L}}$$

Since there is no exact estimate for the value of the private vacancy-filling probability, $\psi_{fp}$, in the literature, we use what is considered as standard by setting it equal to 0.54 and then we assume that $\psi_{fp} = \psi_{fp}^{L}$. Hence, we get $\theta^{j}$, $\nu^{p}$ from (6) after using (4)-(5):

$$\theta^{j} = \frac{\psi_{hj}}{\psi_{fp}}$$

$$\nu^{j} = \theta^{j} \nu^{j}$$

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:

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

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

The matching elasticity, $\alpha$, is set, by the Hosios condition, equal to the bargaining power, $\vartheta$, which takes the value 0.6. Dividing $m_{i}^{PS}$ by $m_{i}^{GS}$ implies from (4)-(5) after using (6):

$$\frac{u^{PS}}{u^{GS}} = \frac{\nu^{p}}{\nu^{g}} \left( \frac{\psi_{hgs}^{PS}}{\psi_{hgs}^{GS}} \right)^{1/\alpha} \quad \text{and} \quad \frac{u^{pL}}{u^{gL}} = \frac{\nu^{p}}{\nu^{g}} \left( \frac{\psi_{hpL}}{\psi_{hpL}} \right)^{1/\alpha}$$

$$u^{S} = u^{PS} + u^{GS} \quad \text{and} \quad u^{L} = u^{PS} + u^{gL} \Rightarrow u^{PS} = \frac{u^{S}}{1 + \frac{u^{PS}}{u^{PS}}} \quad \text{and} \quad u^{L} = u^{PS} + u^{gL} \Rightarrow u^{PS} = \frac{u^{L}}{1 + \frac{u^{PS}}{u^{PS}}}$$

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

Then the matching efficiencies are given by (4) after using (6):

$$\rho_{m}^{S} = \psi_{hgs}^{PS} \left( \frac{u^{PS}}{\nu^{p}} \right)^{\alpha} \quad \text{and} \quad \rho_{m}^{L} = \psi_{hps}^{PS} \left( \frac{u^{PS}}{\nu^{p}} \right)^{\alpha}$$

The probability of a short-term unemployed becoming in the next period long-term unemployed, $\xi$, is determined by (3) in the steady state after using (2) and (6):

$$\xi = \psi_{hp} \frac{u^{P}}{u^{S}} + \psi_{hp} \frac{u^{g}}{u^{S}} - \psi_{hgs} \frac{u^{PS}}{u^{S}} - \psi_{hgs} \frac{u^{GS}}{u^{S}}$$
C.2 Other parameters and steady state relations

We set the capital depreciation rates, $\delta^j$, equal to 0.025. Then we derive $\frac{ij}{kp}$, $\frac{ig}{kg}$ from (10) and (29):

$$\frac{ij}{kp} = \delta^j$$

Following the literature, we set the discount factor, $\beta$, 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 US 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 (A6) and (A7), respectively:

$$r^p = \frac{1}{(1 - \tau_k)} \left( \frac{1}{\beta} - 1 \right) + \delta^p$$

$$R = \frac{1}{\beta}$$

The elasticity of demand for intermediate goods, $\varepsilon$, is set equal to 11, which implies a gross steady-state markup, $\epsilon \varepsilon^{-1}$, equal to 1.1, and the price of the final good is normalized to one. Then $x$ is determined from (25):

$$x = \frac{\varepsilon - 1}{\varepsilon}$$

We set the capital share in the production function of the private good equal to 0.36. Then we obtain $\frac{yp}{kp}$ from (19):

$$\frac{yp}{kp} = \frac{r^p}{\phi x}$$

We set the shares of public capital in public production, $\mu$, equal to 0.36, of the public good in private production, $\nu$, equal to 0.2, and the proportion of public good that is utility-enhancing, $\gamma$, equal to 0.5. Further, using data from Kamps (2006) we set $\frac{k^g}{kp} = 0.31$, 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 from (16) and (28) $k^p$ is determined by:

$$k^p = \left[ \frac{yp}{kp} \left( \varepsilon^{An^p} \right)^{(1-\psi)} \left( 1 - \gamma \right)^{-\nu} \left( \varepsilon^{An^g} \right)^{\mu\nu-\nu} \left( \frac{k^g}{kp} \right)^{-\mu\nu} \right]^\frac{1}{\phi + \mu\nu - 1}$$

and then we get by definition $i^p$, $y^p$, $k^g$, $i^g$:

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

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

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and $y^g$ from (28):

$$y^g = \left( e^{A_t} n^g \right)^{1-\mu} (k^g)^\mu$$

We set the preference parameter for the public good, $z$, equal to 0.2 and we derive total output in the steady state from (36):

$$y = y^p + z\gamma y^g$$

Following Hagedorn and Manovskii (2008), Galí (2011), and Brückner and Pappa (2012), we calibrate the cost of posting a vacancy, $\kappa$, by targeting vacancy costs per filled job as a fraction of the real private wage, $\frac{\kappa w^p}{w^p}$, choosing 0.045 as a target as in Galí (2011). Also, we set the replacement rate, $\frac{b w^p}{w^p}$, equal to 0.3 (in accordance with the range [0.2, 0.4] in Petrongolo and Pissarides, 2001). Then, we can get $w^p$ from (20):

$$w^p = x(1-\varphi)\frac{y^p}{n^p} \left( 1 + \frac{\sigma^p \kappa}{\psi^p w^p} \right)^{-1}$$

and it follows that $\kappa$ 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 $\frac{c}{y} = 0.165$. It follows from (30) and (35):

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

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

$$c^p = y^p - i^p - c^g - i^g - \kappa (v^p + v^g)$$

We set the steady-state debt to GDP ratio, $\frac{B}{y}$, equal to 60%, so that by definition:

$$B = \frac{B}{y}$$

Next, we calibrate the steady state value for lump-sum transfers, $T$, equal to 0.07 so that in the steady state the deficit to GDP ratio is 3%. From the definition of the government deficit in (24) we have:

$$DF = c^g + i^g + w^g n^g + bu + \kappa v^g - T - \tau_k (r^p - \delta^p) k^p - \tau_n (w^p n^p + w^g n^g) - z\gamma y^g$$
We set the intertemporal elasticity of substitution, $\eta$, equal to 1, the Frisch elasticity of labor supply, $\psi$, equal to 0.25 (in the range of Domeij and Floden, 2006). Then we get from (A4) and (27):

$$\lambda_c = (c^p + z\gamma y^g)^{-\eta}$$

$$\lambda_{us} = \lambda_c \frac{b + \frac{(1 - \tau_n)}{\theta}}{\phi} \left\{ -w^p + (1 - \phi) \left( x(1 - \varphi) \psi h_p + \frac{\kappa}{\psi h_p} \psi h_p L \right) \right\}$$

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

$$\lambda_{np} = \lambda_c \frac{(1 - \tau_n) w^p - b + \sigma_p \lambda_{us}}{\psi h_p L - 1 + \sigma_p + \frac{1}{\beta}} \left[ \text{see (A8) after using (A10), (A11)} \right]$$

$$\lambda_{ns} = \lambda_{np} \frac{\psi h_p L}{\psi h_p L} \left[ \text{see (A12)} \right]$$

$$\Phi = (\lambda_c b + \lambda_{np} \psi h_p L) \psi \left[ \text{see (A10) after using (A12)} \right]$$

Finally, the model’s steady state is independent of the degree of price rigidities, the monetary policy rule, the debt-targeting rule for lump-sum taxes, and the size of the capital adjustment costs. We set the probability that a firm does not change its price within a given period, $\chi$, equal to 0.75, the Taylor rule coefficient, $\zeta_n$, equal to 1.5, the coefficient on the debt-targeting rule, $\zeta_b$, equal to 2.0, and the adjustment costs parameter, $\omega$, equal to 1. Finally, we set the parameters for the persistence of the fiscal shocks and the public wage shock, $\rho^g$ and $\rho^w$, equal to 0.8, and the parameters for the persistence of the productivity and the monetary policy shocks, $\rho^A$ and $\rho^R$, equal to 0.95 and 0.65, respectively.