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The Government Wage Bill and Private Activity

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Abstract

We estimate the effects of public wage expenditures on output and the labor market in U.S. data by identifying shocks to public employment and public wages using sign restrictions. Public wage shocks do not induce significant effects on output, but disaggregating by government level reveals that their effects can be contractionary at the federal level and expansionary at the state and local level. Public employment shocks are expansionary at all government levels by crowding in private consumption and increasing labor force participation and private-sector employment. Local government wage shocks lead to a similar crowd in of private consumption, while shocks to federal government wages lead to public-private wage spillovers, inducing a negative labor demand effect, a sharp fall in private-sector employment and an increase in unemployment. We develop a DSGE model with public good production, search and matching frictions, and endogenous labor force participation that matches the qualitative properties of the empirical evidence. The sign of the output response for public wage shocks depends crucially on the degree of complementarity between public and private goods in the consumption bundle.

Keywords: government wage bill, Öscal multipliers, VARs, sign restrictions, DSGE model, search and matching frictions.

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1 Introduction

The last financial crisis and the subsequent Great Recession still take their toll on many advanced economies. They have posed a serious threat on output and the labor markets, leading to an unusually slow recovery. This fact has revived the debate on the effectiveness of discretionary fiscal policy as a tool to stimulate private activity, establish sustainable growth and recover lost jobs. Another relevant question that naturally arises in this context is which fiscal instruments are the most effective for fueling economic activity.

Most of the empirical VAR literature on the macroeconomics of fiscal policy does not distinguish between different types of government spending, and treats total government spending as a single fiscal instrument. Needless to say, not all types of government spending are expected to induce the same effects on the macroeconomy. Furthermore, most of the literature interprets the empirical effects of this total government spending instrument as if they were the result of changes in government consumption of goods and services. However, government spending is not only consumption of goods and services. Wage and salary payments account for a large share of public expenditure in the U.S. During the postwar period, government wage and salary expenditure has accounted for about 50% of government expenditure (See Figure 1(b)). In the aftermath of the Great Recession, concern about the government budget has focused greater attention on the costs that the government incurs to compensate its employees.

Given the weight of wage expenditures in total government spending, the purpose of this paper is to estimate the effects of public wage bill policies on output and the labor market of the private sector, and draw policy implications that could be useful in the aftermath of the crisis. Using U.S. data over the period 1955-2007, we identify exogenous shocks to public employment and public wages. Following Mountford and Uhlig (2009), we adopt an agnostic identification that sets a minimum set of sign restrictions to the fiscal shocks identified. In particular, we identify shocks to government employment that simultaneously raise government spending and employment, and similarly shocks to government wages that simultaneously increase government spending and government wages per employee. We also ensure that the identified shocks to the government wage bill are orthogonal to shocks in other spending components and to shocks to the business cycle, monetary policy and taxes.

In a spirit similar to Ramey (2012), we ask whether the two shocks differ in their ability to stimulate private activity raising employment and lowering unemployment. Our findings indicate that for public wage shocks the effects are not statistically significant at the aggregate level. Yet, a disaggregation by government level reveals that effects can be contractionary at

the federal level and expansionary at the state and local level. On the other hand, public employment shocks are robustly expansionary at all government levels by crowding in private consumption and increasing labor force and private-sector employment. Shocks to state and local government wages lead to a similar crowd in of private consumption, while shocks to federal government wages lead to public-private wage spillovers, inducing a negative labor demand effect, a sharp fall in private-sector employment and an increase in unemployment.

The existing literature is silent about the effects of shocks to the government wage bill on private economic activity. Apart from Linnemann (2009) that has demonstrated in aggregate U.S. time series that increases in government employment generate positive responses of private employment and real output and a short-lived expansion in private consumption, and Pappa (2009) that has reported mixed results for the employment response to government employment shocks using annual U.S. state and aggregate data over the period 1969-2001, very few papers study the effects of changes in the government wage bill. Moreover, we expand the existing literature by (i) disentangling the effects of shocks to both public employment and public wages; (ii) disaggregating the effects by government level; (iii) examining the effects on the labor force participation and unemployment rates.

In order to explain the empirical findings, we develop a Dynamic Stochastic General Equilibrium (DSGE) model with sticky prices augmented with public good production, allowing for both productive and utility-enhancing services for the public good, search and matching frictions, and endogenous labor force participation. Our theoretical model matches qualitatively the empirical evidence for both shocks. More specifically, public employment shocks are expansionary by crowding in private consumption and increasing labor force participation and employment in the private sector. In the standard neoclassical growth model, increases in public employment should reduce private consumption and private employment as the additional labor supply spurred by the fiscal shock's negative income effect is entirely absorbed by the public sector (see Finn (1998)). We show that the complementarity of the public good with private consumption in the aggregate consumption bundle of the household can overturn the negative wealth effect of the shock and lead to an increase in private consumption. Confirming in a different framework the results of Linnemann (2009) who shows that if public services are complementary to private consumption goods in the household's utility function, an increase in public employment raises private consumption and private sector employment.¹ Also in a

¹This mechanism when combined with mild increasing returns and variable capacity utilization is shown to also explain initially positive (though later on negative) responses of investment and real wages to public employment shocks that seem to be consistent with Linnemann's (2009) empirical evidence.

similar framework to ours, Forni et al. (2009) demonstrate that shocks to public employment can lead to increases in private consumption in a model with rule of thumb consumers.² There also results a positive covariation between public and private employment, since the additional consumption demand makes private sector firms, which are demand constrained, expand their labor input to meet the increase in aggregate demand. Here, we study the effects of both public employment and public wage shocks and provide an alternative mechanism which rests on the complementarity channel rather than liquidity constrained households and is able to explain the transmission of both types of shocks.

Our model can also explain how government wage shocks can be contractionary or expansionary, as found in the data, depending on the relative magnitude of the forces at play. More specifically, wage shocks lead to public-private wage spillovers, inducing a negative labor demand effect, a sharp fall in private employment, and an increase in unemployment. At the same time, they can lead to a crowd in of private consumption given the complementarity of the latter with the public good in the aggregate consumption bundle of the household. These two opposite channels can help explain the empirical results. For sufficiently high degree of complementarity between the public good and private consumption in the aggregate consumption bundle, our model predicts positive effects of government wage shocks on private activity, as found for state and local government wages in the data. On the other hand, when the complementarity channel is weaker, the wage spillover effect in the private sector dominates, leading to a substantial fall in private employment and a short-run contraction in private activity.

Our analysis therefore suggests that the public good provided at the federal level may exhibit a different degree of complementarity with private consumption than that at state and local level. This might be justified by the different nature of the public good provided in each case. For instance, federal government employees largely comprise military and defense employees, while state and local government employees provide mainly education, health care and transportation services. Research by Fiorito and Kollintzas (2004) using European data has indeed shown that the degree of complementarity between government and private consumptions is not homogeneous over types of public expenditures. In particular, "merit goods", including health and education, complement private consumption while "public goods", referring to

²The response of private consumption following total government spending shocks has received much attention in the literature. Deep habits or rule-of-thumb consumers have been shown to generate consumption crowding in (e.g., Ravn et al., 2006 and Gali et al., 2007), whereas another class of models includes government investment as part of the production function (Leeper et al., 2010, Drautzburg and Uhlig, 2015). Monacelli et al. (2010) show that a combination of consumption-leisure complementarity in household's preferences and New Keynesian features can generate consumption crowding in a model with search and matching frictions.

defense, public order and justice, are substitutes with private consumption. This idea is in line with recent work by Perotti (2014) who shows that defense spending shocks in a SVAR generate "contractionary" responses, while civilian government spending shocks generate large "expansionary" responses. The theoretical explanation provided in that paper is based on the assumption that civilian spending exhibits Edgeworth complementarity with private consumption, while defense spending is not utility enhancing. In a similar vein, Pieroni and Lorusso (2015) present VAR estimates for the U.S. economy showing that civilian expenditure induces a positive response on private consumption, whereas military spending has a negative impact. Our results square well also with the evidence presented in Bouakez and Rebei (2007) who, using a maximum-likelihood estimation with U.S. data, find a strong Edgeworth complementarity between the two types of consumption goods. Also, Fève et al. (2013) show that government spending multipliers obtained in the literature may be downward biased because the standard approach does not allow for complementarities between private consumption and government spending in the utility function.

Our work has a number of useful policy implications in the aftermath of the crisis and the slow recovery in advanced countries. In particular, increases in public employment can stimulate the private sector's employment, encourage labor force participation and private demand. On the other hand, public wage policies could be expansionary only if the increases in wages are associated with the production of those public goods that strongly complement private consumption. Wage increases should target, for instance, employees that work in public education or the public health system.

The outline of the paper is as follows. The next section describes the data on the U.S. government wage bill and public employment, the estimated VAR model and empirical findings. Section 3 presents our theoretical model which matches qualitatively the empirical evidence. Finally, Section 4 concludes.

2 Empirical analysis

2.1 Data

As shown in Figure 1(a), since the 1970s public wage expenditures have accounted for around 50% on average of government expenditures in the U.S. and around 5% of GDP. Although the literature has looked extensively at the macroeconomic effects of certain components of U.S.

government spending, such as public investment, research on the effects of the public wage bill has been surprisingly limited, despite the fact that it represents the largest component of spending, as shown in Figure 1(b). Looking at a decomposition of public wage expenditures by government level, we see a shift over time towards states and localities, with the federal share amounting to between 20% and 30% from the 2000s (Figure 1(c)). In 1980, federal civilian employees made up 2.3% of the workforce, while they accounted for 1.7% of the workforce in 2010 ((Falk (2012))). For the past 30 years, the number of civilians employed by the federal government has fluctuated around 2 million people (see Figure 2). Besides federal civilian workers, the armed services include steadily more than 2 million uniformed personnel.

In order to take a view of the variation in the government wage bill, in Figure 3 we plot the quarterly growth changes in the two basic components of the wage bill: government employment and the average real wage per employee.³ As can be readily seen, the various fiscal episodes (i.e. unusually large changes in the spending components) are not correlated: public employment at the total government level peaks in 1961Q4, 1966Q1, 1980Q2, 1990Q1 and 2000Q2, while the average wage rate peaks in 1955Q2, 1958Q2, 1969Q1, 1983Q4, 1992Q3 and 2003Q1. Those fiscal episodes can be related to several policy episodes in history. In particular, the data point to a significant increase in public employment in 1966 when the National Historic Preservation Act led to major changes in the federal and state employment in historic preservation fields; in 1977 after Carter’s appointment and job creation stimulus; in 1990 when President Bush increased government employment for defense in the face of the German reunification; and to a fall in public employment in 1980, after Reagan won the presidential election and cut the Comprehensive Employment and Training Act of 1974. Significant changes in government wages are observed in 1964, after the Civil Rights Act was passed, making the discrimination of employees based on race illegal; when the minimum wage increased to \$1.30 per hour in February 1969 and with the Minimum Wage Act of 1983.

2.2 The VAR model

In this subsection, we formalize the econometric framework in order to estimate the short-run effects of public employment and wage shocks on private activity. We consider a VAR model

³Government employment is defined as the number of government employees per capita, including both civilian and military employees. Data on the former comes from the Bureau of Labor Statistics, while the latter is constructed by Ramey (2011). The average real wage per employee is defined as the compensation of government employees divided by government employment and the GDP deflator.

of eleven endogenous variables. We first include the four main items of government spending: the log of real per capita government expenditure in goods purchases, defined as government consumption minus compensation of government employees, the log of real per capita gross fixed investment, the log of average real public wage per employee, and the log of government employment per capita. The second set of seven variables included in the VAR are: the log of real per capita net (of transfers) tax revenue, the log of real per capita private GDP, private consumption and private investment, the inflation rate, a measure of short-term interest rate and a labor market variable. The latter alternates between (i) the log of private employment per capita, (ii) the unemployment rate, (iii) the labor force participation rate, and (iv) the real private wage rate. Finally, in the VAR we include a constant, a linear trend and an exogenous war dummy variable with several lags to control for strong anticipation effects (see Ramey (2011)).

The type and number of variables included in the VAR is mainly dictated by the identification scheme we use in order to identify government employment and wage shocks, as described in the next subsection. The fact that we seek for the effects of fiscal shocks on the private economy is another reason that orientated us towards considering private sector's measures of most variables. The output variable, for instance, refers to the value added produced by the private sector, which equals total GDP net of the government wage bill (according to the definition of "Private Sector Production" in Ramey (2012), Figure 1). The exclusion of the government wage bill also allows us to isolate the second-round effects of public wage expenditures on output, net of the direct impact of the public wage bill on GDP.

According to information criteria, we set the lag length of the VAR to two. We carry out a Bayesian estimation using flat priors on the coefficients of the model and the covariance matrix of the shocks (see Uhlig (2005)).

We use quarterly, seasonally adjusted data for the U.S. from 1955 to 2007, excluding turbulent periods of extraordinary fiscal episodes or other special economic conditions (pre-1955 war periods, post-2007 crisis). We estimate the effects of spending policies by government level: federal government, state and local (S&L henceforth) governments, and total government (sum of federal and S&L). Hence, the VAR exercise is repeated three times, using government expenditure series for each government level. The series come from the Bureau of Economic Analysis, the Bureau of Labor Statistics and other sources. A detailed description is provided in Appendix A.

2.3 Identifying the shocks

We base the identification of the fiscal shocks on the sign restriction approach (Uhlig (2005), Canova and Pappa (2007), Mountford and Uhlig (2009), Pappa (2009)). The use of 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 and the scarceness of reasonable zero-identifying restrictions are to a large extent avoided. Since our goal is to estimate the effects of fiscal shocks on output, we cannot restrict output responses. We opt for an agnostic identification that sets a minimum set of sign restrictions on the responses to the fiscal shocks (Mountford and Uhlig (2009)).

More specifically, we identify idiosyncratic shocks to four government spending items (public employment, average public wage per employee, non-wage consumption and investment) that induce a positive comovement of the respective spending item and total government expenditure (calculated as the sum of the different spending components) for half a year.⁴ We also require the four spending shocks to be orthogonal among them. Given the assumption on orthogonality between the different fiscal shocks, government wage and employment shocks are easily distinguishable. To control for the business cycle, monetary policy and tax policies, the fiscal shocks are also orthogonal to a business cycle, a monetary policy and a tax shock, identified as in Mountford and Uhlig (2009). The sign restrictions used are summarized in Table 1.

The implementation of the sign restriction approach goes as follows. Let Σ be the covariance matrix of the VAR shocks and let $PP' = \Sigma$ an orthogonal decomposition of Σ . Then, structural shocks ε_t are constructed as $\varepsilon_t = P^{-1}u_t$, where u_t are reduced form shocks and, for each element of ε_t , we check if the required restrictions are satisfied. If no structural shock produces the required sign restrictions, the orthogonal decomposition is rotated by an orthonormal matrix H , with $HH' = I$, such that $\varepsilon_t = (PH)^{-1}u_t$, and the responses to the new set of shocks are examined. This search process continues, randomly drawing orthonormal matrices H . Since many H 's can in principle produce the required sign patterns, the error bands we report reflect not only the uncertainty in the reduced form parameter estimates but also how responses vary with different H 's.

⁴Notice that the series of total government spending is not included in the VAR as an extra variable to avoid multicollinearity problems. We implicitly compute its response by combining the responses of the sum of government consumption, investment and the wage bill.

2.4 Results

In Figure 4 we present the responses of output, employment, and the real wage in the private sector, as well as the unemployment and labor force participation rates, to the two fiscal shocks under investigation and for the various government levels considered. For comparability purposes, employment and wage shocks are scaled to represent a 1% of GDP increase in the government wage bill.⁵ Each graph presents median estimates (solid line) and pointwise 68% credible bands (dotted lines). According to Figure 4(a), a shock to total (i.e. the sum of federal and S&L) government employment significantly stimulates private output and consumption for at least ten quarters. Furthermore, private employment significantly rises, the unemployment rate falls and the labor force participation is significantly encouraged in the medium run. Notably, public employment shocks are robustly expansionary at any level of government. Responses for the different government levels are comparable qualitatively for all variables apart from the private wage. At the S&L level the private wage increases significantly after a government employment shock, while at the federal level its response is negative and insignificant. Also, quantitatively the effect of government employment shocks is significantly more pronounced at the S&L level relative to the federal level.

On the other hand, total government wage shocks have weak and almost no significant effects on output, while they induce a fall in private employment, a persistent increase in the private wage rate and an impact increase in the unemployment rate. Yet, conclusions differ substantially when one looks at the federal and the S&L government components of the wage bill spending. Shocks to the public wage at the federal level, according to Figure 4(b), induce a significant drop in private output, employment and investment and a surge in unemployment, while shocks to public wage at the S&L government level induce significant increases in private output and consumption, a significant and persistent increase in private wages and a lagged fall in unemployment (Figure 4(c)).

The difference in the impulse responses translates into differences in the fiscal multipliers. Table 2 presents point estimates of the impact output multipliers and the present-value cumulative multipliers up to five years after the shock. As in Mountford and Uhlig (2009), output multipliers are computed by dividing the present value cumulative response of output, y , by the present value cumulative response of total government spending, g , after a shock to each

⁵As in Perotti (2014), the responses to government employment (wage) shocks are divided by the initial response of government employment (wage), and further divided by the sample mean ratio of the government wage bill to GDP. In other words, this scaling refers to an increase in the wage bill induced only by the shocked wage bill component, as if the other component was kept fixed.

spending component, and finally dividing by the average government spending-to-GDP ratio, g/y (see the formula below). The discounting is based on the sample mean nominal interest rate, r .

$$\text{Present value multiplier at horizon } h = \frac{\sum_{j=0}^h (1+r)^{-j} y_j}{\sum_{j=0}^h (1+r)^{-j} g_j} \frac{1}{g/y}$$

Values for which corresponding 68% confidence intervals do not include zero are indicated with an asterisk.

Looking at the total government spending, shocks to government employment imply the highest output multipliers at all horizons. A 1% of GDP increase in government spending, induced by a shock to government employment implies an expansion of private output by 1.16%, 1.46% and 1.43%, one, three and five years after the shock, respectively. By contrast, government wage shocks generate insignificant multipliers.

Disaggregating by government level reveals that a 1% of GDP increase in government spending induced by a shock to federal government employment implies an expansion of private output by 0.96%, 1.11% and 1.07% one, three and five years after the shock, respectively. On the contrary, a 1% of GDP increase in government spending induced by a shock to federal government wages implies a contraction in private production by 1.15%, 1.08% and 1.01% one, three and five years after the shock, respectively. Finally, at the S&L level, multipliers are positive for both shocks, but take higher values for employment shocks at all horizons and, as noted earlier, multipliers at the S&L level for government employment and wage shocks are significantly higher than at the federal level.

2.5 Robustness

2.5.1 Controlling for all government levels

When identifying shocks to the federal or S&L public wage component one may worry that such shocks are correlated. Increases in the wages of federal employees might correlate with increases in the wages of public employees at the state and local level, for instance. To check the sensitivity of our results to the possible correlation of shocks to federal and local government wage bill spending, we repeat the estimation now controlling for the co-existence of federal and S&L shocks in the same VAR. In other words, when identifying federal (S&L) government shocks we further require the shocks to be orthogonal to a generic S&L (federal) government spending shock. We use the same VAR model enhancing it with an extra variable that stands for either

the federal or S&L government expenditure. The extra shock to federal (S&L) government spending is identified by making it orthogonal to all the rest of shocks, and further requiring federal (S&L) government spending to increase for three quarters.⁶ Figures 5(a) and 5(b) show the impulse responses to federal and S&L government spending shocks, while the middle panel of Table 2 presents the respective output multipliers. As can be easily seen, results remain unchanged: government employment shocks remain robustly expansionary at any government level, and have higher effects at the S&L level. S&L government wage increases also expand output and employment in the private sector, while federal wage increases have contractionary effects. Multipliers are also comparable.

2.5.2 An alternative identification scheme

Another robustness exercise is related to the identification scheme used to extract the fiscal shocks. In particular, we repeat our VAR analysis extracting the fiscal shocks using a simple recursive (Cholesky) identification (Blanchard and Perotti (2002)). We keep the same ordering of the variables as in the benchmark VAR. Impulse responses to total, federal and S&L shocks are presented in Figures 6(a), 6(b) and 6(c), respectively. As in our benchmark specification, a public employment increase leads to a significant expansion of private output, consumption and employment, and a significant increase in the participation rate. Those effects hold across any government level and are stronger at the S&L level as before. On the contrary, government wage shocks induce no significant effects on output at the aggregate level. When looking at the different government levels, we observe that federal wage shocks induce contractionary effects on output and employment in the private sector, while S&L government wage shocks are clearly expansionary, thus further confirming our benchmark conclusions. As demonstrated in Table 2 (bottom panel), the ranking and sign of the multipliers are similar to the ones obtained when we use sign restrictions to recover the shocks.

3 Theoretical analysis

In this section we develop a New Keynesian model with a public sector, search and matching frictions, and endogenous labor force participation. We assume that a public good produced

⁶Notice that, according to our benchmark identification scheme, this restriction to federal (S&L) government spending is common across shocks to government consumption, investment and wage bill. As a result, this restriction can sufficiently identify (and filter out) any government spending shock at the federal (S&L) level.

in the economy provides both productive services to private sector firms and utility-enhancing services to the representative household. There are three types of firms in the economy: (i) a public firm that produces the public good, which is provided for free (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 arise at the retail level, while search frictions occur in the intermediate goods sector. The household's members consist of employees, unemployed, and labor force non-participants. The government collects taxes and uses revenues to finance public expenditures, the cost of new vacancies in the public sector and the provision of unemployment benefits.

3.1 The model

3.1.1 Labor markets

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

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

where we assume that matches become productive in the same period. We also assume that $\sigma^p > \sigma^g$ in order to capture the fact that, relatively speaking, the public sector is characterized by greater job security.⁷ We consider search as being random and so there is one matching function that has unemployment, u_t , and the total number of vacancies, v_t^p and v_t^g , as inputs:

$$m_t^p + m_t^g = \rho_m (v_t^p + v_t^g)^\alpha u_t^{1-\alpha} \quad (2)$$

where the matching efficiency is given by ρ_m . We also assume equal vacancy filling probabilities in the two sectors:

$$\frac{v_t^g}{v_t^p} = \frac{m_t^g}{m_t^p} \quad (3)$$

⁷According to CBO estimates for the period 2005-2010, wages were on average higher for workers in the federal government than for private-sector workers (Falk (2012)).

3.1.2 Households

The representative household consists of a continuum of infinitely lived agents. The members of the household derive utility from leisure, which corresponds to the fraction of members that are out of the labor force, l_t , and a consumption bundle, cc_t , defined as:

$$cc_t = [\alpha_1(c_t)^{\alpha_2} + (1 - \alpha_1)(y_t^g)^{\alpha_2}]^{\frac{1}{\alpha_2}}$$

where y_t^g denotes a public good, taken as exogenous by the household, and c_t is private consumption. The instantaneous utility function is given by:

$$U(cc_t, l_t) = \frac{cc_t^{1-\eta}}{1-\eta} + \Phi \frac{l_t^{1-\varphi}}{1-\varphi}$$

where η is the inverse of the intertemporal elasticity of substitution, $\Phi > 0$ is the relative preference for leisure, and φ is the inverse of the Frisch elasticity of labor supply. The elasticity of substitution between the private and public goods is given by $\frac{\eta}{1-\alpha_2}$.⁸

At any point in time, a fraction n_t^j of the household members are employed in sector $j = p, g$ (i.e. private/public). Following Ravn (2008), the labor force participation choice is modelled as a trade-off between the cost of giving up leisure and the prospect of finding a job. In particular, the household chooses the fraction of the unemployed actively searching for a job, u_t , and the fraction which are out of the labor force and enjoying leisure, l_t , so that:

$$n_t + u_t + l_t = 1 \tag{4}$$

where $n_t = n_t^p + n_t^g$. The household owns the private capital stock, which evolves over time according to:

$$k_{t+1}^p = i_t^p + (1 - \delta^p)k_t^p - \frac{\omega}{2} \left(\frac{k_{t+1}^p}{k_t^p} - 1 \right)^2 k_t^p \tag{5}$$

where i_t^p is private investment, δ^p is a constant depreciation rate and $\frac{\omega}{2} \left(\frac{k_{t+1}^p}{k_t^p} - 1 \right)^2 k_t^p$ are adjustment costs. The intertemporal budget constraint is given by:

$$c_t + i_t^p + \frac{B_{t+1}\pi_{t+1}}{R_t} \leq [r_t^p - \tau_k(r_t^p - \delta^p)]k_t^p + (1 - \tau_n)(w_t^p n_t^p + w_t^g n_t^g) + \varpi u_t + B_t + \Pi_t^p + T_t \tag{6}$$

⁸When this elasticity is greater than one, c_t and y_t^g are substitutes, while when it is below one, they are complements. The Cobb-Douglas specification is obtained when the elasticity is equal to zero.

where $\pi_t \equiv p_t/p_{t-1}$ is the gross inflation rate, w_t^j , $j = p, g$, is the real wage in each sector, r_t^p is the real return on capital, ϖ denotes unemployment benefits, B_t is the real government bond holdings, R_t is the gross nominal interest rate, Π_t^p are the profits of the monopolistic retailers, discussed below, and τ_k, τ_n, T_t represent taxes on private capital, labor income and lump-sum transfers, respectively. The household's first order conditions are reported in Appendix B.

3.1.3 Production

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

$$y_t^p = (A_t n_t^p)^{1-\psi} (k_t^p)^\psi (y_t^g)^\nu \quad (7)$$

where A_t is aggregate technology, k_t^p and n_t^p are private capital and labor inputs, and y_t^g is the public good used in production, taken as exogenous by the firms. The public good is provided for free. The parameter ν regulates how the public input affects private production: when ν is zero, the government good is unproductive.

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

$$Q^p(n_t^p, k_t^p) = \max_{k_t^p, v_t^p} \{x_t y_t^p - w_t^p n_t^p - r_t^p k_t^p - \kappa v_t^p + E_t [\Lambda_{t,t+1} Q^p(n_{t+1}^p, k_{t+1}^p)]\} \quad (8)$$

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

$$n_t^p = (1 - \sigma^p) n_{t-1}^p + \psi_t^{fp} v_t^p \quad (9)$$

The first-order conditions are:

$$x_t \psi \frac{y_t^p}{k_t^p} = r_t^p \quad (10)$$

$$\frac{\kappa}{\psi_t^{fp}} = x_t(1 - \psi) \frac{y_t^p}{n_t^p} - w_t^p + E_t \Lambda_{t,t+1} [(1 - \sigma^p) \frac{\kappa}{\psi_{t+1}^{fp}}] \quad (11)$$

According to (10) and (11) the value of the marginal product of private capital should equal the real rental rate and the marginal cost of opening a vacancy should equal the expected marginal benefit. The latter includes the marginal productivity of labor minus the wage plus the continuation value, knowing that with probability σ^p the match can be destroyed.

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

$$V_{n^p t}^F \equiv \frac{\partial Q^p}{\partial n_t^p} = x_t(1 - \psi) \frac{y_t^p}{n_t^p} - w_t^p + \frac{(1 - \sigma^p)\kappa}{\psi_t^{fp}} \quad (12)$$

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, and thus the relative price of intermediate goods, x_t , coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i . The final consumption good can be expressed as:

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

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

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

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

$$p_t = [(1 - \chi)(p_t^*)^{1-\epsilon} + \chi(p_{t-1})^{1-\epsilon}]^{\frac{1}{1-\epsilon}} \quad (13)$$

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

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

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

$$p_{it}^* = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} p_{t+s}^x y_{it+s}}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} y_{it+s}} \quad (14)$$

3.1.4 Wage bargaining

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

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

where $V_{n^p t}^H$ and $V_{n^p t}^F$ have been defined above. The optimization problem leads to the following solution for w_t^p :

$$w_t^p = (1 - \vartheta) \left[x_t (1 - \psi) \frac{y_t^p}{n_t^p} + \frac{(1 - \sigma^p) \kappa}{\psi_t^{fp}} \psi_t^{hp} \right] + \frac{\vartheta}{(1 - \tau_n) \lambda_{c,t}} (\Phi l_t^{-\varphi} - (1 - \sigma^p) \lambda_{n,t}) \quad (15)$$

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, weighted by the worker's bargaining power, and the outside option of being unemployed, weighted by the firm's bargaining power.

3.1.5 Government

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

$$y_t^g = (A_t n_t^g)^{1-\mu} (k_t^g)^\mu \quad (16)$$

where we assume that TFP is not sector specific and μ is the share of public capital. The government holds the public capital stock. Similar to the case of private capital, the government capital stock evolves according to:

$$k_{t+1}^g = i_t^g + (1 - \delta^g) k_t^g - \frac{\omega}{2} \left(\frac{k_{t+1}^g}{k_t^g} - 1 \right)^2 k_t^g \quad (17)$$

Government expenditure consists of government consumption, modelled as a waste, public investment, public wage payments, public vacancy costs, unemployment benefits, and lump-sum transfers, while revenues come from the capital and labor income. The government deficit is therefore defined by:

$$DF_t = c_t^g + i_t^g + w_t^g n_t^g + \kappa v_t^g + \varpi u_t - TR_t$$

where $TR_t \equiv (w_t^p n_t^p + w_t^g n_t^g) + \tau_k (r_t^p - \delta^p) k_t^p - T_t$ denotes tax revenues net of transfers. The government budget constraint is given by:

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

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:

$$T_t = \bar{T} \exp(\zeta_{\mathfrak{B}} (\mathfrak{B}_t - \bar{\mathfrak{B}})) \quad (18)$$

where $\bar{\mathfrak{B}}$ is the steady state level of debt to GDP ratio, $\mathfrak{B}_t = \frac{B_t}{y_t}$. If $\Psi^g = v^g$, w^g denotes the different fiscal instruments, we assume fiscal rules of the form:

$$\Psi_t^g = \bar{\Psi}^g (\Psi_{t-1}^g)^{\rho_g^{\psi}} \exp(\varepsilon_t^{\psi g}) \quad (19)$$

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

3.1.6 Monetary policy

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

$$R_t = \bar{R} \exp(\zeta_{\pi} \pi_t) \quad (20)$$

where π_t measures inflation in deviation from the steady state.

3.1.7 Resource constraint

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

$$y_t^p = c_t^p + i_t^p + i_t^g + \kappa(v_t^p + v_t^g) \quad (21)$$

3.2 Calibration

We solve the model by linearizing the equilibrium conditions around a non-stochastic steady state in which all prices are flexible, the price of the private good is normalized to unity, and inflation is zero. We calibrate the model for the U.S. at a quarterly frequency. Table 3 shows the key parameters and steady-state values targeted in our calibration.

We calibrate the labor force participation and unemployment rate to match the observed average values. Thus, we set labor force participation, $1-l \equiv n + u$, equal to 65% and the unemployment rate to 6.5%. We fix the separation rate in the public sector $\sigma^g = 0.045$ and in the private sector $\sigma^p = 0.05$, which is comparable with the estimates for the job separation rate in Hobijn and Sahin (2009). We set the probability of filling a vacancy $\psi^{fp} = 0.4$, and the matching elasticity with respect to vacancies $a = 0.6$.

The capital depreciation rates, δ^g and δ^p , are set equal to 0.025. Following the literature, we set the discount factor $\beta = 0.99$, which implies a quarterly real rate of interest of approximately 1%. The elasticity of demand for retail goods, ϵ , is set such that the gross steady state markup, $\frac{\epsilon}{\epsilon-1}$, is equal to 1.25, and the price of the final good is normalized to one. The TFP parameter, A , is normalized to one. For the capital share in the private sector production function we assume a standard value $\psi = 0.36$, and in the public sector production function we use $\mu = 0.1$. We set the capital ratio $k^g/k^p = 0.31$ using data from Kamps (2006).

We set the replacement rate $\frac{\varpi}{w^p} = 0.45$, following Brückner and Pappa (2012). The tax rates are set as follows: $\tau^n = 30\%$, and $\tau^k = 20\%$. The steady state debt-to-GDP ratio takes the value $\beta_t = 60\%$ annually.

We set $\alpha_1 = 0.95$ for the share of private consumption in the aggregate consumption bundle of the household. Regarding the inverse elasticity of intertemporal substitution, η , much of the literature cites the econometric estimates of Hansen and Singleton (1983), which place it "between 0 and 2". In our calibration, we set $\eta = 0.5$. Following the literature on Edgeworth complementarity between private and public consumption goods (see, e.g., Bouakez and Rebei (2007), Fiorito and Kollintzas (2004), Fève et al. (2013)), we set $\alpha_2 = -1.95$, which implies

elasticity of substitution between the private and public goods given by $\frac{\eta}{1-\alpha_2}$ equal to -0.5. The inverse of the Frisch elasticity, φ , is set equal to 1.5, in the range of Domeij and Floden (2006).

Finally, the model's steady state is independent of the degree of price rigidities, the monetary policy rule, and the size of the capital adjustment costs. Capital adjustment costs are included to moderate the response of investment with respect to fiscal shocks. We set the inflation targeting parameter in the Taylor rule $\zeta_\pi = 1.5$, the capital adjustment costs $\omega = 0.1$ and the price-stickiness parameter $\chi = 0.75$.

3.3 Results

In Figure 7 we present impulse response functions to a 1% of steady state output increase in the public wage bill induced by an increase in public vacancies and in public wages, respectively. The responses of our benchmark parameterization are denoted by solid lines. All responses are expressed in percentage deviations from respective steady state values, with the exception of the unemployment and labor force participation rates that are expressed in absolute percentage points. We first report the results of our benchmark calibration for which public wage shocks have contractionary effects on private sector production in the short run. We then investigate which are the key elements of the model that can account for the case of positive output effects, as found for S&L government wage shocks.

The predictions of our theoretical model match well the empirical evidence for public employment shocks (see Figure 7, top panel). It can be readily seen that this type of shock to the government wage bill is expansionary for the private sector by crowding in consumption and increasing labor force participation and employment. In particular, the complementarity of the public good with private consumption in the aggregate consumption bundle of the household overturns the negative wealth effect of the shock and leads to an increase in private consumption. The unemployment rate initially rises due to the increase in labor market participation and then falls given the rise in employment. This pattern matches especially well the response observed in the data for S&L government employment shocks.

Our model can also explain how government wage shocks can be contractionary or expansionary, as found in the data, depending on the relative magnitude of the forces at play. More specifically, wage shocks lead to public-private wage spillovers, inducing a negative labor demand effect and a fall in employment in the private sector, as well as an increase in unemployment. At the same time, there is a boost in the production of the public good as labor supply

and employment in the public sector increase. Consequently, public wage shocks can lead to a crowd in of private consumption given the complementarity of the latter with the public good in the aggregate consumption bundle of the household. These two opposite channels can help explain the empirical results. As we can see in Figure 7 (bottom panel), with our benchmark calibration we observe a short run contraction in private-sector production and a rise in the unemployment rate, which matches the empirical evidence found for federal wage shocks. In this case the complementarity channel is not sufficiently strong to overturn the wage increase and the negative labor demand effect in the private sector. We next examine whether increasing the degree of complementarity between the public good and private consumption can generate an expansion in the private sector, as observed in the data for S&L government wage shocks.

3.4 The complementarity between public and private goods

As already emphasized, the degree of complementarity between the public good and private consumption in the aggregate consumption bundle of the household is key for determining the effects of government wage shocks. In this subsection, we investigate how varying this complementarity affects the transmission of both types of shocks to the public wage bill. The dashed lines in Figure 7 (top panel) represent responses to a shock in government vacancies when we increase the degree of complementarity between public and private goods (by setting $\alpha_2 = -3.9$). As we can see, the effects of government vacancy shocks are significantly more pronounced than in our benchmark calibration. This is line with the empirical evidence for public employment shocks exhibiting stronger effects at the S&L level relative to the federal level.⁹ Turning to the public wage shocks (see Figure 7, bottom panel), with a higher complementarity between public and private goods, the increase in private consumption becomes larger, which is in line with the empirical evidence on the responses of consumption (i.e., significantly positive for S&L government wage shocks and insignificant for federal government wage shocks). Also in line with the empirical evidence, the fall in investment is somewhat more pronounced now. In turn, the fall in private employment becomes smaller and so does the rise in the private wage. The increase in public employment and output leads now to an expansion in private-sector production.

Our theoretical analysis therefore seems to suggest that the public good provided at the federal level may exhibit a different degree of complementarity with private consumption. This

⁹Note that one exception is the response of the real wage, which however is not robust to the alternative Cholesky identification scheme.

might be justified by the different nature of the public good provided in each case. For instance, federal government employees largely comprise military employees, and even one-third of the federal civilian workforce are employed in the Department of Defense.¹⁰ On the other hand, S&L government employees provide mainly education, health care and transportation services.¹¹ Research by Fiorito and Kollintzas (2004) with European data has indeed shown that the degree of complementarity between government and private consumptions is not homogeneous over types of public expenditures. In particular, they find that while some categories of public spending seem to be substitutable with private consumption, there are also public expenditure categories which are complements to private spending. More importantly, they report that the latter case of complementarity seems to be the stronger relation, such that overall government and private consumption are complements in the aggregate. "Merit goods", including health and education, complement private consumption while "public goods", referring to defense, public order and justice, are substitutes with private consumption. Bouakez and Rebei (2007) further note that examples of public goods that are highly complementary with private consumption include education and transportation. This idea is in line with recent work by Perotti (2014) who shows that defense spending shocks in a SVAR generate "contractionary" responses, while civilian government spending shocks generate large "expansionary" responses. The theoretical explanation provided in that paper is based on the assumption that civilian spending exhibits Edgeworth complementarity with private consumption, while defense spending is a waste. In a similar vein, Pieroni and Lorusso (2015) present VAR estimates for the U.S. economy showing that government civilian expenditure induces a positive response on private consumption, whereas military spending has a negative impact.

3.5 The productive role of the public good

Our analysis so far highlights the importance of the public good in the utility function of the household. One might ask though whether the presence of the public good in the production function of the private sector could be an alternative channel that can explain the mixed

¹⁰Falk (2012) provides detailed information on the occupational tasks of the federal civilian workforce: 57% of them worked at three departments in 2010: (i) the Department of Defense employs more than one-third; (ii) the Department of Veterans Affairs employs 14%; (iii) the Department of Homeland Security employs 8%. Another 40% of federal civilian employees work for the other departments and agencies of the executive branch, while the remaining 3% is employed by the legislative and judicial branches of government.

¹¹As reported by McNichol (2012), by far the largest share of S&L government workers in 2010 were the nearly 7 million teachers and support staff working in the nation's schools. Other important categories of S&L employment are protective services (including police officers and fire fighters), higher education, health care, and transportation (including road maintenance workers and bus drivers).

sign of the output response for public wage shocks. In this subsection, we show in Figure 8 that even though increasing the degree of productivity of the public good (by setting $\nu = 0.35$) can generate an expansion in private sector production following a government wage shock, it fails nevertheless to account for the positive response of private employment after a shock to government vacancies. As can be seen by the dashed lines in Figure 8 (top panel), private employment falls in this case as the rise in labor market participation is not sufficiently strong to overturn the drop in hirings in the private sector associated with the larger marginal product of labor and the larger increase in wages. The rise of private employment after a public employment shock is a robust finding in the data that holds across all government levels considered. We therefore conclude that the main theoretical channel explaining our empirical evidence remains the complementarity between private consumption and the public good in the aggregate consumption bundle of the household.

4 Concluding remarks

This paper estimated the effects of public wage expenditures on output and the labor market of the private sector in U.S. data by identifying shocks to public employment and public wages. Public wage shocks do not induce significant effects on output, but a disaggregation by government level reveals that the effects can be contractionary at the federal level and expansionary at the state and local level. On the other hand, public employment shocks are robustly expansionary at all government levels by crowding in private consumption and increasing labor force participation and private-sector employment. Shocks to state and local government wages lead to a similar crowd in of private consumption, while shocks to federal government wages lead to public-private wage spillovers, inducing a negative labor demand effect, a sharp fall in private-sector employment and an increase in unemployment. We developed a DSGE model with a public good providing both productive and utility-enhancing services, search and matching frictions, and endogenous labor force participation which was able to explain the qualitative properties of the empirical evidence. Our theoretical framework showed that the sign of the output response for public wage shocks depends crucially on the degree of complementarity between the public good and private consumption in the aggregate consumption bundle.

Our analysis therefore suggests that the public good provided at the federal level may exhibit a different degree of complementarity with private consumption than that at state and local level. This might be justified by the different nature of the public good provided in each

case. For instance, federal government employees largely comprise military and defense employees, while state and local government employees provide mainly education, health care and transportation services. Our work has a number of useful policy implications in the aftermath of the crisis and the slow recovery in advanced countries. In particular, increases in public employment can stimulate the private sector's employment, encourage labor force participation and private demand. On the other hand, public wage policies could be expansionary only if the increases in wages are associated with the production of those public goods that strongly complement private consumption. Wage increases should target, for instance, employees that work in public education or the public health system.

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APPENDIX

A Data definitions and sources

Government consumption: Consumption expenditures, Item 18, Table 3.1. (Total Government) - Item 21, Table 3.2. (Federal Government) - Item 23, Table 3.3. (S&L Governments) - Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Government wage bill: Compensation of general government employees, Item 4 (Total Government) - Item 15 (Federal Government) - Item 50 (S&L Governments), Table 3.10.5. Government Consumption Expenditures and General Government Gross Output, Source: Bureau of Economic Analysis.

Government non-wage consumption: *Government consumption* minus *Government wage bill*

Government investment: Gross government investment, Item 36, Table 3.1. (Total Government) - Item 41, Table 3.2. (Federal Government) - Item 39, Table 3.3. (S&L Governments) - Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Civilian government employment (Total): All Employees: Government, CES9000000001, Source: US. Bureau of Labor Statistics.

Civilian government employment (Federal): All Employees: Government: Federal, CES9091000001, Source: US. Bureau of Labor Statistics.

Government employment (State and Local): *Civilian government employment (Total)* minus *Civilian government employment (Federal)*

Military employment: Source: Ramey's (2011) dataset

Government employment (Total): the sum of *Civilian government employment (Total)* and *Military employment*

Government employment (Federal): the sum of *Civilian government employment (Federal)* and *Military employment*

Government wages per employee: the ratio of *Government wage bill* to *Government employment*

Net (of transfers) tax revenue (Total government): Current tax receipts (Item 2) plus Contributions for government social insurance (Item 7) plus Current transfer receipts (Item 13) minus Current transfer payments (Item 19) minus Subsidies (Item 27), Table 3.1. Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Net (of transfers) tax revenue (Federal): Current tax receipts (Item 2) plus Contributions for government social insurance (Item 11) plus Current transfer receipts (Item 16) minus Current transfer payments (Item 22) minus Subsidies (Item 32), Table 3.2. Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

Net (of transfers) tax revenue (State and Local): Current tax receipts (Item 2) plus Contributions for government social insurance (Item 11) plus Current transfer receipts (Item 16) minus Current transfer payments (Item 24) minus Subsidies (Item 30), Table 3.3. Government Current Receipts and Expenditures, Source: Bureau of Economic Analysis.

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

Private output: Total output minus Government wage bill.

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

Private investment: Non-residential investment, Item 9, Table 1.1.5. Gross Domestic Product, Source: Bureau of Economic Analysis.

Private employment: All Employees: Private, CES0500000001, Source: US. Bureau of Labor Statistics.

Private wage rate: Nonfarm Business Sector: Real Compensation Per Hour, Source: US. Bureau of Labor Statistics.

Unemployment rate: Unemployment Rate, LNS14000000, Source: US. Bureau of Labor Statistics.

Labor force participation: Labor Force Participation Rate, LNS11300000, Source: US. Bureau of Labor Statistics.

Inflation rate: the quarterly growth rate of GDP deflator

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

GDP deflator: Gross Domestic Product, Item 1, Table 1.1.4 Price Indexes for Gross Domestic Product, Source: Bureau of Economic Analysis.

Population: Series LNU00000000, Source: US. Bureau of Labor Statistics.

B F.O.C. from the household's problem

If we denote by λ_{ct} , $\lambda_{n^p t}$, $\lambda_{n^g t}$, λ_{ut} the Lagrange multipliers, the first-order conditions of the household's optimization problem are:

[wrt c_t]

$$cc_t^{(1-\eta-\alpha_2)} \alpha_1 (c_t)^{(\alpha_2-1)} = \lambda_{ct} \quad (\text{A1})$$

[wrt K_{t+1}^p]

$$\lambda_{ct} \left[1 + \omega \left(\frac{K_{t+1}^p}{K_t^p} - 1 \right) \right] = \beta E_t \lambda_{ct+1} \left\{ 1 - \delta^p + [r_{t+1}^p - \tau_k (r_{t+1}^p - \delta^p)] + \frac{\omega}{2} \left[\left(\frac{K_{t+2}^p}{K_{t+1}^p} \right)^2 - 1 \right] \right\} \quad (\text{A2})$$

[wrt B_{t+1}]

$$\lambda_{ct} \pi_{t+1} = \beta E_t \lambda_{ct+1} R_t \quad (\text{A3})$$

[wrt n_{t+1}^j]

$$\lambda_{n^j t} = \beta E_t [\lambda_{ct+1} (1 - \tau^n) w_{t+1}^j + \lambda_{n^j t+1} (1 - \sigma^j) - U_{l,t+1}] \quad \text{for } j = p, g \quad (\text{A4})$$

[wrt u_t]

$$\lambda_{n^p t} \psi_t^{hp} + \lambda_{n^g t} \psi_t^{hg} + \lambda_{ct} \varpi = U_{l,t} \quad (\text{A5})$$

where $U_{l,t} \equiv \Phi l_t^{-\varphi}$ is the marginal utility from leisure (labor market non-participation). Equations (A1)-(A3) are standard and include the arbitrage conditions for the returns to private consumption, private capital and bonds. Equation (A4) 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 (A5) states that the value of being search active (rather than non-participating), $\lambda_{ct} \varpi$, plus the expected marginal values of being employed, $\lambda_{n^j t}$, weighted by the job finding probabilities, ψ_t^{hj} , should equal the marginal utility from leisure, $U_{l,t}$.

Tables

Table 1: Identifying restrictions							
Restricted variables	<i>shocks</i>						
	ε_t^{cg}	ε_t^{ig}	ε_t^{ng}	ε_t^{wg}	ε_t^{BC}	ε_t^{MP}	ε_t^T
Output					+		
Private consumption					+		
Private investment					+		
Inflation rate						+	
Interest rate						-	
Tax revenue							+
Total government expenditure	+	+	+	+			
Government (non-wage) consumption	+						
Government investment		+					
Government employment			+				
Government wage per employee				+			
Notes: All restrictions apply to 0-3 periods after the shock.							
ε_t^{cg} : government consumption shock, ε_t^{ig} : government investment shock, ε_t^{vg} : government employment shock							
ε_t^{wg} : government wage shock, ε_t^{BC} : business cycle shock, ε_t^{MP} : monetary policy shock, ε_t^T : tax shock							

Table 2: Output Multipliers

	Benchmark VAR					
	Total		Federal		State & Local	
	Ng	Wg	Ng	Wg	Ng	Wg
T=0	0.87	0.52	0.72*	-0.27	3.13*	3.73
T=1	1.16*	0.16	0.96*	-1.15*	3.57*	3.22*
T=2	1.41*	0.31	1.06*	-1.17*	4.42*	3.38*
T=3	1.46*	0.40	1.11*	-1.08*	4.64*	3.44*
T=4	1.44*	0.42	1.09*	-1.03*	4.59*	3.46*
T=5	1.43*	0.42	1.07*	-1.01*	4.49*	3.44*

	VAR, controlling for all government levels			
	Federal		State & Local	
	Ng	Wg	Ng	Wg
T=0	1.12	-0.42	2.01	3.37*
T=1	1.74*	-1.54*	2.81*	2.56*
T=2	1.97*	-1.21*	3.74*	2.79*
T=3	2.00*	-0.87	3.97*	2.99*
T=4	1.97*	-0.69	3.90*	3.05*
T=5	1.96*	-0.61	3.81*	3.05*

	VAR, Cholesky identification					
	Total		Federal		State & Local	
	Ng	Wg	Ng	Wg	Ng	Wg
T=0	1.92*	0.19	1.47*	-3.81*	5.12*	5.28*
T=1	2.72*	-0.66	3.13*	-4.97*	5.06*	5.23*
T=2	3.16*	-0.70	4.28*	-5.16*	6.14*	2.76*
T=3	3.21*	-0.29	4.48*	-4.35*	5.67*	2.57*
T=4	3.05*	0.06	3.34	-3.73*	4.48*	2.89*
T=5	2.59	0.20	1.26	-3.10*	3.40*	3.02*

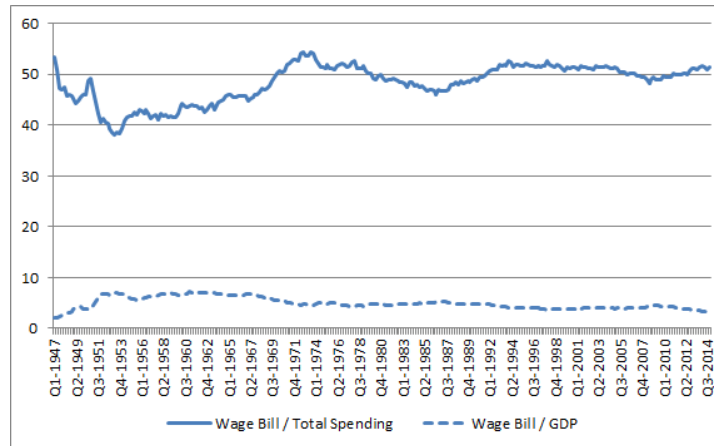
Ng: government employment, Wg: government wages

Table 3: Parameter values

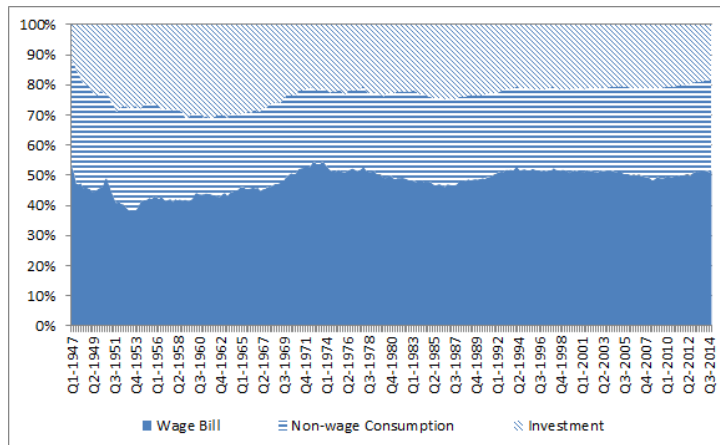
Parameters	Description	Values	Parameters	Description	Values
β	discount factor	0.99	ψ^{fp}	priv. vacancy filling probability	0.4
η	risk aversion coefficient	0.5	$\frac{\kappa}{w^p}$	vacancy cost - wage ratio	0.045
α_1	private consumption share in CC	0.95	$\frac{u}{1-l}$	unemployment rate	0.065
α_2	CES elasticity	-1.95	$\frac{n^g}{n}$	public employment share	0.16
φ	inverse of Frisch elasticity	1.5	$\frac{\varpi}{w^p}$	replacement rate	0.45
ν	productivity of public goods	0.15	$\frac{w^g}{w^p}$	steady-state wage ratio	1.01
ψ	productivity of private capital	0.36	α	matching elasticity	0.6
μ	productivity of public capital	0.1	$1 - l$	labor participation rate	0.65
$\frac{K^g}{K^p}$	steady-state capital ratio	0.31	σ^g	public separation rate	0.045
δ^j	capital depreciation rate	0.025	σ^p	private separation rate	0.05
ω	adjustment costs parameter	0.1	$\frac{\varepsilon}{\varepsilon-1}$	steady-state markup	1.25
τ^n	labor tax rate	0.3	χ	price stickiness	0.75
τ^k	capital tax rate	0.2	ϱ_g^ψ	persistence of shocks	0.8
$\bar{\beta}$	debt to GDP ratio	0.6	ζ_β	debt coefficient	-2
A	steady-state TFP	1	ζ_π	Taylor's π coefficient	1.5

Notes: $j = p, g$ and $\psi = v^g, w^g$

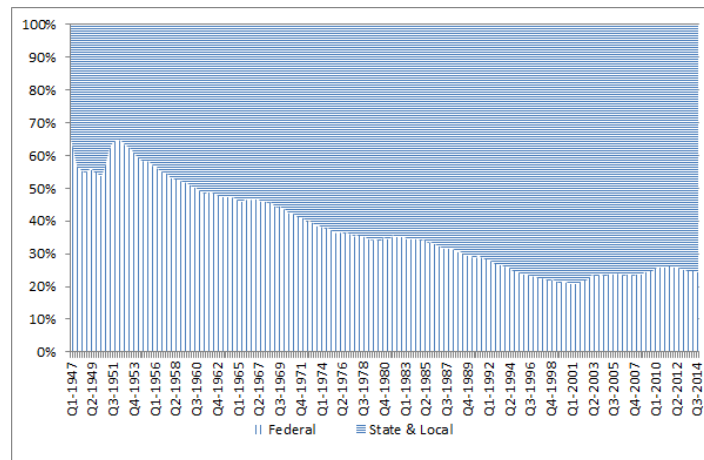
Figures



(a) Historical evolution



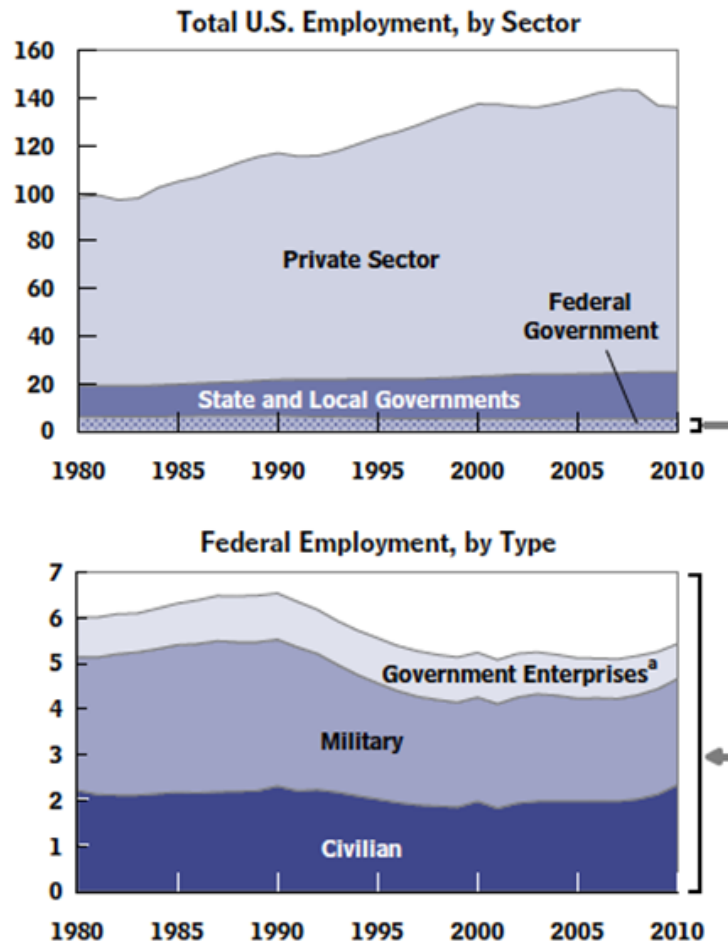
(b) Comparison with the other spending components (as % of total spending)



(c) Disaggregation by government level

Figure 1: The government wage bill in the U.S. (Data source: BEA)

(Millions of people)

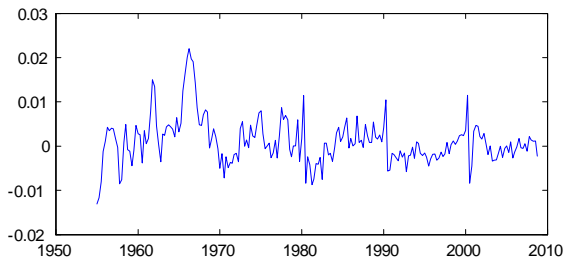


Source: Congressional Budget Office based on data from the national income and product accounts.

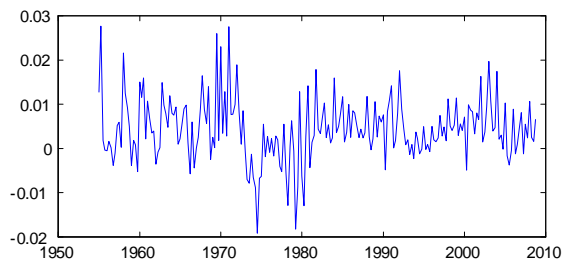
Note: This figure includes employees who work part time or part of the year.

a. Government enterprises are federal entities that typically fund their operating costs, including employees' compensation, through the sale of services rather than through tax revenue. By far the largest government enterprise in terms of employment is the Postal Service.

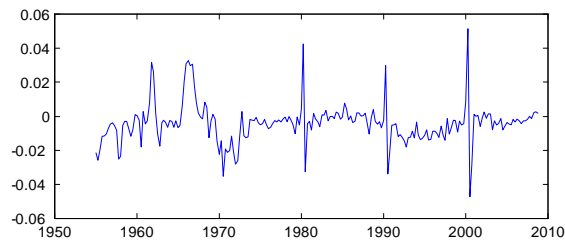
Figure 2: Trends in U.S. government employment, 1980-2010 (Source: Falk (2012))



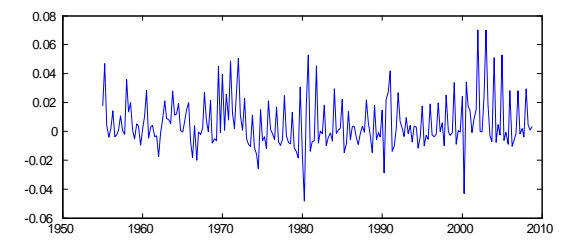
(a) Growth rate of total government employment



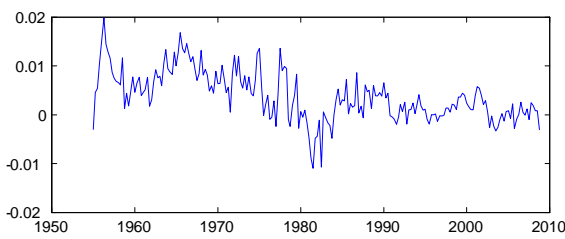
(b) Growth rate of total government wage rate



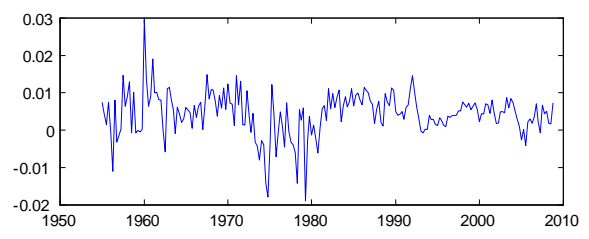
(c) Growth rate of federal government employment



(d) Growth rate of federal government wage rate

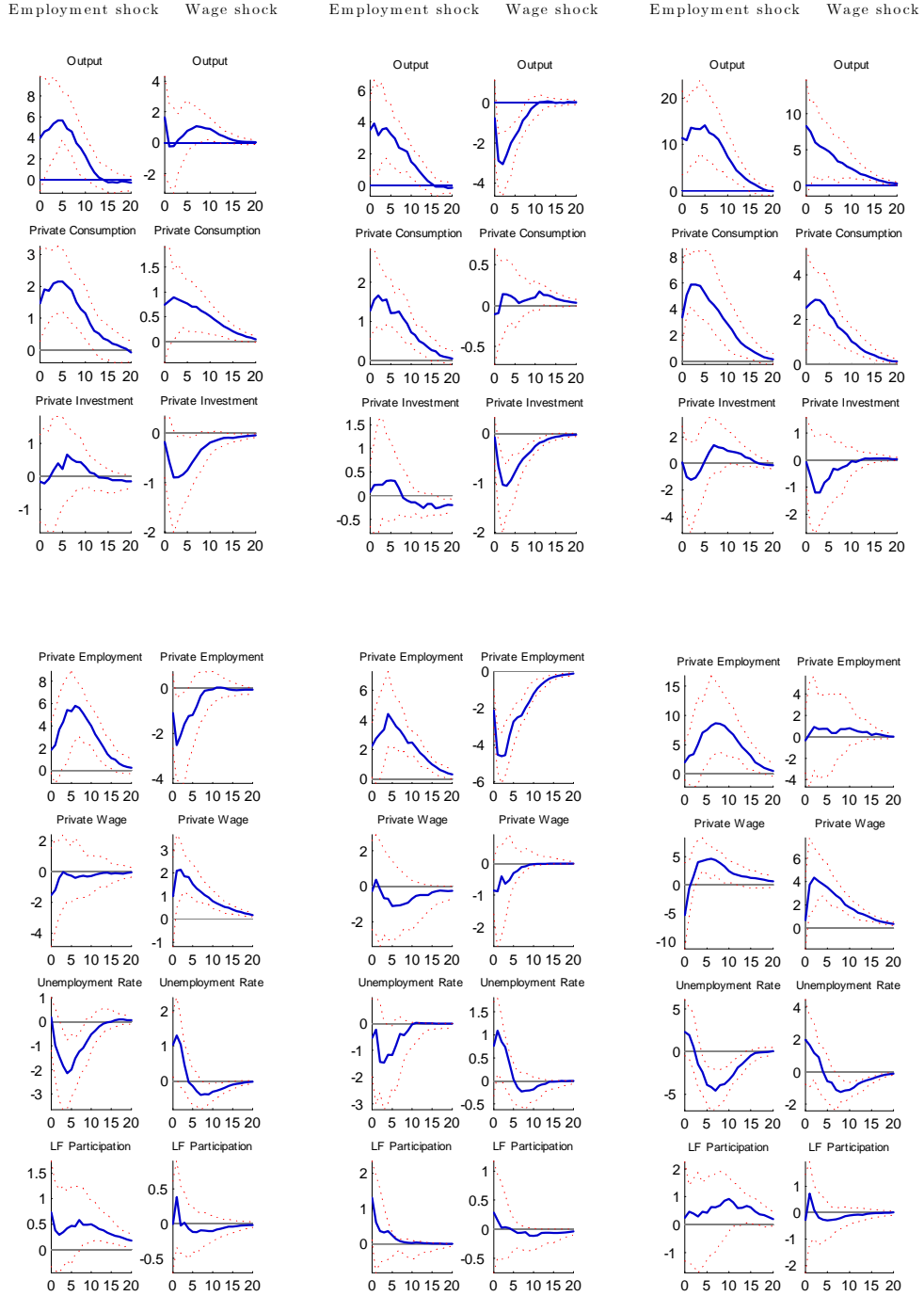


(e) Growth rate of S&L government employment



(f) Growth rate of S&L government wage rate

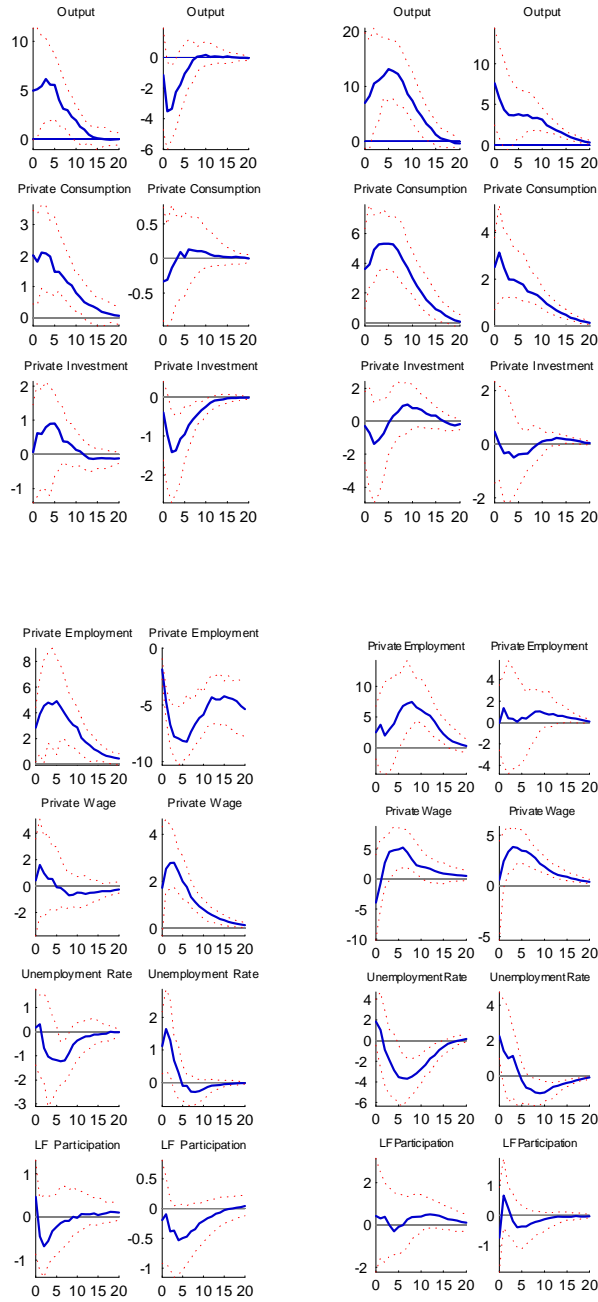
Figure 3: The volatility in U.S. government expenditure series



(a) Total Government (b) Federal Government (c) S&L Government

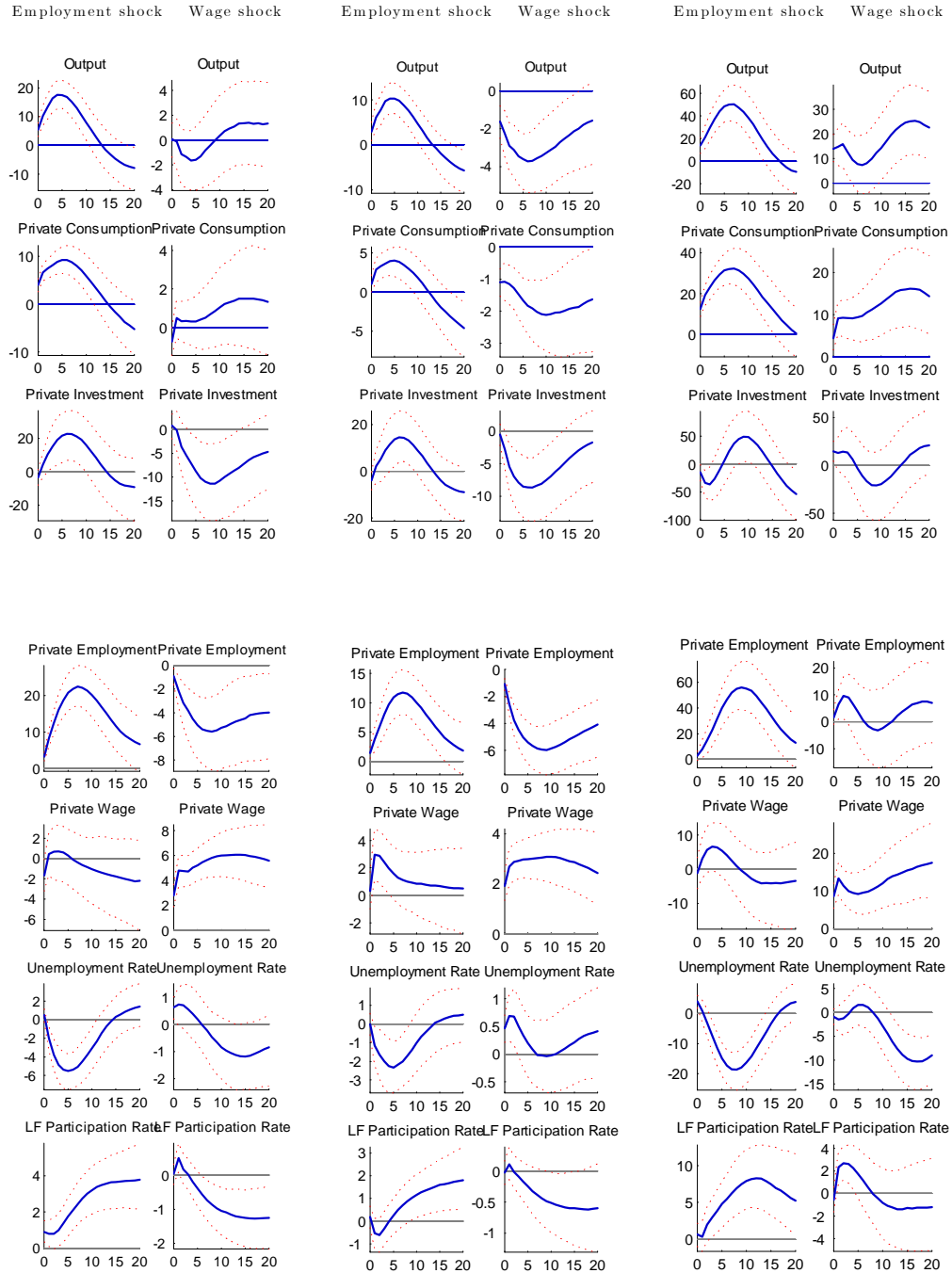
Figure 4: Impulse responses to government employment and wage shocks

Employment shock Wage shock Employment shock Wage shock



(a) Federal Government (b) S&L Government

Figure 5: Impulse responses to government employment and wage shocks, controlling for shocks at all government levels



(a) Total Government (b) Federal Government (c) S&L Government

Figure 6: Impulse responses to government employment and wage shocks,
Cholesky identification

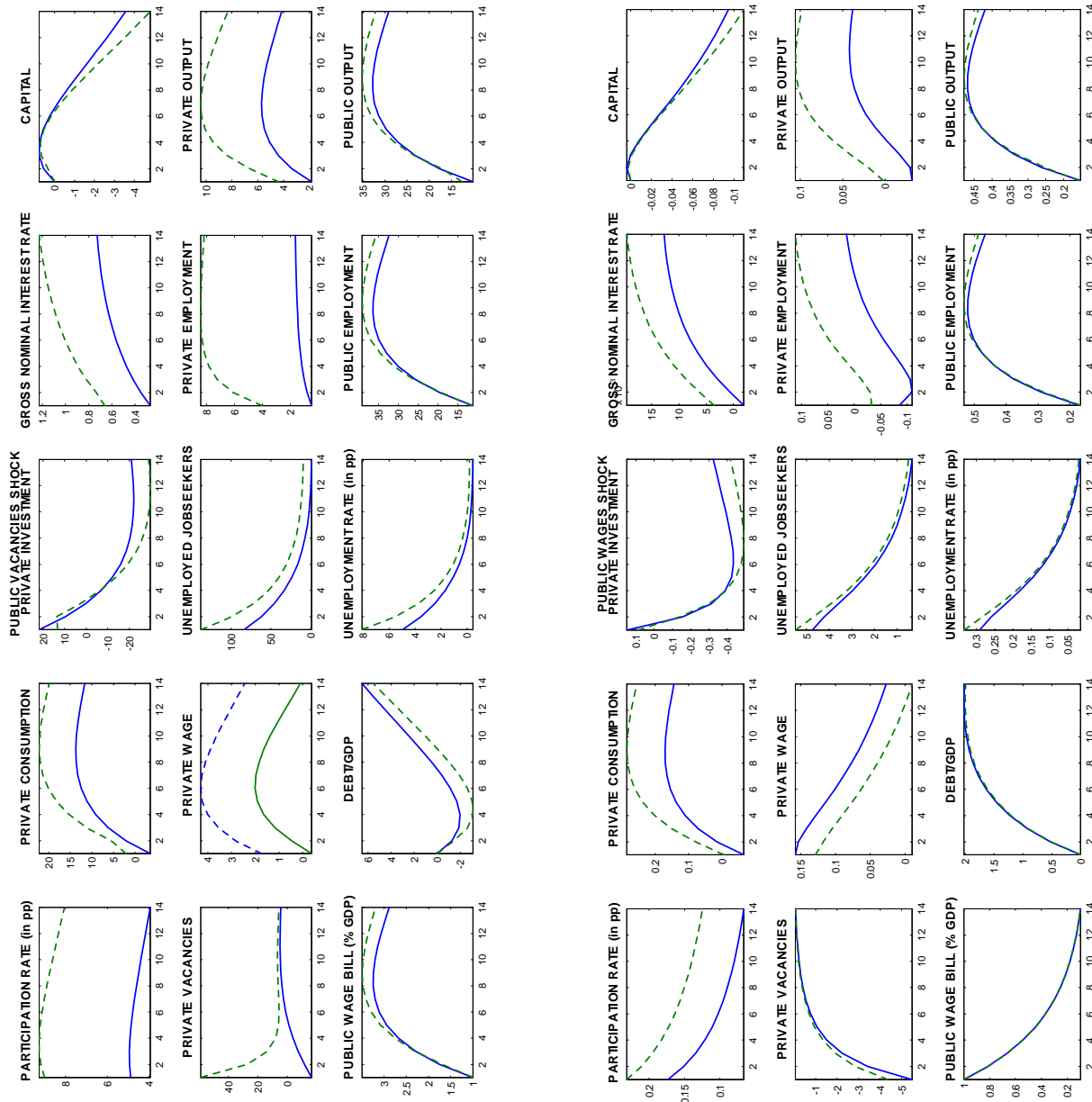


Figure 7: Theoretical impulse responses to a rise in the public wage bill equal to 1% of GDP (solid lines: benchmark calibration, dashed lines: higher degree of complementarity)

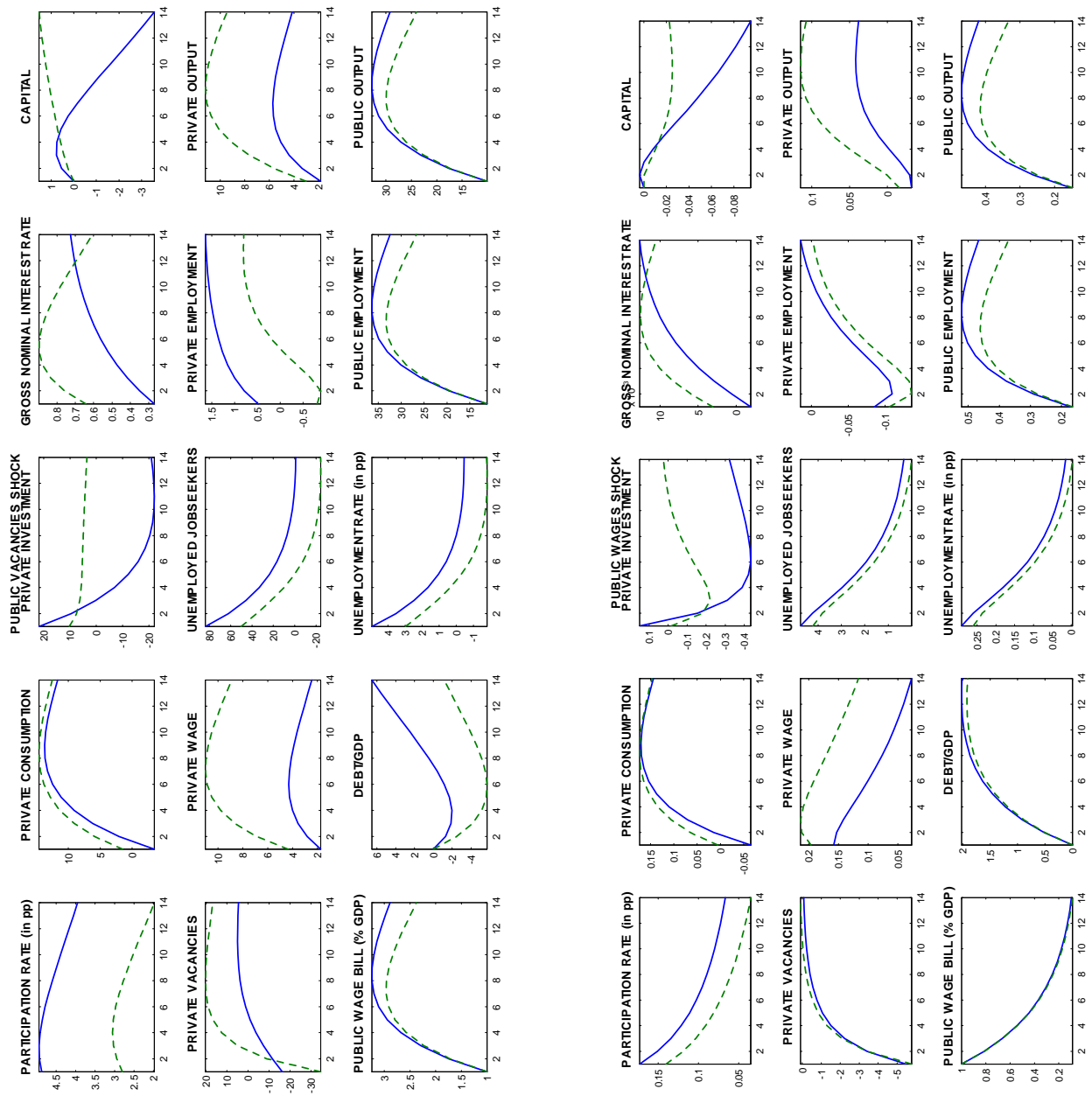


Figure 8: Theoretical impulse responses to a rise in the public wage bill equal to 1% of GDP (solid lines: benchmark calibration, dashed lines: higher degree of public good productivity)