Public Employment and the Business Cycle

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Abstract

We add a public employment sector to the basic search and matching model in order to study the business cycle impact of public wage and employment policies. The government is assumed to follow exogenous rules for public wages and employment calibrated to match some cyclical features of the US policies. These features include a positive public wage premium and mildly pro-cyclical public wages and employment. We find that the presence of the public sector increases the volatility of employment and output.

1   Introduction

In every country a significant fraction of workers are employed in the public sector. For example, among OECD countries, public employment accounts between 15 and 20 percent of total employment. The large presence of the government in the labor market suggests that public employment may have important consequences for the overall performance of the labor market as the creation of jobs in the public sector and their compensation affect the searching decisions of workers and the employment decisions of employers in the private sector.

Casual as well as systematic observations show that the number of public employees and their compensation is weakly related to the business cycle. This is in contrast to the cyclical pattern of employment and wages in the

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private sector where they display much higher procyclicality. The goal of this paper is to investigate how the presence of a large public employer affects the behavior of the private labor market.

To investigate these issues we use a parsimonious dynamic labor market equilibrium model with search and matching frictions similar to Pissarides (1988) but with the addition of a public sector. Workers can search for a private or a public job. While employment and wages in the private sector are determined through the usual channels—profit maximization and Nash bargaining—in the public sector they are chosen exogenously by the government. The exogenous nature of the government policy is an approximation to the actual policy observed for wages and employment in the public sector. This is characterized by a positive public wage premium and by public wages and employment that are less pro-cyclical than in the private sector.

Starting from the calibrated model we ask how the presence of the public sector affects the business cycle properties of the economy. The main finding shows that the presence of the public sector increases the volatility of total employment by a factor of two or four, depending on the sample period: before or after 1970.

The key feature of the government policy that generates this result is the low cyclicality of public wages and employment, coupled with a premium paid on average to public workers. After a negative productivity shock, public jobs become more attractive for two reasons: lower creation of jobs in the private sector and higher public wage premium (due to the fall in private wages). Therefore, during a recession, public jobs become more attractive and more workers will search in the public sector. This reduces the probability of filling a vacancy in the private sector, which further decreases the creation of new jobs. In this way the presence of the public sector amplifies the macroeconomic impact of aggregate shocks.

A further question we address is whether the volatility of employment (and output) is reduced when the government actively pursues a pro-cyclical employment policy, that is, it hires more workers during expansions and less workers during recessions. Because of the large crowding out effect of public employment on private employment, pro-cyclical employment policies reduce the business cycle volatility . The cyclical properties of public wages are also central to the business cycle properties of the economy. In particular, the macroeconomic volatility is greatly reduced when public wages follow private wages. By adjusting the compensation of public workers to the compensation received in the private sector, fewer workers switch searching from one sector

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to the other after a negative productivity shock.

The studies that are more closely related to our paper are Ardagna (2006) and Algan, Cahuc & Zylberberg (2002). The first paper studies the effects of fiscal policy in a dynamic general equilibrium model with a unionized labor market. It shows that an increase in public employment, public wages and unemployment benefits raises the wages bargained by unions and leads to lower employment. Although in our model wages are not negotiated by centralized unions, the same policies lead to similar results. The focus of our paper is different though. Our interest is to study the implications of employment and wage policies for the cyclical behavior of the economy rather than for their long-term impact. Also, differently from Ardagna, we do not explain why the government policies take a certain configuration. We simple study the implications of exogenous rules calibrated to replicate key properties of the public employment policies observed in the data.

The study by Algan, Cahuc & Zylberberg (2002) conducts an empirical analysis of whether public employment has a crowding out effect on private employment and its impact on unemployment. Using data for 17 industrialized economies over the 1960-2000 period, they find strong evidence that public employment crowds out private employment and weak evidence that it increases unemployment. Also related are the empirical studies of Fatas and Mihov (2001) and Lane (2003). The first investigates the role of government spending for the macroeconomic volatility and the second characterizes the cyclical properties of different components of government spending.

The plan of the paper is as follows. In the next section we describe some of the business cycle properties of employment and wages in the private and public sectors. We then describe the model and derive the equilibrium conditions. Using the calibrated version of the model we show how alternative government policies affect the cyclical behavior of the whole economy. The sensitivity analysis shows the robustness of the results to alternative assumptions about some features of the model.

2 Cyclical properties of employment and wages

The objective of this section is to compare the cyclical properties of employment and wages in the private and the public sectors for the postwar period. The data on employment are from the Current Employment Statistics (CES), the Bureau of Labor Statistics (BLS) monthly employer survey. This program provides detailed industry data on employment, hours and earnings of

workers on nonfarm payrolls.

Our measure of private sector employment, n^P, includes all employees in the total private sector. Public sector employment, n^G, includes all employees at the federal, state and local government. We also construct a series for the ratio of public to private employment, n^G/n^P. We take the log of the quarterly averages of the seasonally adjusted monthly series, detrended by the Hodrik-Prescott filter with a smoothing parameter of 1600. The overall sample period is 1948-2003 but we also consider the subsamples 1948-1970 and 1970-2003. We also report statistics for the subsample 1979-2003 because some additional wage data is available starting in 1979.

Table 1 reports the correlations of private employment, public employment and the ratio of public to private employment with GDP, as well as the correlation between public and private employment. We also report the elasticities and the standard deviations. The elasticities are computed by estimating the equation $\log(y_t) = \alpha + \beta\log(x_t) + \varepsilon_t$ by ordinary least squares. The regression coefficient β measures the elasticity of y_t with respect to x_t.

Table 1: US Employment, CES (BLS)

	1948-03	1948-70	1970-03	1979-03
$\mathrm{Corr}(n^P, GDP)$	0.84	0.85	0.84	0.82
$\mathrm{Elas}(n^P, GDP)$	0.81	0.81	0.82	0.78
$\mathrm{Std}(n^P)/\mathrm{Std}(GDP)$	0.97	0.96	0.99	0.95
$\mathrm{Corr}(n^G, GDP)$	0.29	0.35	0.24	0.21
$\mathrm{Elas}(n^G, GDP)$	0.15	0.21	0.11	0.11
$\mathrm{Std}(n^G)/\mathrm{Std}(GDP)$	0.53	0.61	0.45	0.51
$\mathrm{Corr}(\frac{n^G}{n^P}, GDP)$	-0.74	-0.68	-0.79	-0.75
$\mathrm{Elas}(\frac{n^G}{n^P}, GDP)$	-0.66	-0.60	-0.71	-0.67
$\mathrm{Std}(\frac{n^G}{n^P})/\mathrm{Std}(GDP)$	0.89	0.88	0.91	0.90
$\mathrm{Corr}(n^G, n^P)$	0.41	0.41	0.40	0.38
$\mathrm{Elas}(n^G, n^P)$	0.23	0.28	0.18	0.20
$\mathrm{Std}(n^G)/\mathrm{Std}(n^P)$	0.55	0.64	0.46	0.54

The table shows that private employment is strongly procyclical: the

correlation with GDP is above 0.8 over the entire sample period. Public sector employment, in contrast, is only mildly procyclical. The correlation between public employment and GDP ranges from about 0.2 to 0.35. Public employment moves cyclically with the employment in the private sector, even though the correlation is not high, around 0.4. However, the share of public employment is strongly countercyclical. The correlation with output ranges from -0.68 to almost -0.8. These cyclical properties do not change significantly across the different subsamples. The elasticities deliver the same picture as the correlations.

Unfortunately, the CES survey provides earnings data only for the private sector. Then, in order to compare the cyclicality of wages in the public and private sectors we rely on two alternative sources. The first is from the National Income and Product Accounts (NIPA) of the Bureau of Economic Analysis (BEA). Using annual data we construct two wage series for each sector: one using wage and salaries accruals and the other using compensation of employees. Wages are obtained by dividing the aggregate income variable by the number of employees. Wage and salary accruals consist of the monetary remuneration of employees (including commissions, tips, bonuses and severance pay), as well as an imputation for pay-in-kind. Compensation of employees is the sum of wage and salary accruals and supplements to wages and salaries. The latter consists of the employer contributions for social insurance and pension. Both measures are deflated using the CPI. We also construct series for the public sector wage premium. All series are detrended using the Hodrik-Prescott filter with a smoothing parameter of 6.5.[1]

Tables 2 and 3 present the wage statistics: the correlation and elasticity of private wages, public wages and public wage premium with GDP. They also report the correlation and elasticity of public wages with private wages. Private wages are procyclical, with correlations ranging from 0.4 to 0.64. Public wages, instead, are only mildly procyclical. This is true for both measures of wages (wage and salary accruals per employee and compensation per employee) and for both measures of cyclicality (correlation and elasticity with GDP). During the period 1948-1970, compensation per employee in the public sector is even mildly countercyclical.

One feature of the data is that wages in the public sector are considerably less cyclical in the earlier sample period 1948-1970 than in the second period

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[1]Ravn and Uhlig (2002) show that the smoothing parameter of 6.5 is the appropriate monthly analog of 1600 used for quarterly data. See also Canova (2007).

Table 2: US Wages and Salaries per Employee, NIPA (BEA)

	1948-03	1948-70	1970-03	1979-03
$\mathrm{Corr}(w^P, GDP)$	0.55	0.44	0.64	0.50
$\mathrm{Elas}(w^P, GDP)$	0.36	0.23	0.50	0.43
$\mathrm{Std}(w^P)/\mathrm{Std}(GDP)$	0.67	0.53	0.78	0.85
$\mathrm{Corr}(w^G, GDP)$	0.27	0.05	0.41	0.26
$\mathrm{Elas}(w^G, GDP)$	0.22	0.03	0.41	0.19
$\mathrm{Std}(w^G)/\mathrm{Std}(GDP)$	0.79	0.48	0.98	0.75
$\mathrm{Corr}(\frac{w^G}{w^P}, GDP)$	-0.22	-0.32	-0.14	-0.33
$\mathrm{Elas}(\frac{w^G}{w^P}, GDP)$	-0.14	-0.20	-0.09	-0.23
$\mathrm{Std}(\frac{w^G}{w^P})/\mathrm{Std}(GDP)$	0.64	0.63	0.64	0.70
$\mathrm{Corr}(w^G, w^P)$	0.62	0.21	0.75	0.63
$\mathrm{Elas}(w^G, w^P)$	0.73	0.19	0.94	0.55
$\mathrm{Std}(w^G)/\mathrm{Std}(w^P)$	1.18	0.92	1.25	0.88

1970-2003. The correlation of public wages with GDP in the early period is either negative or close to zero, while in the later period it ranges from about 0.35 to 0.4. Public wages do co-move with private wages (see the last three rows of Tables 2 and 3). However, the correlation is much smaller in the earlier period. The cyclical properties of the public wage premium are consistent with these findings: overall, the wage premium moves countercyclically, but more so during the first sample period.

The second source of data we use to obtain comparable measures of wages in the private and public sectors is the Current Population Survey (CPS). The quarterly wage series for the 1979-2003 period are obtained by aggregating individual data as described in the appendix. To account for potential compositional bias, we distinguish skilled and unskilled workers according to formal education. Table 4 reports the results.

The CPS data provides a similar picture as the NIPA series for the second period 1979-2003. Private wages are more procyclical than public wages. The correlation of private wages with GDP ranges from 0.42 to 0.45, depending on whether we control for the skill level. For public wages this correlation

Table 3: US Compensation per Employee, NIPA (BEA)

	1948-03	1948-70	1970-03	1979-03
$\text{Corr}(w^P, GDP)$	0.54	0.49	0.59	0.40
$\text{Elas}(w^P, GDP)$	0.36	0.26	0.47	0.33
$\text{Std}(w^P)/\text{Std}(GDP)$	0.68	0.52	0.80	0.82
$\text{Corr}(w^G, GDP)$	0.16	-0.28	0.37	0.32
$\text{Elas}(w^G, GDP)$	0.13	-0.14	0.37	0.26
$\text{Std}(w^G)/\text{Std}(GDP)$	0.80	0.50	0.99	0.82
$\text{Corr}(\frac{w^G}{w^P}, GDP)$	-0.35	-0.58	-0.16	-0.10
$\text{Elas}(\frac{w^G}{w^P}, GDP)$	-0.24	-0.39	-0.10	-0.07
$\text{Std}(\frac{w^G}{w^P})/\text{Std}(GDP)$	0.67	0.68	0.65	0.72
$\text{Corr}(w^G, w^P)$	0.60	0.10	0.76	0.62
$\text{Elas}(w^G, w^P)$	0.72	0.10	0.94	0.63
$\text{Std}(w^G)/\text{Std}(w^P)$	1.18	0.96	1.23	1.01

drops to a range of values between 0.19 and 0.29. The elasticities also provide a similar picture, though the cyclical difference between public and private wages are smaller. Wages in the public and private sector move together over the cycle, with correlation ranging from about 0.4 to 0.6. The public wage premium is almost acyclical or mildly countercyclical.

In summary, these are the main facts outlined in this section:

- Employment is significantly less procyclical in the public sector than in the private sector over the period 1948-2003.

- Public wages are less procyclical than private wages and the public sector wage premium is countercyclical over the period 1948-2003.

- The cyclical differences between the private and public sectors have become smaller in the more recent period. In particular, over the 1948-1970 period, public wages were less procyclical and the public wage premium more countercyclical than in the later period 1970-2003.

Table 4: US Weekly Wages, 1979-2003, CPS (BLS)

	All individuals	Unskilled	Skilled
$\mathrm{Corr}(w^P, GDP)$	0.44	0.45	0.42
$\mathrm{Elas}(w^P, GDP)$	0.36	0.37	0.40
$\mathrm{Std}(w^P)/\mathrm{Std}(GDP)$	0.82	0.82	0.96
$\mathrm{Corr}(w^G, GDP)$	0.29	0.19	0.25
$\mathrm{Elas}(w^G, GDP)$	0.31	0.26	0.29
$\mathrm{Std}(w^G)/\mathrm{Std}(GDP)$	1.06	1.37	1.16
$\mathrm{Corr}(\frac{w^G}{w^P}, GDP)$	-0.06	-0.09	-0.10
$\mathrm{Elas}(\frac{w^G}{w^P}, GDP)$	-0.05	-0.11	-0.11
$\mathrm{Std}(\frac{w^G}{w^P})/\mathrm{Std}(GDP)$	0.87	1.26	1.07
$\mathrm{Corr}(w^G, w^P)$	0.60	0.43	0.50
$\mathrm{Elas}(w^G, w^P)$	0.77	0.72	0.60
$\mathrm{Std}(w^G)/\mathrm{Std}(w^P)$	1.29	1.68	1.21

3 Model

We consider a two-sector matching model with a private and a public sector. The two sectors are indexed by $i \in \{P, G\}$ where P denotes the 'private' sector and G the 'government' sector. Wages in the private sector are determined through Nash bargaining while in the public sector they are set exogenously by the government. The number of public workers is also set exogenously by the government.

The hiring process takes place through searching and matching. The process of job creation in the two sectors is governed by separate matching functions. In each period workers decide whether to search in the private or public sector. Let v_t^i be the number of vacancies posted in sector i and s_t^i the number of workers searching for a job in this sector. The number of new jobs or matches are equal to $m_t^i = m^i(v_t^i, s_t^i)$, where $m^i(.,.)$ is the matching function satisfying the usual properties.

The probabilities that a vacancy is filled and a searching worker finds a job are given by $q_t^i = m_t^i/v_t^i$ and $p_t^i = m_t^i/s_t^i$ respectively. Matches are

exogenously separated at rate λ^i.

Posting a vacancy requires a fixed cost κ in both sectors. A matched worker in the private sector produces y_t units of goods that can be used for consumption or investment (the cost of posting a vacancy κ). The variable y_t is stochastic and follows a first order Markov process.

The government follows an exogenous rule for public employment and public wages. Public employment depends on private employment according to the rule:

$$\log n_{t+1}^G = \log \bar{n}^G + \rho_n(\log n_{t+1}^P - \log \bar{n}^P) + \varepsilon_n, \tag{1}$$

where the bar sign over the variable denotes its steady state value and ε_n is a zero-mean iid shock to public employment. Therefore, a cyclical policy will be characterized by $\rho_n > 0$ while a countercyclical policy will have $\rho_n < 0$.

Public wages depend on private wages according to:

$$\log w_t^G = \log \bar{w}^G + \rho_w(\log w_t^P - \log \bar{w}^P) + \varepsilon_w, \tag{2}$$

where ε_w is a zero-mean iid shock to the public wage.

The government also provides unemployment insurance proportional to the private sector wage, that is, $b_t = \alpha w_t^P$. In the sensitivity analysis we will consider alternative specifications of unemployment benefits. In order to abstract from the effect of distortionary taxes, we assume that public expenditures are financed with lump-sum taxes T_t. Government budget balances in every period.

Households' utility takes the form:

$$\nu(e_t, c_t, g_t) = (1 - e_t)h + c_t + \gamma n_t^G, \tag{3}$$

where $e_t \in \{0, 1\}$ is the employment status, c_t is private consumption and γn_t^G are the services provided by public employment.

Unemployed workers enjoy a constant flow of utility h in addition to the unemployment benefit b_t. The utility flow could derive from forgone home-work production and from the disutility of working. We can also interpret this value as resulting from some mechanism that stabilizes the worker threat in the bargaining game along the lines of Hall and Milgrom (2006). The motivation to include this term is to bring the volatility of employment closer to the data. Since Shimer (2005), several authors have proposed alternative mechanisms to generate this result. Hall (2005b) provides a comprehensive

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survey. One way is to increase the relative utility flow from unemployment, which has the effect of stabilizing the threat value in the bargaining process. This is the approach we follow in this paper. It is important to emphasize that in doing so we do not take any stand on the most plausible mechanism that can generate greater employment volatility. Our goal is simply to understand the role of public employment within a framework that can capture the cyclical properties of employment sufficiently well. We would also like to point out that our results do not depend on h. The prediction of the model in terms of 'relative' contribution of public employment to the business cycle remains valid when $h = 0$.

3.1 Value functions and equilibrium conditions

After describing the model economy, we can now define the basic value functions used to derive the equilibrium. We would like first to point out that the linearity of the utility function in private and public consumption, which is typical in this class of models, implies that the choices made by individual households are not affected by the government's choice of public employment and lump-sum taxes. Therefore, in the specification of the individual value functions we neglect the terms γn_t^G and T_t.

Let U_t^i be the value of searching in sector $i \in \{P, G\}$ and $U_t = \max\{U_t^P, U_t^G\}$. These values are given by:

$$U_t^P = h + b_t + \beta E_t\Big[p_t^P W_{t+1}^P + (1 - p_t^P)U_{t+1}\Big], \qquad (4)$$

$$U_t^G = h + b_t + \beta E_t\Big[p_t^G W_{t+1}^G + (1 - p_t^G)U_{t+1}\Big]. \qquad (5)$$

The values of being employed are defined as:

$$W_t^P = w_t^P + \beta E_t\Big[\Big(1 - \lambda^P(1 - p_t^P)\Big) W_{t+1}^P + \lambda^P(1 - p_t^P)U_{t+1}\Big], \qquad (6)$$

$$W_t^G = w_t^G + \beta E_t\Big[\Big(1 - \lambda^G(1 - p_t^G)\Big) W_{t+1}^G + \lambda^G(1 - p_t^G)U_{t+1}\Big]. \qquad (7)$$

Workers who separate from their employers re-enter immediately the labor market. Therefore, there is a probability $\lambda^i p_t^i$ that some workers change job without becoming unemployed. This assumption allows us to capture the job-to-job flow which is quite large in the data. Notice that the number of unemployed workers, that is, workers without a job, is smaller than the number of searching workers, which includes those currently displaced. More

specifically, given n_t^i the number of employed workers in sector i, the number of unemployed workers is $u_t = 1 - n_t^P - n_t^G$. The number of searching workers is $s_t^P + s_t^G = 1 - n_t^P(1 - \lambda^P) - n_t^G(1 - \lambda^G)$.

Because workers can search in both sectors without restrictions, the values of searching in the private or the public sector must be equal, that is,

$$U_t^P = U_t^G = U_t. \tag{8}$$

We now define the value of posting a vacancy, V_t, and the value of a job in the private sector J_t. These are given by:

$$V_t = -\kappa + \beta E_t\left[q_t^P J_{t+1} + (1 - q_t^P)V_{t+1}\right],$$

$$J_t = y_t - w_t^P + \beta E_t\left[(1 - \lambda^P)J_{t+1} + \lambda^P V_{t+1}\right].$$

Free entry guarantees that in equilibrium the value of posting a vacancy is zero. Therefore, we can rewrite the two equations as:

$$\frac{\kappa}{q_t^P} = \beta E_t J_{t+1}, \tag{9}$$

$$J_t = y_t - w_t^P + (1 - \lambda^P)\beta E_t J_{t+1}. \tag{10}$$

The first equation defines the job creation condition. It equates the expected cost of posting a vacancy, κ/q_t^P, to the expected discounted value of a new job, $\beta E_t J_{t+1}^P$. It implies that the higher the expected value of a new job, the smaller the probability of filling a vacancy, q_t^P. For a given number of workers searching in the private sector, this implies a higher number of vacancies, and therefore, more jobs created.

Wages in the private sector are determined through Nash bargaining. Given the bargaining power of workers, η, the wage in the private sector solves the maximization problem:

$$\max_{w_t^P} \left(W_t^P - U_t\right)^\eta \left(J_t - V_t\right)^{1-\eta},$$

with the first order condition given by:

$$\eta J_t = (1 - \eta)(W_t^P - U_t). \tag{11}$$

Using (4), (6), (9), (10), (11) and rearranging we get the wage equation:

$$w_t^P = \eta y_t + (1 - \eta)(h + b_t) + \frac{\eta \kappa p_t^P(1 - \lambda^P)}{q_t^P}. \tag{12}$$

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The government budget must balance in every period, that is,

$$w_t^G n_t^G + b_t u_t + \kappa v_t^G = T_t. \tag{13}$$

We can now define a competitive equilibrium. Denote by $\mathbf{s}_t$ the aggregate states of the economy at time t: the productivity in the private sector, y_t, the employment in the private sector, n_t^P, and the employment in the public sector, n_t^G. The competitive equilibrium is defined recursively as follows:

Definition 3.1 *Given the rules for public employment and public wages (equations (1) and (2)), a Recursive Competitive Equilibrium is defined by a set of functions for (i) $U^P(\mathbf{s})$, $U^G(\mathbf{s})$, $W^P(\mathbf{s})$, $W^G(\mathbf{s})$, $V(\mathbf{s})$, $J(\mathbf{s})$; (ii) Vacancies $v^P(\mathbf{s})$ and $v^G(\mathbf{s})$; (iii) Searching workers $s^P(\mathbf{s})$ and $s^G(\mathbf{s})$; (iv) Private wage $w^P(\mathbf{s})$; (v) Lump-sum taxes $T(\mathbf{s})$. Such that: (i) Private sector vacancies $v^P(\mathbf{s})$ satisfy the free entry condition $V(\mathbf{s}) = 0$; (ii) Public sector vacancies $v^G(\mathbf{s})$ are such that next period public employment satisfies (1); (iii) The allocation of searching workers, $s^P(\mathbf{s})$ and $s^G(\mathbf{s})$, is such that the values of searching in the two sectors equalize, that is, $U^P(\mathbf{s}) = U^G(\mathbf{s})$; (iv) The private wage $w^P(\mathbf{s})$ solves the bargaining condition (11); (v) Taxes $T(\mathbf{s})$ are chosen to balance the government budget (equation (13)).*

4 Public employment and the business cycle

The goal of this section is to investigate quantitatively how the public sector affects the business cycle. We first parameterize the model to replicate certain features of the US public employment and wage policies. We then compare the business cycle statistics generated under these policies to those generated by alternative and counterfactual policy rules.

4.1 Calibration

We calibrate the model on a quarterly basis and, when possible, we assign standard parameter values. The intertemporal discount rate is set to $\beta = 0.99$ and the separation rate in both sectors is set to $\lambda^P = \lambda^G = 0.1$. Following the recent literature, the matching function in the private sector is Cobb-Douglas, that is, $m_t^P = A \left(v_t^P\right)^\theta \left(s_t^P\right)^{1-\theta}$, with $\theta = 1/2$. The calibration of

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A will be described below. Also in line with the recent literature, we set the bargaining power to $\eta = 1/2$.

The matching function in the public sector is $m_t^G = \min\{v_t^G, s_t^G\}$. This choice of this function is made only for its analytical simplicity: as long as there is a sufficiently high wage premium for working in the public sector, the number of searchers in the public sector is always greater than the number of vacancies. Therefore, the number of matches is equal to the posted vacancies, that is, $m_t^G = v_t^G$. This property is satisfied for the calibration of the public wage policy described below.

The steady state employment in the public sector is set to $\overline{n}^G = 0.16$. Given the steady state unemployment rate of 0.055 imposed below, the share of public employment is 0.17. This is the postwar average share in the US. The replacement ratio for unemployment benefits is $\alpha = 0.35$.

Next we consider the calibration of the following four parameters: (i) the matching parameter A; (ii) the cost of posting a vacancy κ; (iii) the average wage in the public sector $\overline{w}^G$; (iv) the utility flow from unemployment h. These parameters are chosen jointly to replicate the following steady state targets: (a) 3.75 percent public wage premium, that is, $\overline{w}^G/\overline{w}^P = 1.0375$; (b) 5.5 percent unemployment rate, that is, $\bar{u} = 0.055$; (c) 93 percent probability of finding a job in the private sector, that is, $\bar{p}^P = 0.93$; (d) 70 percent probability of filling a vacancy in the private sector, that is, $\bar{q}^P = 0.7$.

The 3.75 percent premium is the average for unskilled and skilled workers found in CPS data during the period 1979-2003. The 5.5 percent unemployment is the approximate average during the postwar period. The 93 percent finding rate corresponds to a 60 percent monthly job finding probability, which is the number used in Hall (2005a).[2] There is no clear evidence for the probability of filling a vacancy. However, this number is not relevant for the properties of the model: larger values of q^P simply result in higher values of κ but they do not change the steady state and business cycle properties.

The productivity variable y_t follows an AR(1) process with mean value of 1, autoregressive parameter of 0.95 and standard deviation of 0.007. These are standard values in the RBC literature.

The final step is the specification of the parameters of the policy rules for public wages and public employment. The shocks ε_w and ε_n are assumed to be uniform with mean zero and standard deviations σ_w and σ_n. The average

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[2]Given the probability of finding a job in one month, p, the probability of finding a job in three months is $p + (1-p)p + (1-p)^2 p$. With $p = 0.6$, this number is 0.936.

values of public wages and employment have been set above to $\bar{n}^G = 0.16$ and $\bar{w}^G = 1.0237$, and the steady state values $\bar{n}^P$ and $\bar{w}^P$ are determined endogenously from the deterministic version of the model. Therefore, we have four remaining parameters: ρ_w, σ_w, ρ_n and σ_n. They are chosen to replicate the following four statistics: (i) the elasticity of public wages to private wages; (ii) the standard deviation of public wages to private wages; (iii) the elasticity of public employment to private employment; (iv) the standard deviation of public employment to private employment. These statistics are reported in Tables 1 and 2. Because the cyclical properties of public wages and employment have changed between the first sample period, 1948-70, and the second sample period, 1970-03, we report the results for both sub-periods.

Table 5: Parameter values.

Description	Parameter values
Discount factor	$\beta = 0.99$
Separation rate	$\lambda^P = \lambda^G = 0.1$
Bargaining power	$\eta = 0.5$
Replacement rate	$\alpha = 0.35$
Productivity	$\bar{y} = 1$, $\rho = 0.95$, $\sigma = 0.007$
Matching function	$\theta = 0.5$, $A = 0.807$
Cost of vacancy	$\kappa = 0.0845$
Utility parameter	$h = 0.527$
Average public wage	$\bar{w}^G = 1.0237$
Average public employment	$\bar{n}^G = 0.16$
Other policy parameters, 48-70	$\rho_w = 0.19$, $\sigma_w = 0.008$, $\rho_n = 0.51$, $\sigma_n = 0.0078$
Other policy parameters, 70-03	$\rho_w = 0.94$, $\sigma_w = 0.0075$, $\rho_n = 0.32$, $\sigma_n = 0.0028$

The full set of parameter values are reported in Table 5. Regarding the parametrization of the policy rules, we observe that both public wages and public employment are positively related to the corresponding variables in the private sector. What is important to notice is that the policy rule for wages has become more tightly linked to the private wage. The coefficient ρ_w has changed from 0.19 to 0.94. The link between public employment and private employment, although positive, has remained relatively weak, with

the elasticity below 0.3 in both sub-periods.[3] These changes in policy will be important for understanding how the public sector affects the business cycle properties of the whole economy.

4.2 Cyclical properties of the economy

The first column of Table 6 reports the standard deviations of key macroeconomic variables when the policy rules are calibrated to the 1948-70 data. The second column is with the policy rules calibrated to the 1970-03 data.

Table 6: Business cycle statistics of the artificial economy.

	1948-70 policy rules	1970-03 policy rules	Absence of public employment
Standard Deviations			
Productivity	0.90	0.91	0.90
Employment	1.09	0.52	0.27
Output	1.70	1.30	1.10
Wages	0.76	0.87	0.87
Private employment	1.23	0.60	0.27
Public employment	0.78	0.28	-
Private wages	0.87	0.87	0.87
Public wages	0.79	1.09	-
Elasticities			
Wages, (n^G, n^P)	0.19	0.94	-
Employment, (n^G, n^P)	0.28	0.18	-

Notes: Artificial data is generated by simulating the model for 250 periods. The numbers are averages over 50 simulations. Artificial data is detrended using the Hodrik-Prescott filter with $\lambda = 1600$.

The first thing to notice is that the model with the 1948-70 rules generates substantial volatility of employment. The volatility for the US economy during the postwar period is 1.45 percent. The model generates a standard deviation of 1.09 percent. Two factors contribute to this result. The first factor is the presence of the utility flow h. As observed earlier, a positive value of h increases the value of being unemployed. Hence, the workers'

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[3]The value of ρ_n differs from the elasticity of n^G to n^P reported in Table 1 because the shock to public employment is correlated with private employment.

threat value in the bargaining process becomes less dependent on the labor market conditions. By stabilizing the threat value, wages become more stable and the model generates greater employment fluctuations. In the current calibration the sum of unemployment benefits plus the utility flow, $b + h$, is about 88 percent the wage in the private sector.

The second factor is the weak pro-cyclicality of public wages. With the 1948-70 calibration, the elasticity of public wages to private wages is only 0.19. The presence of a public sector whose wages are only mildly cyclical stabilizes the unemployment value and has a similar effect as h. This is clearly visible when we parameterize the policy rules using the 1970-03 data. In this case the elasticity of public wages to private wages is 0.94, implying that the movements of public wages are almost aligned to the movements of private wages. Therefore, when the compensation in the private labor market deteriorates, it also deteriorates in public sector by a similar amount. Because of that, the presence of the public sector has a smaller stabilizing role for the unemployment value. As a result, the standard deviation of employment falls from 1.09 to 0.52 percent. There is also some changes in the policy rule for employment, but as we will see below, the cyclicality of wages plays a much bigger role.

The last column of Table 6 reports the standard deviations generated by the model when public employment is eliminated. This is achieved by setting $\bar{n}^G$ to zero, keeping all other parameters unchanged. This reduces the volatility of employment considerably. When the government follows the 1948-70 policy, the removal of the public sector reduces the standard deviation of employment by a factor of four. With the 1970-03 policy, the volatility of employment falls by half.

The elimination of the public sector has two effects on the private labor market. The first effect, described above, is to eliminate the stabilizing role played on the unemployment value. This makes the threat value of workers in the private sector more responsive to labor market conditions reducing the volatility of employment.

To better understand this effect, let us consider first what happens in the standard matching model without a public sector when a productivity shock hits the economy. We know that in this model a negative productivity shock reduces the incentive of firms to engage in hiring activities, and therefore, it reduces the creation of jobs. This increases the duration of unemployment and thus decreases the value of being unemployed. Because the value of being unemployed is the threat value in the bargaining game, the contracted wage

takes a cut. This will reduce the fall in the profitability of a new job, and therefore, it lowers somewhat the fall in the creation of jobs.[4]

This mechanism is also at work when there is a public sector. What is different is that now, after a negative productivity shock, searching in the public sector becomes more attractive. This arises for two reasons: it becomes harder to find a job in the private sector due to the reduction in job creation and, contrary to the private sector, there is no reduction in public wages. Because more workers search in the public sector, private employers find it harder to fill a vacancy and they further decrease the creation of jobs. Therefore, the larger the public sector is, the larger the response of employment to productivity shocks.

The second reason the elimination of the public sector affects the volatility of employment is because the steady state value of unemployment is lower. The wage premium in the public sector, in fact, has the effect of diverting workers from searching in the private sector even if the probability of finding a job is smaller. As a result, a larger number of workers remain unemployed. The elimination of the public sector redirects workers to the private sector where the probability of finding a job is higher and fewer workers remain unemployed. Then, with a smaller stock of unemployed workers, productivity shocks induce smaller changes in the stock of employed workers.[5]

To further investigate how the cyclicality of public wages and public employment affects the business cycle, Table 7 reports simulation statistics for alternative parameterizations of the policy rules. We concentrate only on deterministic rules, that is, $\sigma_w = \sigma_n = 0$.

The first column considers the extreme case of passive public policies where the government keeps public wages and public employment fixed. This is obtained by setting $\rho_w = \rho_n = 0$. The second column, keeps the passive policy for employment but assumes that public wages remain always aligned to private wages, that is, $\rho_w = 1$. The comparison between the first two columns reveals that making public wages move with private wages reduces the volatility of total employment considerably, close to a factor of three.

The third column of Table 7 considers an active policy for public employ-

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[4]Shimer (2005), in its critique to the standard searching and matching model, shows that the fall in wages is quite large so that this model cannot generate enough volatility in employment. Most of the productivity change is absorbed by the change in wages.

[5]The probability of filling a vacancy is more sensitive to a change in the number of unemployed workers when the unemployment stock is small. As a result, firms increase (decrease) less the number of vacancies after a positive (negative) productivity shock.

Table 7: Business cycle statistics with alternative policy rules. No policy shocks ($\sigma_w = \sigma_n = 0$). The average public wage premium is 3.75%.

	Fixed wages & empl $\rho_w = 0, \rho_n = 0$	Cyclical wages $\rho_w = 1, \rho_n = 0$	Cyclical employment $\rho_w = 0, \rho_n = 1$	Cyclical wages & empl $\rho_w = 1, \rho_n = 1$
Productivity	0.90	0.90	0.90	0.90
Employment	1.28	0.48	1.11	0.41
Output	1.88	1.28	1.70	1.21
Wages	0.71	0.87	0.72	0.87
Private employment	1.55	0.57	1.11	0.41
Public employment	0.00	0.00	1.11	0.41
Private wages	0.87	0.87	0.87	0.87
Public wages	0.00	0.87	0.00	0.87

Notes: Artificial data is generated by simulating the model for 250 periods. The numbers are averages over 50 simulations. Artificial data is detrended using the Hodrik-Prescott filter with $\lambda = 1600$.

ment ($\rho_n = 1$), keeping public wages constant. Now the elasticity between public and private employment is one. The volatility of employment falls significantly. This is a consequence of the crowding out effect: private employment increases after positive productivity shocks. If the government increases public employment too, as it happens when $\rho_n = 1$, it will attract more searchers in the public sector discouraging the creation of vacancies in the private sector. Because the probability of finding a job in the public sector is lower than in the private sector, fewer workers will find a job.

Although the cyclicality of public wages and public employment both seem to reduce the volatility of employment, the impact of cyclical public wages is much bigger than the impact of cyclical public employment. In fact, when we consider both policies to be pro-cyclical by setting $\rho_w = 1$ and $\rho_n = 1$ (see the last column), the volatility of employment is not very different from the volatility reported in the second column.

Armed with these findings, it is now easy to understand the statistics reported in the first two columns of Table 6. We can see that the business cycle statistics generated by the 1948-70 rule are not very different from those generated by the passive rule reported in the first column of Table 7. At the same time, the business cycle statistics generated by the 1970-03 rule are not

very different from those reported in the second column of Table 7. This is because in the 1948-70 rule the cyclicality of public wages was low (the elasticity with private wages was 0.19) while in the 1970-03 rule, public wages were more cyclical (the elasticity was 0.94). Although public employment has become less cyclical in the later period (the elasticity has declined from 0.28 to 0.18), we have seen that the cyclicality of public employment plays a secondary role compared to the cyclicality of public wages.

Discussion Before concluding this section, we would like to further comment on the finding that pro-cyclical employment policies ($\rho_n > 0$) have a stabilization effect. This follows from the crowding out effect of public employment described earlier.[6]

It is important to emphasize that our results are derived within a framework in which the main driving force of the business cycle are productivity shocks in the private sector. But policies that try to stabilize the economy in response to productivity shocks are not desirable from an efficiency point of view. On the contrary, counter-cyclical public employment policies might be desirable because they facilitate the expansion of the private sector when this sector is more productive. Therefore, our finding that counter-cyclical employment policies make aggregate employment more volatile does not mean that countercyclical policies are not optimal.

The second point to emphasize is that fluctuations in employment can also be driven by demand shocks. These shocks have been studied within monetary models with nominal rigidities and/or financial markets frictions. With these shocks, counter-cyclical employment policies might have a stabilizing effect. They may also be desirable from an efficiency point of view because they mitigate the inefficiencies induced by rigidities in nominal prices and/or financial markets frictions. Therefore, the results of this paper should not be interpreted as suggesting that countercyclical employment policies are not optimal. Our analysis is not intended to provide a normative answer to the optimality of public employment and public wage policies.

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[6]The literature has mostly focused on the stabilization effects of government purchases of consumption and capital goods and of different types of taxes. Examples are Christiano and Eichenbaum (1992), McGrattan (1994), Shi and Wen (1999) and Cavallo (2005). We focus on the direct impact of employment policies abstracting from distortionary taxes.

5 Sensitivity analysis

The first sensitivity exercise considers another feature of the government policy: the public wage premium. Are the findings shown so far robust to a change in the premium paid by the government to public employees? To address this question we now assume that the government reduces the average premium by half, from 3.75 percent to 1.88 percent. All other parameters are kept constant. By changing the premium, but keeping all other parameters unchanged, the steady state unemployment rate will be smaller.

Table 8 reports the business cycle statistics for alternative policy rules. A quick glance at the table, compared to the previous Table 7, reveals that the role played by the public sector for the business cycle does not change in important ways. In particular, the exercise confirms the centrality of the cyclical properties of public wages and, to a lower extend, of public employment. The overall volatility declines somewhat due to the lower steady state unemployment rate but the change is relatively small.

Table 8: Business cycle statistics with alternative policy rules. No policy shocks ($\sigma_w = \sigma_n = 0$). The average public wage premium is 1.88%.

	Fixed wages & empl $\rho_w = 0, \rho_n = 0$	Cyclical wages $\rho_w = 1, \rho_n = 0$	Cyclical employment $\rho_w = 0, \rho_n = 1$	Cyclical wages & empl $\rho_w = 1, \rho_n = 1$
Productivity	0.90	0.90	0.90	0.90
Employment	1.13	0.37	1.05	0.34
Output	1.74	1.18	1.66	1.16
Wages	0.72	0.85	0.72	0.87
Private employment	1.36	0.44	1.05	0.34
Public employment	0.00	0.00	1.05	0.34
Private wages	0.87	0.86	0.87	0.87
Public wages	0.00	0.86	0.00	0.87

Notes: Artificial data is generated by simulating the model for 250 periods. The numbers are averages over 50 simulations. Artificial data is detrended using the Hodrik-Prescott filter with $\lambda = 1600$.

The exercise reported in Table 8, however, still considers a positive premium. Unfortunately, the linearization of the dynamic system used to solve

the model does not provide reliable results when the premium is negative.[7]

We have also conducted a sensitivity analysis with respect to the unemployment benefits b and the utility flow h. In particular, we have considered the cases in which b is constant and h is zero. Our results, not reported for economy of space, are qualitatively robust to these alternative specifications.

A related question is whether we can generate the same volatility of employment without public employment, if we change the utility flow h. This can be accomplished by increasing h from 0.527 to 0.618. The utility flow plus the unemployment benefits, $h + b$, increases from 88 percent of private wages to 97 percent. Hence, with the public sector we can generate substantial volatilities of employment with a more reasonable unemployment value.

6   Conclusion

We have studied how public employment and wage policies affect the business cycle within a two-sector matching model. When the government follows acyclical wage policies, the presence of a large public sector creates a sizable amplification mechanism. This is because the employment opportunity created by the public sector stabilizes the value of being unemployed, and therefore, the threat value in the bargaining of private wages. In this sense, the paper provides a micro-foundation for a more stable unemployment value which is one of possible mechanisms allowing for greater fluctuation of employment in the standard searching and matching model.

In the empirical section of the paper we have shown that public wages in the US economy have become more market oriented over the most recent period. Our model predicts that this change would induce lower macroeconomic volatility. Thus, this policy change could be one of the factors contributing to the lower macroeconomic volatility observed during the last two decades.

The finding that the lower procyclicality of wages in the public sector amplifies the macroeconomic impact of shocks suggests that a similar mechanism may also originate from sub-sectors of the private economy. For example, sectors that are highly unionized may have wages that are higher on average (premium) and less procyclical. Even if these sectors employ a small percentage of the labor force, the implication for the aggregate volatility could be sizable. We leave the study of this issue for future research.

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[7]With a negative premium, workers may occasionally search only in the private sector. This is a corner solution which cannot be easily handled with the linearization technique.

Appendix: CPS data treatment

- Dataset: CPS Labor Extracts, MORG, 1979-2003, NBER.

- The earning variable is nominal weekly wages (earnwke). Weekly wages include any overtime pay, commissions or tips usually received. Earnings are collected per hour for hourly workers and per week for other workers. For hourly workers, CPS calculates weekly wages as the product of hourly wages and usual hours per week.

- Sample restrictions: i) we keep individuals over 16 years of age; ii) we exclude self-employed workers; iii) we keep both full time and part time workers;[8] iv) replace allocated values as missing according to allocation flags: when the flag is missing, data are kept; v) we replace weekly wages with missing values if they are below 1/4 of the minimum wage; vi) we multiply top-coded weekly wages by 1.5.

- Aggregation: data is aggregated to obtain a nominal monthly time series for the period 1979-2003. For example, the monthly weekly wage series is the average of individual weekly wages according to the interview date (month and year). That is, the weekly monthly wage for, say, October 2000, is the average of individual weekly wages for those individuals whose interview date is October 2000. Data is aggregated computing weighted averages using CPS earnings weights. Sub-sample averages are computed distinguishing government and private sector; federal, state and local within the government sector; skilled and unskilled workers according to education. The measure of education is: skilled if at least started college; unskilled if no college. The nominal monthly wages are seasonally adjusted using the Census X12 procedure and deflated by the seasonally adjusted CPI. Finally, quarterly averages are computed and the wage series are detrended using the Hodrik-Prescott filter with a smoothing parameter of 1600.

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[8]In earlier versions we calculated the weekly wage series only for full-time workers. However, we report the data for all workers in order to compare the CPS data with the aggregate data, which includes both part-time and full-time workers.

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