Heterogeneity and the public sector wage policy*

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Abstract

A model with search and matching frictions and heterogeneous workers was established to evaluate a reform of the public sector wage policy, in the steady-state and over the business cycle. The model was calibrated to the UK economy based on Labour Force Survey data. A review of the pay received by all public sector workers to align the distribution of wages with the private sector reduces steady-state unemployment by 3 percentage points. Implementing a procyclical simple rule to determine the yearly growth rate of public sector wages reduces the volatility of unemployment by 3 to 8 percent and of private consumption by 4 to 12 percent.

JEL Classification: E24; E32; E62; J45.

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1 Introduction

Three sets of stylized facts characterise the public sector employment and wage policy. These facts relate to their size, cyclicality, and heterogeneity across skills. First, public sector employment and wages always stand out as major components, whether one looks at the labour market or government budget. Governments of OECD countries account for 18 percent of total employment and their wage bills represent more than half of their government consumption expenditures. Regarding cyclicality, public sector wages fluctuate less than those in the private sector and are less procyclical.[1]

Perhaps less known is the policy heterogeneity across the skill dimension. The public sector predominantly hires skilled workers. In the United Kingdom, for instance, the government employs 37 percent of college graduates, but only 17 percent of workers with lower qualifications. The pay rates also vary across workers. Researchers estimate that the public sector wage premium, although positive on average, differs across education groups. Less educated individuals are paid a high premium, while more educated individuals receive a lower premium.[2] Finally, adding to the wage compression observed across education levels, a wage compression also exists within education categories, with the bottom quantile having higher premium and the top quantile having lower or even negative premium.[3]

This paper builds a quantitative macro model with search and matching frictions that incorporates these three sets of stylized facts. I use the model to evaluate a reform that strengthen the link with private sector wages, both across workers and over time. The loose relation between public and private sector pay creates distortions in the labour market. Higher public sector wages create queues for those jobs, while lower wages generate recruitment problems. It also alters the incentives of the government on which type of workers to hire. These distortions affect the unemployment rate and its volatility over the cycle.

Given the heterogeneity across skills, it is surprising that most theoretical literature on public employment has ignored this dimension by assuming homogeneous workers. Examples include: Finn (1998), Algan *et al.* (2002), Ardagna (2007), Quadrini and Trigari (2007) or more recently Michaillat (2014), Gomes (2014) and Afonso and Gomes (2014). Two reasons motivate me to address this gap in the literature.

[1]This was found using aggregate data by Quadrini and Trigari (2007) for the United States, by Lamo *et al.* (2013) and Lane (2003) for OECD countries and by Devereux and Hart (2006) using UK microdata.

[2]This was found in the United States by Katz and Krueger (1991), in the United Kingdom by Postel-Vinay and Turon (2007) or Disney and Gosling (1998) and in several European countries by Christofides and Michael (2013), Castro *et al.* (2013) and Giordano *et al.* (2011).

[3]This was found in Poterba and Rueben (1994) for the United States, Postel-Vinay and Turon (2007), or Disney and Gosling (1998) for the United Kingdom or Mueller (1998) for Canada.

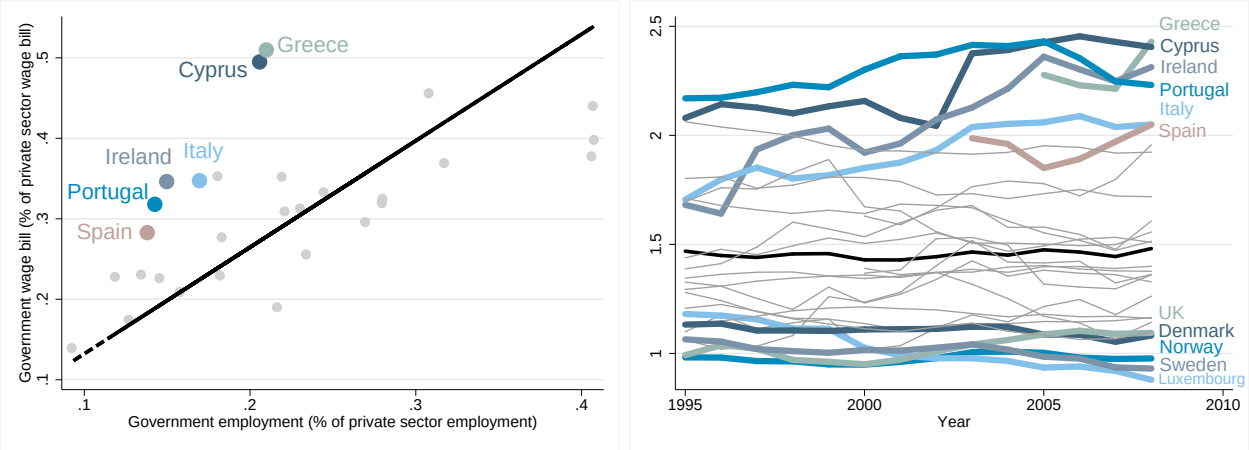
In a simple RBC model, as in Finn (1998), even if the productivity differs across sectors, identical workers receive the same wage due to arbitrage. With frictions, the labour market tolerates different wages. Gomes (2014) examines the optimal wage policy in the context of a stylized two-sector search and matching model. If the government sets a high wage, it induces too many unemployed to queue for public sector jobs and raises private sector wages; thus, reducing private sector job creation and increasing unemployment. Conversely, if it sets a lower wage, few unemployed want a public sector job and the government faces recruitment problems. The heterogeneous public sector wage premium suggests that we may have the two inefficiencies operating simultaneously, with long queues and high unemployment for unskilled workers and recruitment problems for high-ability skilled workers.

The second reason stems from the recent experience of European countries subject to austerity packages. Figure 1a displays the government's wage bill as a fraction of the private sector wage bill and the size of government employment relative to private sector employment, of OECD countries in 2008. Six countries stand out for having a high public sector wage bill relative to their level of public employment: Greece, Cyprus, Ireland, Portugal, Italy and Spain. These countries would end up in the centre of the Euro area crisis due their poor public finances and sclerotic labour markets. The implemented austerity measures naturally included public sector wage cuts. However, most governments opted for asymmetric cuts, centered on the highest earners, instead of reforms aligning the wage distribution with that of the private sector.[4] Although the cuts reduced spending, they did not correct inefficiencies at the bottom and probably exacerbated inefficiencies at the top.

Figure 1b motivates the interest on the dynamic side of the government's wage policy. The figure shows the evolution of the ratio of average wages in the two sectors. How could government wages grow by such a large factor relative to the private sector, in so many countries? The reason is that, in the absence of a clear and accepted rule determining the public sector wage growth, it is vulnerable to manipulation for electoral reasons, in the spirit of Nordhaus (1975) political cycles. Borjas (1984) finds that, in the United States, pay rises in federal agencies are two to three percent higher in election years. Matschke (2003) also finds systematic public wage increases of two to three percent prior to federal elections in Germany. In Portugal in 2009 - year of crisis and three elections - public sector workers saw their real wage increase by four percent. To avoid such situations in the future, we should design institutions that limit the scope of politicians to manipulate public sector wages whilst still maintaining a certain degree of optimality.

[4]In Portugal in 2012, the wage cuts were 22 percent on the highest earners and zero percent on the lowest. In Spain in 2010, they were 10 percent on top and zero at the bottom. In Ireland in 2010, the cuts where 15 percent at the top and 5 percent at the bottom.

Figure 1: Government wage bill and employment, OECD countries



(a) Government wage bill and employment in 2008 *Source: EUROSTAT, AMECO and OECD.*

(b) Ratio of gov. wage bill (% private wage bill) over gov. employment (% of private employment)

Gomes (2014) finds that, over the business cycle, public sector wages should track private wages. In recessions, if private sector wage drops are not accompanied by similar falls in the public sector, the unemployed turn for jobs there, which further reduces job creation, thus amplifying the business cycle. This policy can be impose by a simple rule aiming to stabilize as aggregate ratio as in Figure 1b. However, the presence of worker heterogeneity gives rise to composition effects of aggregate wages that might undermine the benefits of such rule. Analyzing the business cycle properties of a model with worker heterogeneity allows us to evaluate alternative policies in the presence of composition effects.

I set up a two-sector model with search and matching frictions and introduce worker heterogeneity along two dimensions: education and ability. I consider heterogeneous ability for two reasons. First, the public sector wage premium also varies within education groups. Second, such inclusion acknowledges the common argument that public sector wage cuts limit the scope of governments to hire high-ability workers. Nickell and Quintini (2002) document the fall in relative pay of British public sector workers during the 1980s and find that men entering the public sector had significantly lower test score positions compared with public sector entrants in the previous decade.

Instead of deriving the optimal policy in a stylized setting, as in Gomes (2014), this paper aims to quantitative assess the gains of a reform that embodies the optimality principle that public wage should be linked to the private sector. To do it, the model features several realistic elements. Instead of a social planner, the model features a government that provides an exogenous amount of services. Taking the wage schedule as given, the government decides

the number and type of workers to hire to minimize the costs of providing those services. I also include capital stock, distortionary taxes and an idiosyncratic preference for the public sector, all quantitatively relevant. The model is calibrated for the United Kingdom. I use the Labour Force Survey from 1996 to 2006 to calibrate the parameters related to the worker heterogeneity, labour market and wages.

First, I measure the steady-state effects of a pay review covering different types of public sector workers on the following variables: the equilibrium unemployment rate, the quality and composition of the public sector worker pool, total government spending and welfare. Wage cuts of skilled workers can reduce spending, but up to a limit. If the cuts are too severe, they actually increase government spending and reduce welfare. As the government lowers the pay of skilled workers too severely, it faces recruitment problems. It spends more to recruit a skilled worker and substitutes hiring towards unskilled workers. Cuts above 7 percent of skilled wages are welfare-reducing. On the other hand, wage cuts of unskilled government employees reduce both the unemployment rate and government spending. A seven percent cut reduces the unemployment rate by more than 3 percentage points. A large wage premium at the bottom, makes these workers expensive compared to their productivity. A government that minimizes costs neglects these workers in favour of more productive workers that are relatively cheaper. By decompressing the wages, the government hires more of these workers reducing their unemployment rate.

Second, I quantify how the volatility of unemployment, consumption and inflation depend upon the government's wage policy. Quadrini and Trigari (2007) and Gomes (2014) have shown that a procyclical policy reduces unemployment volatility in response to technology shocks. However, in policy circles there is the view that procyclical public sector wages amplify the fluctuations of aggregate demand, leading to wage spirals and higher volatility. This was argued by Holm-Hadulla *et al.* (2010) and restated in Lamo *et al.* (2013). To acknowledge this point, I introduce nominal rigidities and consider technology, government employment and cost-push shocks. I propose a simple rule to determine public sector wage growth that aims to stabilize a ratio of average aggregate wages as in Figure 1b. This procyclical fiscal rule reduces the volatility relative to the benchmark policy estimated for the United Kingdom, suggesting that the labour market channel dominates the demand channel and that composition effects are not relevant. If taxes are lump-sum, unemployment and consumption volatilities are reduced by three and four percent. If taxes are distortionary, the volatilities are reduced by eight and twelve percent. This highlights one important dimension of procyclical wages: it allows for some tax smoothing in the absence of government debt. In recessions when the tax revenues fall, with an acyclical or counter-cyclical policy, the government requires higher tax rates and higher distortions when they are most detrimental.

The proposed policy resembles the one followed by Nordic countries. Across the 1970's and 1980's, these countries reformed the public sector, simultaneously reducing the wage premium and employing more unskilled workers; see Domeij and Ljungqvist (2006) for Sweden and Pederson *et al.* (1990) for Denmark. The policy allowed these countries to have large public sectors without asphyxiating the private sector and maintain low levels of unemployment. These countries also seem to implicitly follow the simple rule, as we can see from Figure 1b. They are also the countries in the sample with lower volatility of unemployment.

2 Model with search and matching frictions

The model extends Gomes (2014) in some realistic dimensions. It adds heterogeneous workers to capture the stylized facts on heterogeneity discussed in the introduction. It introduces capital accumulation because capital-skill complementarity is an important determinant of productivity difference across workers. Also because investment is a quantitative important feature of business cycles.

Instead of following the optimal policy as in Gomes (2014), the government takes the wage schedule as given. It chooses how many workers of different types to hire to guarantee the provision of a minimum level of services, while minimizing the cost of providing those services. It finances its spending with a distortionary income tax. Finally, nominal rigidities are added as in the simplest New-Keynesian model, see Galí (2008).

2.1 General setting

The economy has two sectors $j \in \{p, g\}$. Public sector variables are denoted by the superscript g and private sector variables by p. Time is discrete and denoted by t. The economy is populated by a measure one of workers. Workers differ ex-ante from each other, with all workers falling into one of four categories $i \in \{\bar{h}, \underline{h}, \bar{\mu}, \underline{\mu}\}$, with two dimensions of heterogeneity. The first dimension is education, with skilled workers (college degree) denoted by h and unskilled (bellow college degree) workers denoted by μ. Within each group, there are workers with higher ability, $(\bar{h}, \bar{\mu})$, and others with lower ability $(\underline{h}, \underline{\mu})$. The productivity of workers of type i is denoted by z^i, with $z^{\bar{h}} > z^{\underline{h}}$ and $z^{\bar{\mu}} > z^{\underline{\mu}}$. The mass of workers of type i is ω^i, with $\sum_i \omega^i = 1$.

For each type, a fraction of workers are unemployed (u_t^i), whilst the remaining are working either in the public $(l_t^{g,i})$ or private $(l_t^{p,i})$ sector.

$$1 = l_t^{p,i} + l_t^{g,i} + u_t^i, \quad \forall i. \tag{1}$$

Total unemployment is denoted by $u_t = \sum_i \omega^i u_t^i$. The presence of search and matching frictions prevent some unemployed individuals from finding jobs, see Pissarides (2000). The evolution of employment of type i in sector j depends on the number of new matches $m_t^{j,i}$ and on job separations. In each period, jobs are destroyed at rate $\lambda^{j,i}$, which potentially differs across sectors and types.

$$l_{t+1}^{j,i} = (1 - \lambda^{j,i}) l_t^{j,i} + m_t^{j,i}, \quad \forall ji. \tag{2}$$

I assume that the markets are segmented and independent across types. This assumption is worth discussing. While employers can easily observe potential employees' length of education from their CVs, this is not necessarily the case with ability. We have to state whether it is observable ex-ante by the employer or is private information. If ability is unobservable, low-ability workers can apply to high-ability jobs, breaking down an equilibrium with segmented markets. I want to abstract from the complications arising from asymmetric information. I rely on previous papers on adverse selection with labour market frictions, such as Guerrieri *et al.* (2010) or Fernández-Blanco (2013). These papers argue that firms can design mechanisms such that workers self-select into the correct segment.[5] Section 2.4 explains why assuming observable types is not a problem.

I assume that the unemployed can direct their search to the private or public sectors. This assumption finds support in micro-econometric evidence and was discussed in length in Gomes (2014). Together with the assumption of segmented markets, it allows new matches to be expressed with the following matching functions:

$$m_t^{j,i} = m^j(u_t^{j,i}, v_t^{j,i}), \quad \forall ji. \tag{3}$$

I assume that the unemployed choose the sector in which they concentrate their search; thus, $u_t^{j,i}$ represents the number of unemployed of type i searching in sector j. Vacancies in each segment are denoted by $v_t^{j,i}$. An important part of the analysis focuses on the behaviour of those unemployed specifically searching for public sector jobs, defined as: $s_t^i \equiv \frac{u_t^{g,i}}{u_t^i}$. We also define $q_t^{j,i}$ as the probability of filling a vacancy of type i is sector j and $f_t^{j,i}$ as the

[5] In Guerrieri *et al.* (2010) this is done by contracts specifying the hours worked. Assuming that high-ability workers have lower disutility of work, firms post a contract specifying a higher wage and more hours, which excludes the low-ability type. I follow the setting of Fernández-Blanco (2013). He assumes that the output of a match depends on the capital supplied by firms and that firms and workers bargain over wages. Firms specify a capital plan ex-ante. With capital-skill complementarity, the low-ability worker does not have an incentive to apply to high-ability jobs, as it implies too much capital, and hence lower wages.

job-finding rate of an unemployed of type i conditional on searching in sector j:

$$q_t^{j,i} = \frac{m_t^{j,i}}{v_t^{j,i}}, \ f_t^{j,i} = \frac{m_t^{j,i}}{u_t^{j,i}}, \ \ \forall ji.$$

2.2 Households

Following Merz (1995), I assume that household members pool their income so private consumption is equalised across members. This is a common assumption in the literature to maintain a representative agent framework in the presence of unemployment. Without this risk sharing assumption, risk-averse workers with different employment histories would accumulate different levels of wealth. As the wealth distribution is not relevant to our problem, I prefer to simplify and retain the representative agent framework. The household is infinitely lived and has the following preferences:

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(c_t) + \nu(u_t)], \tag{4}$$

where

$$c_t \equiv \left(\int_0^1 c_{n,t}^{\frac{\xi-1}{\xi}} \, dn \right)^{\frac{\xi}{\xi-1}} \tag{5}$$

is the Dixit-Stiglitz basket of consumption goods produced by the final goods retail sector. The household also derives utility from members who are unemployed $\nu(u_t)$, which captures the value of leisure and home production. $\beta \in (0, 1)$ is the discount factor. The budget constraint in period t is given in real terms by

$$c_t + \frac{B_{t+1}}{p_t} + K_{t+1} = \frac{(1+i_{t-1})B_t}{p_t} + (1-\delta)K_t + (1-\tau_t)\left(\frac{r_t}{p_t} K_t + \sum_j \sum_i \omega^i \frac{w_t^{j,i}}{p_t} l_t^{j,i} \right) + \chi^g u_t + \Pi_t, \tag{6}$$

where i_{t-1} is the nominal interest rate from period $t-1$ to t, and B_t are the holdings of one-period bonds. Households can also save by accumulating capital stock K_t. The capital stock depreciates at a rate δ and can be rented to firms at a nominal rental rate of r_t. The second source of income is labour income, with $w_t^{j,i}$ being the nominal wage rate from the members of type i working in sector j. Unemployed members collect unemployment benefits χ^g. The household pays a tax τ_t on both its labour and capital income. Finally, Π_t encompasses the lump-sum taxes or transfers from the government and possible net profits from the private

sector firms. The aggregate price level, p_t, is given by

$$p_t \equiv \left(\int_0^1 (p_t^n)^{1-\xi} dn \right)^{\frac{1}{1-\xi}}. \tag{7}$$

The household chooses the sequence of $\{c_t, K_{t+1}, B_{t+1}\}_{t=0}^{\infty}$ to maximise the expected utility subject to the sequence of budget constraints, taking taxes and prices as given. The solution is the Euler equation and an arbitrage condition between capital and bonds:

$$u_c(c_t) = \beta(1+i_t) E_t[\frac{p_t}{p_{t+1}} u_c(c_{t+1})], \tag{8}$$

$$1 + i_t = E_t[\frac{p_{t+1}}{p_t}(1 - \delta + \tilde{r}_{t+1}(1-\tau_{t+1})], \tag{9}$$

where $\tilde{r}_t = \frac{r_t}{p_t}$ is the real rental rate of capital. The second condition compares the interest rate paid by a one-period bond with the expected nominal return on a unit of investment. In this specification, income tax introduces an extra burden on investment in capital relative to bonds.

2.3 Workers

The unweighted value of each member of type i to the household depends on their current state. The values of being employed are:

$$W_t^{j,i} = (1-\tau_t)\tilde{w}_t^{j,i} + E_t \beta_{t,t+1}[(1-\lambda^{j,i}) W_{t+1}^{j,i} + \lambda^{j,i} U_{t+1}^i], \quad \forall i, j, \tag{10}$$

where $\beta_{t,t+k} = \beta^k \frac{u_c(c_{t+k})}{u_c(c_t)}$ is the stochastic discount factor and $\tilde{w}_t^{j,i} = \frac{w_t^{j,i}}{p_t}$ is the real wage. The value of being employed in a specific sector depends on the current wage as well as the continuation value of the job, which depends on the separation probability. Under the assumption of direct search, those unemployed are searching for a job in either the private or public sectors, with value functions given by

$$U_t^{j,i} = \frac{\nu_u(u_t)}{u_c(c_t)} + \chi^b + E_t \beta_{t,t+1}[f_t^{j,i} W_{t+1}^{j,i} + (1 - f_t^{j,i}) U_{t+1}^i], \quad \forall i, j. \tag{11}$$

As in Hall and Milgrom (2008), the unemployed collect unemployment benefits χ^b and contribute to home production (marginal utility from unemployment relative to the marginal utility of consumption). The continuation value of being unemployed and searching in a particular sector depends on the probability of finding a job and the value of working in that sector. I assume that each unemployed member decides on which sector to search according

to the following condition:

$$U_t^{p,i} = U_t^{g,i} + \gamma_t^i, \quad \forall i. \tag{12}$$

Optimality implies that movement between the two segments guarantees no additional gain for searching in one sector *vis-à-vis* the other. To this condition, I add, γ_t^i, a random variable with cumulative distribution Γ, which stands for an idiosyncratic preference for the public sector. In each period all the unemployed draw γ_t^i and decide where to search. This is a shortcut, but a quantitatively important one. Without it, as in Gomes (2014), small changes in relative wages generate implausibly large swings in the fraction of unemployed searching in the public sector. With a distribution of preferences, even if the government pays low wages, workers with strong preferences for the public sector would still apply for jobs there.[6] Γ puts discipline on the fluctuations on s_t^i, that are given in equilibrium by

$$s_t^i = 1 - \Gamma(\gamma_t^{i,*}), \quad \forall i, \tag{13}$$

where $\gamma_t^{i,*}$ is the cut-off point of the distribution for type i at time t. All unemployed household members with preferences above the cut-off will search for jobs in the public sector, while the ones below search in the private sector. This threshold is given by

$$\gamma_t^{i,*} = f_t^{p,i} E_t \beta_{t,t+1} [W_{t+1}^{p,i} - U_{t+1}^i] - f_t^{g,i} E_t \beta_{t,t+1} [W_{t+1}^{g,i} - U_{t+1}^i], \quad \forall i. \tag{14}$$

An increase in the value of employment in the public sector, driven by either wage increase or decrease in the separation rate, raises s_t until no extra gain exists for searching in that sector. However, the marginal searcher has a lower preference for the public sector. In each period there is a wedge between the two values of unemployment. The ex-ante value of being unemployed is given by:

$$U_t^i = (1 - s_t^i) U_t^{p,i} + s_t^i U_t^{g,i}, \quad \forall i. \tag{15}$$

2.4 Intermediate goods producers

There is a large continuum of firms that produce one of four types of intermediate goods x_t^i, which is sold at price $p_t^{x,i}$. Firms open vacancies in a given sub-market i. If the vacancy is filled, the firm is matched to a type-i worker and produces $f(a_t, z^i, k_t^i)$, where a_t is an aggregate productivity that is stochastic and k_t^i is the capital used in the match. The production technology $f(\cdot, \cdot, \cdot)$ is increasing and concave in all its arguments with a positive

[6] Artuç *et al.* (2010) argue that wage differentials alone cannot explain several facts about mobility. The idiosyncratic shock is crucial to a realistic treatment of worker mobility.

cross partial derivative of capital and skill. The value of a job in real terms is given by

$$J_t^i = \max_{k_t^i}[\tilde{p}_t^{x,i} f^i(a_t, z^i, k_t^i) - \tilde{w}_t^{p,i} - \tilde{r}_t^{p,i} k_t^i + E_t \beta_{t,t+1}[(1-\lambda^{p,i}) J_{t+1}^i], \quad \forall i. \tag{16}$$

For each match, the firm chooses how much capital it wants to rent to provide to the worker. The optimal level of capital k_t^{*i} solves the first-order condition:

$$\tilde{p}_t^{x,i} f_k^i(a_t, z^i, k_t^{*i}) = \tilde{r}_t, \quad \forall i. \tag{17}$$

Therefore, we can write the value of a job as

$$J_t^i = [\tilde{p}_t^{x,i} f^i(a_t, z^i, k_t^{*i}) - \tilde{w}_t^{p,i} - \tilde{r}_t^{p,i} k_t^{*i} + E_t \beta_{t,t+1}[(1-\lambda^{p,i}) J_{t+1}^i], \quad \forall i. \tag{18}$$

The value of opening a vacancy for type i is given by

$$V_t^i = -\kappa^{p,i} + E_t \beta_{t,t+1}[q_t^{p,i} J_{t+1}^i + (1-q_t^{p,i}) V_{t+1}^i], \quad \forall i, \tag{19}$$

where $\kappa^{p,i}$ is the cost of posting a vacancy. The number of firms is determined in equilibrium by free entry:

$$V_t^i = 0, \quad \forall i. \tag{20}$$

The surplus from the match is shared by the firm and workers as wages are the outcome of Nash bargaining:

$$\tilde{w}_t^{p,i} = \arg\max_{\tilde{w}_t^{p,i}} (W_t^{p,i} - {U^i}_t)^b (J_t^i)^{1-b}, \quad \forall i. \tag{21}$$

where b denote the worker's bargaining power. The solution is given by

$$(W_t^{p,i} - U_t^i) = \frac{b(1-\tau_t)}{1-b\tau_t}(W_t^{p,i} - U_t^i + J_t^i), \quad \forall i. \tag{22}$$

With distortionary taxes, the share of the surplus going to workers is lower than their bargaining power. For every unit that the firm gives up in favour of the worker, the pair lose a fraction τ_t to the government. Therefore, they economise on their tax payments by agreeing to a lower wage.

Notice that, from Equation (17), one capital level maximises the surplus of the match, and hence wages. Given the capital-skill complementarity, the optimal level of capital increases with ability, provided the price of the good is not decreasing in ability, which is guaranteed in the numerical exercise. This ensures that, even if ability was not observable, we could design a separating equilibrium. If firms commit to supplying a capital stock of the high

type in every period, low-ability workers would not pretend to have high ability. Even if they would have a higher job-finding rate, they would be paired with too much capital for the duration of the match, implying lower wages; see Fernández-Blanco (2013).

2.5 Wholesale firms

The representative wholesale firm buys intermediate inputs in a competitive market, produces a final good and sells it at price $\tilde{p}_t^y$. The objective is to choose inputs to maximise profits given by

$$\max_{\mathbf{x}_t}[\tilde{p}_t^y F(\mathbf{x}_t) - \sum_i \tilde{p}_t^{x,i} x_t^i], \tag{23}$$

where bold denotes a vector, that is, $\mathbf{x}_t$ denotes a vector with all four intermediate inputs. The solution is given by the first-order conditions:

$$\tilde{p}_t^y F'_{x^i} = \tilde{p}_t^{x,i}, \quad \forall i. \tag{24}$$

2.6 Retails firms

There is a continuum of retailers facing monopolistic competition. Each firm n buys a intermediate good $y_{n,t}$ and sells it as a differentiated good. Each firm faces a sequence of downward slopping demand curves:

$$y_{n,t+s} = \left(\frac{p_{t+s}^n}{p_{t+s}}\right)^{-\xi} Y_{t+s}, s = 0, 1, ... \tag{25}$$

where Y_t is the aggregate demand of differentiated final goods and ξ is the elasticity of substitution between them. The real marginal cost is

$$mc_t = \tilde{p}_t^y + \varphi_t^c, \tag{26}$$

where φ_t^c is a cost-push shock. I follow the Calvo price setting model. In each quarter, a share θ of firms do not reset their price. All firms re-optimising at date t solve an identical

problem given by

$$\max_{p_t^{n,*}} E_t \left\{ \sum_{s=0}^{\infty} \theta^s \beta_{t,t+s} \left[\frac{p_t^{n,*}}{p_{t+s}} - mc_{t+s} \right] y_{n,t+s|t} \right\}$$

$$s.t.$$

$$y_{n,t+s|t} = \left(\frac{p_t^{n,*}}{p_{t+s}} \right)^{-\xi} Y_{t+s}.$$

The optimal pricing decision and law of motion for the price level are given by

$$E_t \sum_{s=0}^{\infty} (\theta)^s \beta_{t,t+s} Y_{t+s} p_{t+s}^{\xi} \left(\frac{p_t^*}{p_{t+s}} - \frac{\xi}{\xi - 1} mc_{t+s} \right) = 0. \tag{27}$$

$$p_t^{1-\xi} = \theta p_{t-1}^{1-\xi} + (1-\theta) p_t^{*1-\xi}. \tag{28}$$

2.7 Government

I assume that the government needs to produce a minimum number of services, g_t, that is stochastic. To produce these services, the government has to hire different types of workers. I consider public sector wages to be exogenous policy variables determined a period in advance when vacancies are posted. Given a wage schedule, the government chooses the number of vacancies for each type of worker to minimise the total cost of providing the government services. The total costs, in real terms, encompass the wage bill and recruitment costs.

$$\min_{v_t^{g,i}} \sum_i \omega^i \kappa^{g,i} v_t^{g,i} + E_t \beta_{t,t+1} [\sum_i \omega^i \frac{w_{t+1}^{g,i}}{p_{t+1}} l_{t+1}^{g,i}]$$

$$s.t.$$

$$g_{t+1} = g(\mathbf{l}_{t+1}^g)$$

$$l_{t+1}^{g,i} = (1 - \lambda^{j,i}) l_t^{g,i} + q_t^{g,i} v_t^{g,i}, \quad \forall i,$$

where $g(\mathbf{l}_t^g)$ is the production function of government services that use the four types of workers, $\mathbf{l}_t^g$. Given the level of public wages and market tightness, the government has to guarantee that it posts sufficient vacancies to maintain an employment level capable of

providing its services.[7] The first-order conditions are

$$\frac{\omega^i \kappa^{g,i}}{q_t^{g,i}} + E_t \beta_{t,t+1} [\omega^i \frac{w_{t+1}^{g,i}}{p_{t+1}}] = \zeta_t E_t g'_{i,t+1}, \quad \forall i, \tag{29}$$

where ζ_t is the real multiplier of the constraint on government services and $g'_{i,t}$ is the partial derivative of the government services with respect to government's employment of type i workers. This problem incorporates the two opposite forces that are important to understand the role of public sector wages. When wages of one employee type go down, the government would save on the wage bill if it hired more of them. However, simultaneously, it may be more expensive to recruit them. The overall effect depends on the tightness of the labour market.

The government budget constraint in real terms is given by

$$\tau_t \left(\sum_j \sum_i \omega^i l_t^{j,i} \tilde{w}_t^{j,i} + \tilde{r}_t K_t \right) = \sum_i \omega^i l_t^{g,i} \tilde{w}_t^{g,i} + \sum_i \omega^i v_t^{g,i} \kappa^{g,i} + \chi^b u_t + T_t + \bar{g}^{int}, \tag{30}$$

where T_t are lump-sum transfers and $\bar{g}^{int}$ are exogenous purchases of intermediate goods. The costs of recruiting are external, meaning they come out of the budget constraint. Throughout the paper, I consider two cases: one where any adjustment of the government budget is guaranteed by changes in lump-sum transfers and the other where distortionary income tax rate adjusts to balance the budget.

2.8 Central bank

Finally, the central bank sets the following nominal interest rate i_t

$$1 + i_t = \rho^m (1 + i_{t-1}) + (1 - \rho^m)(\frac{1}{\beta} + \phi(\pi_t - 1)), \tag{31}$$

where $\pi_t = \frac{p_t}{p_{t-1}}$ is the inflation rate, ϕ is the response of the target interest rate to changes in inflation and ρ^m is the degree of persistence of the interest rate.

[7] I consider a relatively myopic government that does not care about the infinite sequence of government services and the present discounted value of the costs. Under this alternative the government would also have a continuation value for each type of workers, but the nature of the behaviour would be the same.

2.9 Market clearing

The market clearing conditions in the intermediate and final goods' markets are

$$x_t^i = \omega^i l_t^{p,i} f^i(a_t, z^i, k_t^i), \quad \forall i, \tag{32}$$

$$Y_t = F(\mathbf{x}_t) = c_t + \bar{g}^{int} + K_{t+1} - (1-\delta)K_t + \sum_i \sum_j \omega^i v_t^{j,i} \kappa^{j,i}. \tag{33}$$

In this economy, the measure of GDP in the national accounts would be $GDP_t = F(\mathbf{x}_t) + \sum_i \omega^i l_t^{g,i} w_t^{g,i}$. The market clearing in the capital market implies that all capital is rented to intermediate goods producers:

$$K_t = \sum_i \omega^i k_t^i l_t^{p,i}. \tag{34}$$

As bonds have zero-net supply, the market clearing is

$$B_t = 0. \tag{35}$$

2.10 Business cycle

I assume three main sources of fluctuations: technology, cost-push and government employment shocks.

$$a_t = (1-\rho^a)\bar{a} + \rho^a a_{t-1} + \varepsilon_t^a, \tag{36}$$

$$\varphi_t^c = \rho^c \varphi_{t-1}^c + \varepsilon_t^c, \tag{37}$$

$$g_{t+1} = (1-\rho^g)\bar{g} + \rho^g g_t + \varepsilon_t^g, \tag{38}$$

where ε_t^a, ε_t^c and ε_t^g are iid innovations with standard deviations σ^a, σ^c and σ^g. $\bar{a}$ and $\bar{g}$ are the steady-state levels of technology and government services, respectively.

I also need to characterize the business cycle policy for public sector wages. I assume that, over the business cycle, the government proportionally adjusts the wages of all types of workers. I consider that the government decides the evolution of wages as:

$$\log(\frac{w_{t+1}^{g,i}}{p_t}) \quad = \quad \log(\bar{w}^g) + \iota[\log(\frac{w_t^p}{p_t}) - \log(\bar{w}^p)] + \varphi_t^w, \tag{39}$$

where $w_t^p \equiv \frac{\mathbf{w}_t^p \mathbf{l}_t^p}{l_t^p}$ and $w_t^g \equiv \frac{\mathbf{w}_t^g \mathbf{l}_t^g}{l_t^g}$ represent the average nominal wage in the private and public sectors. The parameter ι measures the cyclicality of wages. If $\iota = 0$ public sector wages are acyclical. If $\iota > 0$ they are procyclical. If $\iota < 0$, they are countercyclical. φ_t^w is an

autocorrelated public sector wage shock given by

$$\varphi_t^w = \rho^w \varphi_{t-1}^w + \varepsilon_t^w. \tag{40}$$

I propose and evaluate an alternative simple rule that generates procyclical public sector wages. The government sets the growth rate of public sector wages for the subsequent period Ξ_{t+1}, such that an aggregate target for the average wage is met:

$$Rule: \quad \Xi_{t+1} \frac{\mathbf{w}_t^g \mathbf{l}_t^g}{l_t^g} \;=\; \Upsilon \times \frac{\mathbf{w}_t^p \mathbf{l}_t^p}{l_t^p}. \tag{41}$$

Motivated by the Figure 1b in the introduction, the government aims to maintain the average nominal public sector wages relative to average nominal private sector wages as in the steady-state, given by $\Upsilon \equiv \frac{\bar{w}^g}{\bar{w}^p}$. This rule is equivalent to Equation (39), when $\iota = 1$, but without wage shocks. In other words, by explicitly assuming this rule, the government purges the political involvement and eliminates the uncertainty around public sector wages.

3 Calibration

To solve the model, I consider the following functional forms for the matching functions, production functions and preferences.

$$m_t^{j,i} = \zeta^{j,i} (u_t^{j,i})^{\eta^j} (v_t^{j,i})^{1-\eta^j}, \forall i, j,$$

$$u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma},$$

$$\nu(u_t) = \chi^u u_t,$$

$$f(a_t, z^i, k^i) = a_t z^i (k^i)^\alpha \quad \forall i$$

$$F(\mathbf{x}_t) = \left(\Psi((x_t^{\bar{h}})^\varrho + (x_t^{\underline{h}})^\varrho)^{\frac{\varsigma}{\varrho}} + (1-\Psi)((x_t^{\bar{\mu}})^\varrho + (x_t^{\underline{\mu}})^\varrho)^{\frac{\varsigma}{\varrho}} \right)^{\frac{1}{\varsigma}}$$

$$g(\mathbf{l}_{t+1}^g) = \left(\Phi((\omega^{\bar{h}} z^{\bar{h}} l_{t+1}^{g,\bar{h}})^\varrho + (\omega^{\underline{h}} z^{\underline{h}} l_{t+1}^{g,\underline{h}})^\varrho)^{\frac{\varsigma}{\varrho}} + (1-\Phi)((\omega^{\bar{\mu}} z^{\bar{\mu}} l_{t+1}^{g,\bar{\mu}})^\varrho + (\omega^{\underline{\mu}} z^{\underline{\mu}} l_{t+1}^{g,\underline{\mu}})^\varrho)^{\frac{\varsigma}{\varrho}} \right)^{\frac{1}{\varsigma}}$$

I assume a CRRA utility function with a coefficient of risk aversion σ and linear utility of unemployment. For the matching function, the matching elasticity with respect to unemployment, η^j, can be different across sectors, but not across types, while the matching efficiency, $\zeta^{j,i}$, differs across sectors and education, but not ability. For the production function of individual firms, I assume an elasticity of output with respect to capital per worker of α. The final output is produced by two nested CES functions. Both skilled and unskilled

inputs are an aggregation of low- and high-ability workers, with the parameter ϱ determining the elasticity of substitution between types. The final good is then produced by a CES of the skilled and unskilled intermediate inputs with a parameter ς. Ψ governs the importance of the skilled input in production. Finally, the government's production function has the same elasticity of substitutions between low- and high-ability workers (ϱ) and between skilled and unskilled inputs (ς) as the private sector.

The model is calibrated to match the UK economy on a quarterly frequency, drawing largely on the Labour Force Survey (LFS) microdata for the period 1996-2010. The educational attainment of the labour force has significantly improved over the past two decades, as documented in Gomes (2012). I take an average of the period 1996-2010, which places the share of university graduates at 32 percent of the population. I consider that high- and low-ability workers have the same mass, so $\omega^{\bar{h}} = \omega^{\underline{h}} = 0.16$ and $\omega^{\bar{\mu}} = \omega^{\underline{\mu}} = 0.34$. I also report the results assuming the share of college graduates is: i) the one at the beginning of the sample (25 percent) and ii) the one at end of the sample (40 percent).

The contribution of skilled workers to the provision of government services, Φ, and their steady-state level $\bar{g}$ are such that the government hires 37.3 percent of university graduates and 16.7 percent of workers without a university degree. These numbers, taken from the LFS, reflect the fact that the government predominantly hires skilled workers. Following Gomes (2012), I construct data on worker flows to calibrate the separation rates, which I assume are equal for workers of different abilities, but differ by education and sector. The numbers are $\lambda^{p,h} = 0.012$, $\lambda^{p,\mu} = 0.017$, $\lambda^{g,h} = 0.004$ and $\lambda^{p,\mu} = 0.006$. The private sector has two to three times more separations than the public sector. Unskilled workers are more likely to lose their jobs than skilled workers.

To calibrate the public sector wage premium for skilled workers, I run quantile regressions of the log of net wages of college graduates on a dummy for the public sector. I control for: sex, industry and occupation, status in previous quarter, tenure, age and its square, marital status, time and region and average hours worked and its square. The sample runs from 1996 to 2006. I take the coefficients of the public sector dummy of the 25 and 75 percentiles as the premium of the low- and high-ability skilled workers. I repeat the regressions for non-college graduates. The steady-state public sector wages of the four types are set such that $\frac{\bar{w}^{g,\bar{h}}}{\bar{w}^{p,\bar{h}}} = 1.016$, $\frac{\bar{w}^{g,\underline{h}}}{\bar{w}^{p,\underline{h}}} = 1.039$, $\frac{\bar{w}^{g,\bar{\mu}}}{\bar{w}^{p,\bar{\mu}}} = 1.037$ and $\frac{\bar{w}^{g,\underline{\mu}}}{\bar{w}^{p,\underline{\mu}}} = 1.071$. These numbers are consistent with several studies using micro data from the United Kingdom, such as Disney and Gosling (1998) or Postel-Vinay and Turon (2007), which document a wage compression within and across education groups.

The United Kingdom has a unique source of data on recruitment costs by sector. Ev-

ery year, the Chartered Institute of Personal Development conducts a recruitment practice survey covering 800 organizations ranging from manufacturing to private and public sectors services (CIPD (2009)). The costs of recruiting a worker, which encompass advertising and agency costs, are approximately £13000 for a skilled worker in the private sector and £8000 in the public sector, corresponding to 26 and 16 weeks of the UK median income. For a low-skilled worker, the costs are £3500 and £2000 for private and public sectors, respectively. The costs of posting vacancies are set to target these numbers ($\kappa^{p,h} = 1.35$, $\kappa^{g,h} = 0.90$, $\kappa^{p,\mu} = 0.14$ and $\kappa^{g,\mu} = 0.13$). The CIPD data also reports vacancy durations. It takes 14.5 weeks to hire a skilled worker in the private sector and 16 weeks in the public sector. For unskilled workers, it takes 5.5 weeks in the private sector, compared with 9.1 weeks in the public sector. The matching elasticities are set to match these moments ($\zeta^{g,h} = 0.70$, $\zeta^{p,h} = 0.57$, $\zeta^{g,\mu} = 0.99$ and $\zeta^{p,\mu} = 0.98$). The matching elasticities with respect to unemployment are set to $\eta^p = 0.4$ and $\eta^g = 0.15$, estimated by Gomes (2014).

The parameter of the private production function Ψ is set to 0.41 to target a college premium of 40 percent, which was found by regressing the log net wages on a dummy for college education, and average hours and its square. I normalise $z^{\underline{h}} = z^{\bar{\mu}} = 1$. I link the productivity differences within skilled and unskilled workers to a measure of within-group wage dispersion. I run a mincer regression of log net wages on several controls and retrieve the 25-75 percentile difference of the wage residuals. The difference is 0.461 for skilled and 0.416 for unskilled workers. It is a strong assumption to consider that all the wage dispersion is due to productivity differences. Other factors, namely, search frictions may also contribute. Abowd, Kramarz, and Margolis (1999) find that search frictions can explain 7-25 percent of the French inter-industry differential. Tjaden and Wellschmied (2014) find that 13.7 percent of overall wage inequality is due to the presence of search frictions. I assume that 20 percent of the wage dispersion is due to other factors and set $z^{\bar{h}} = 1.24$ and $z^{\underline{\mu}} = 0.80$ to target a wage gap between high- and low-ability of 0.368 for skilled and 0.332 for unskilled workers. I also report the results assuming: i) all wage dispersion is due to productivity differences and ii) only 20 percent of wage dispersion is due to productivity differences across workers.

To accurately predict the welfare and budgetary effects of public sector pay, we have to distinguish the flow value of unemployment due to home production versus unemployment benefits. Salomäki and Munzi (1999) find that the net replacement rate is 61 percent for low-educated workers and 49 percent for highly educated workers in the United Kingdom. I set $\chi^b = 0.21$ such that the replacement rate for a low-ability unskilled worker is 60 percent of the net wage. It implies a replacement rate of 30 percent for the high-ability skilled workers and of 45 percent for the remaining workers. I calibrate the utility value of unemployment ($\chi^u = 0.33$) and bargaining power of workers ($b = 0.28$) to target an average unemployment

rate of six percent and of 7.3 percent for unskilled workers, values extracted from the LFS. The joint flow value of unemployment varies from 50 of the net private sector wage for a high-ability skilled worker to 95 percent for a low-ability unskilled worker. The average is around 70 percent, suggested by Hall and Milgrom (2008).

Regarding the technology parameters, the elasticity of output with respect to capital α is set to 0.35 to target a labour share of 60.8 percent, the UK economy's average between 1996 and 2010. The parameter determining the elasticity of substitution between skilled and unskilled input, ς, is set to 0.4, a value estimated by Krusell *et al.* (2000). I assume that workers of the same skill group are close to perfect substitutes with $\varrho = 0.95$.

The rest of the parameters are standard: β is set to 0.99, σ to 2 and the depreciation rate δ to 0.02. I use textbook values [Galí (2008)] for the nominal frictions. The elasticity of substitution between different varieties, ξ, is set to 6, implying a markup of 20 percent. The share of firms not allowed to reset prices, θ, is $\frac{2}{3}$. The central bank responds to inflation with $\phi = 1.5$ and with an inertia of $\rho^m = 0.8$. For the government, I set the income tax equal to 0.2 and the purchase of intermediate inputs such that total government consumption is 20 percent of GDP, the UK average from 1996 to 2010 ($\bar{g}^{int} = 0.03$). Lump-sum transfers balance the budget in the steady-state.

Turning to the business cycle, I assume in the baseline case that the government maintains a constant tax rate over the business cycle, and any budgetary imbalance is neutralized by lump-sum taxes. To calculate the cyclicality of government wages, ι, I regress the log of the average public sector wage on the lagged log of the average private sector wage. The quarterly data series, from 1970 to 1996, are taken from OECD and were previously detrended using a linear, quadratic and cubic trend. I found a cyclicality of $\iota = 0.58$, implying that public sector wages are less procyclical than private sector wages. I use the residual of the regression to estimate the stochastic components: $\rho^w = 0.83$ and $\sigma^w = 0.025$.

I consider three sources of fluctuations: technology, government employment and cost-push shocks. I estimate the technology process using the OECD detrended quarterly productivity index, resulting in $\rho^a = 0.74$ and $\sigma^a = 0.01$. I follow a similar procedure for government employment, for which I found a much higher persistence ($\rho^g = 0.96$) and a standard deviation of $\sigma^g = 0.0005$. The volatility of the cost-push shock is such that the standard deviation of inflation is 0.005, the average for the period 1996-2010. The autocorrelation of the cost-push shock is set to 0.7, implying that the autocorrelation of inflation is bellow zero, and close to -0.05 observed in the United Kingdom.

An important element for the quantitative exercise is the distribution of sector preference Γ. A higher dispersion implies lower volatility of the fraction of unemployed searching in the

public sector in response of shocks. I assume a uniform distribution with parameters $[\nu_1, \nu_2]$. Given that the search patterns of the unemployed are unobservable, there are no obvious data sources to use. I exploit data from *Google Trends* as a proxy. *Google Trends* provides indexes of keyword searches reflecting the instances people have "Googled" a specific word or combination of words relative to overall traffic. These indexes are available on a *weekly* basis dating back to 2004.[8] I retrieved the index of keyword searches of 'jobs' and one that includes several keywords related to the public sector such as 'government jobs', 'council jobs', 'nhs jobs' or 'army jobs'. The average ratio of the two indexes is 0.14 and the quarterly standard deviation is 0.04. The constructed series has a correlation of 0.9 with the aggregate public sector wage premium for the common sample between 2004 and 2010. I calibrate the two parameters of the distribution, ν_1 and ν_2 to match these two moments. I also report the results assuming: i) a logistic distribution and ii) the average fraction of searchers in the public sector and its volatility is 50 percent higher or 50 percent lower than the baseline.[9]

4 Reforming the public sector's wage policy

4.1 The effects of heterogeneous pay in steady-state

I start by examining the effects of progressive and regressive wage cuts. The progressive wage cuts target skilled workers. I assume that, for each one percent cut of high-ability wages, the wages of the low-ability are cut by 0.5 percent. Unskilled wages remain constant. The regressive wage cuts target only unskilled workers. For each one percent cut of low-ability wages, the wages of the high-ability are cut by 0.5 percent. The income tax adjusts to balance the budget. Figure 2 shows the outcomes.

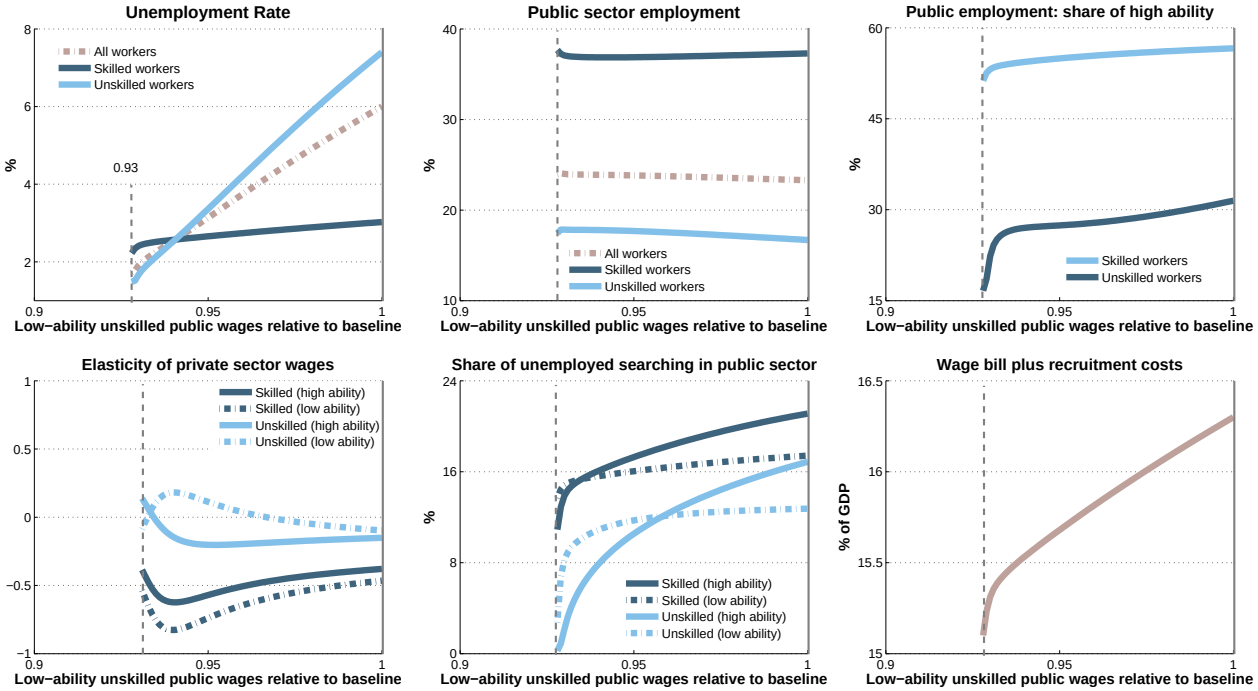
As the government reduces the unskilled workers' wages (top panel), the composition of public employment shifts from skilled to unskilled workers. Lowering wages has two opposite effects: wage bill effect and recruitment effect. As workers become cheaper, the government wants to employ more to save on the wage bill. However, offering lower wages makes the public sector less attractive, implying that fewer unemployed search for jobs there, making the recruitment more costly. When the government reduces unskilled workers' wages, the first effect dominates because unemployed workers are still queuing for jobs in the public sector. To maintain the same level of services, the government hires more workers, but reduces spending on the total wage bill plus recruitment costs.

[8] Researchers have used these data to forecast: financial markets, labour and housing markets, automobile sector, inflation expectations or private consumption. See the review in Gomes and Taamouti (2014).

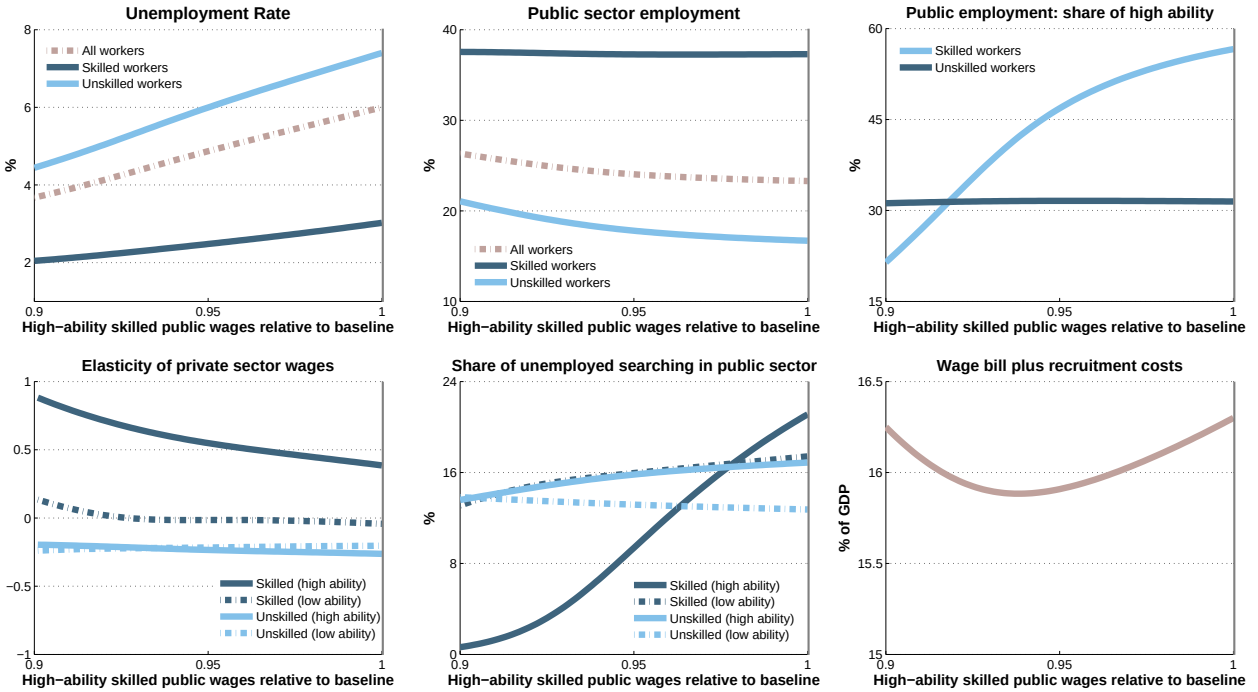
[9] Further details of the calibration, data sources and a summary table can be found in the Appendix.

Figure 2: Steady-state effects of public sector wages adjustments

Regressive public sector wage cuts: unskilled wages only



Progressive public sector wage cuts: skilled wages only



Note: model simulations under the baseline calibration. Regressive public sector wage cuts: for each 1 percent cut in low-ability unskilled wages, the wages of the high-ability unskilled are cut by 0.5 percent. Skilled wages are constant. Progressive public sector wage cuts: for each 1 percent cut in high-ability skilled wages, the wages of the low-ability skilled are cut by 0.5 percent. Unskilled wages are constant. The vertical line in the top panel indicates the maximum cuts that guarantee positive search in the public sector of all types.

The government faces a constraint when reducing wages: they have to guarantee that some unemployed search for public sector jobs. For the baseline calibration, the government cannot cut the low-ability unskilled wages by more than seven percent (3.5 percent for the high-ability) or the public sector vacancies do not receive any applicants.

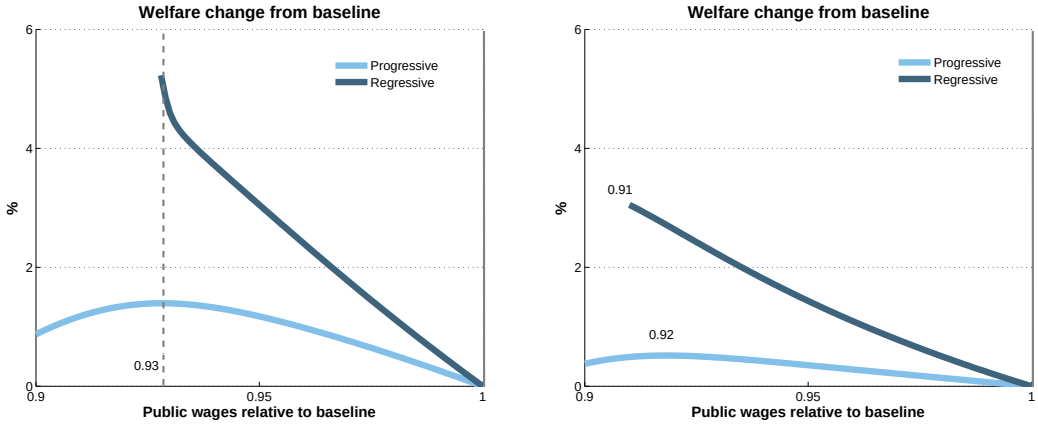
Still, the consequences in the labour market are dramatic. With a seven percent wage cut, the unemployment rate of unskilled workers falls from 7.3 percent to bellow 2 percent. Lowering wages shifts the job searches to the private sector and firms post more vacancies. But the improvement in the labour market cannot explain the magnitude of the unemployment reduction. The key reason is that the unskilled wage cuts encourages the government to hire more unskilled workers, particularly with low ability. In the baseline case, the government hires 23 percent of these workers, but when paying lower wages it hires as much as 26 percent. This is the group with the highest unemployment rate, that is reduced massively with the increase in hiring. A large wage premium at the bottom, makes these workers expensive compared to their productivity. A government that minimizes costs neglects these workers in favour of more productive workers that are relatively cheaper.

The elasticities of private sector wages with respect to the average public sector wage are heterogeneous. Wage cuts in the public sector initially raise all wages in the private sector, particularly skilled wages. Two effects explain this negative elasticity. First, by lowering unemployment and raising total production and private consumption, they entail a wealth effect. As marginal utility decreases, the utility value of unemployment increases, putting pressure on wage bargaining. Second, as the government saves on the wage bill, it cuts income taxes and hence the distortions on wage bargaining and capital accumulation. Only when cuts are too severe, the elasticity of unskilled wages become positive.

The bottom panel of Figure 2 shows the consequences of reducing skilled workers' wages. First, it shifts the composition of public employment to unskilled workers. In the case of skilled worker wage cuts, the recruitment effect dominates the wage bill effect. By offering too low wages, only a few devoted skilled unemployed will look for public sector jobs. The government faces recruitment problems, making it costly to hire a skilled worker. To maintain its services, the government hires more unskilled workers, increasing the size of the public sector. This is a case where lowering wages have perverse effects. With wage cuts of more than 7 percent on top earners, the total wage bill plus recruitment costs increase (bottom right graph). They do, however, reduce the unemployment for unskilled workers.

The demonstration effect of the public sector as a wage leader depends on how tight the market is. The elasticity of private wages with respect to the average public sector wage is higher for skilled workers with high ability. It is also higher, the stronger the wage cuts

Figure 3: Welfare effects of public sector wages adjustments



(a) Distortionary taxes

(b) Lump-sum taxes

and the lower the unemployment. The government can only significantly affect wages in the private sector when unemployment is low.

Figure 3 shows the welfare effects of public sector wage cuts in terms of steady-state consumption-equivalent variations. On the top, high-ability skilled wage cuts above 7 percent are shown to be welfare reducing.

4.2 Equal pay in the public sector

Let us now consider a policy reform, consisting of a review of public sector wages to have a clearer parity with those in the private sector across workers in the steady-state. I consider two scenarios with a common public sector premium: one where all wages are equal to those in the private sector and second with the lowest possible premium that guarantees a positive search in the public sector. The results are shown in Table 1.

This reform significantly lowers the unemployment rate. If the government equates wages to those in the private sector, the aggregate unemployment rate falls by 3.8 percentage points, driven by the 5 percentage points decrease in the unemployment rate for unskilled workers. This reform generates sufficient savings to cut the income tax by two percentage points. Consumption increases by 4.7 percent and the welfare gains amount to 4 percent of steady-state consumption. A further reduction in public sector wages would further reduce unemployment and raise welfare.

If lump-sum taxes adjust instead of the income tax, the unemployment rate falls by 3.3 percentage points and welfare increase by only 2.5 percent of steady-state consumption. A large fraction of the gains from the reform comes from the labour market effect rather than the consequent tax reduction.

Table 1: Steady-state effects of a reform of public sector wages

		Distortionary Taxes		*Lump-Sum Taxes*	
Public-private wage premium	Baseline	0%	$-0.5\%^*$	0%	$-0.5\%^*$
Variables					
Unemployment rate	0.060	0.022	0.018	0.027	0.023
Skilled	0.030	0.024	0.023	0.025	0.024
Unskilled	0.074	0.020	0.016	0.028	0.023
Public employment	0.233	0.238	0.238	0.239	0.240
Skilled	0.373	0.365	0.366	0.364	0.364
Unskilled	0.167	0.178	0.178	0.181	0.182
Consumption	0.615	0.644	0.647	0.634	0.637
Wage bill + recruitment costs**	0.163	0.155	0.154	0.156	0.155
Welfare Gains relative to baseline	-	3.93%	4.36%	2.47%	2.85%
Income taxes	0.2	0.181	0.179	0.200	0.200
Implied public sector wage change					
Skilled (high ability)	-	0.9%	0.6%	-0.9%	-1.4%
Skilled (low ability)	-	-2.1%	-2.3%	-3.7%	-4.1%
Unskilled (high ability)	-	-2.9%	-3.3%	-3.9%	-4.5%
Unskilled (low ability)	-	-6.9%	-7.4%	-7.5%	-8.1%

Note: model simulations under the baseline calibration. * *minimum common public sector wage premium that guarantees a positive search in the public sector of all types of workers.* ** *given in percent of GDP.*

In Gomes (2014) I discussed the optimal public sector wage policy in a simple setting. I showed that wages should be lower than in the private sector, to compensate for job security and the differences in the labour market frictions. The optimal policy problem in this setting is complicated, with tax distortions and externalities across different workers and sectors adding to the congestion and thick market externalities. Hence, I evaluate the welfare gains of this simple reform that can be realistically implemented. I could have examined the welfare gains from other policies with distinct premia for different types of workers, but type-contingent reforms are difficult to justify without computing the optimal policy.

4.3 Business cycle policies

Quadrini and Trigari (2007) find that more procyclical public sector wages reduce unemployment fluctuations following technology shocks. Gomes (2014) explains it by computing the optimal policy and finding it to be procyclical. In recessions, if private sector wage drops are not accompanied by similar falls in public sector wages, unemployed turn to the public sector for jobs, which in turn further reduces job creation, thus amplifying the business cycle.

I measure these effects in a more realistic setting with three sources of fluctuations: technology, government services and cost-push shocks. I quantify how different wage policies affect the volatility of: private consumption, unemployment and inflation. Besides the benchmark wage policy $\iota = 0.58$, I consider an acyclical policy $\iota = 0$, a countercyclical policy $\iota = -0.4$ and a procyclical policy $\iota = 1$. My contribution is to consider a simple rule given

Table 2: Volatility of key variables relative to baseline wage policy

Variable	Volatility	**Percentage change of volatility relative to baseline**			
	Baseline	Acyclical	Countercyclical	Procyclical	Simple rule
Lump-Sum Taxes					
Unemployment	0.021	4.79%	10.39%	-1.58%	-2.83%
Consumption	0.017	6.30%	11.36%	-4.14%	-4.32%
Inflation	0.005	0.50%	0.94%	-0.30%	-0.32%
Distortionary taxes					
Unemployment	0.028	10.19%	19.16%	-5.62%	-8.11%
Consumption	0.023	15.65%	28.06%	-10.14%	-11.95%
Inflation	0.006	5.87%	10.21%	-4.17%	-4.90%

Note: model simulations under baseline calibration. Baseline case ($\iota = 0.58$), acyclical policy ($\iota = 0$), countercyclical policy ($\iota = -0.4$), procyclical policy ($\iota = 1$) and the simple rule given by equation (41).

by Equation (41), that institutionalizes procyclical wages. Table 2 shows the results.

Although not a target, the volatility of the unemployment rate is 0.021, slightly above the 0.019 observed in the United Kingdom since 1990. Shimer (2005) argues that the basic search and matching model cannot match fluctuations in unemployment. The model performs well in this dimension for the same reason as in Hagedorn and Manovskii (2008). In the baseline calibration, wage heterogeneity implies that the flow value of low-ability unemployed workers is close to 95 percent of its net wage. Given that most unemployment is concentrated in this group, the overall unemployment rate becomes more sensitive to shocks.[10]

Both the acyclical and countercyclical policies raise the volatility of the three variables. Under the countercyclical rule, the volatility of unemployment and private consumption increase by more than 10 percent. If the income tax adjusts to balance the budget, volatility increases by 20 and 28 percent, respectively. Even with nominal frictions, attempting to stabilize demand by using counter-cyclical wages has the opposite effects.

The procyclical rule, on the other hand, reduces the volatility of all variables: the unemployment rate by 1.6 percent, consumption by 4 percent and inflation by 0.3 percent. With distortionary taxes, the reduction of volatility is even stronger: 6, 10 and 4 percent. This shows one important dimension of the procyclical policy. By lowering its wages in recessions, the government requires a low tax burden. If taxes are distortionary, such a policy allows some tax smoothing in the absence of debt. Notice that the simple rule reduces volatility even more because it eliminates uncertainty regarding public sector wages.

[10]The good performance of the model in terms of volatility is the reason why I disregarded wage rigidity. Wage rigidity has been proposed as another solution to the Shimer Puzzle but its relevance is still under discussion. For the main mechanism of the model, only the wages of new-hires are relevant in the decisions. As been argued by Pissarides (2009), microeconometric evidence suggests that wages in new matches are more procyclical and volatile than average wages; see the discussion in Gomes (2014).

4.4 Robustness

Table 3 shows that the previous quantitative results are robust to different calibrations. I consider scenarios with different levels and volatilities of search of public sector jobs, different magnitudes of heterogeneity in ability and different shares of college graduates. I also consider a scenario with a logistic distribution of preferences for the public sector instead of a uniform distribution.

The steady-state reform that equates the public sector wages to their private sector counterparts, reduces unemployment rate between 3.2 and 4.7 percentage points if taxes are distortionary and about 3 percentage points if taxes are lump-sum. The welfare gain are, in all cases, above 2 percent of steady-state consumption and can be as high as 4.6 percent.

Implementing the simple rule over the business cycle reduces the volatility of all variables in all scenarios. As in the benchmark case, the effects are stronger if taxes are distortionary.

Table 3: Effects of the reform in steady-state and over the business cycle, robustness

	Logistic	Search in public sector		Heterogeneity in ability		Weight of skilled	
	Distribution	High	Low	High	Low	High	Low
A. Steady-state reform: percentage change from baseline							
Distortionary taxes							
Unemployment	-3.8pp	-3.9pp	-3.8pp	-3.9pp	-3.7pp	-3.2pp	-4.7pp
Consumption	4.8%	4.8%	4.7%	4.6%	5.2%	4.0%	5.7%
Welfare	3.9%	4.0%	3.9%	3.8%	4.2%	3.3%	4.6%
Lump-sum taxes							
Unemployment	-3.3pp	-3.3pp	-3.2pp	-3.3pp	-3.0pp	-2.8pp	-4.0%
Consumption	3.2%	3.2%	3.1%	3.1%	3.3%	2.7%	3.8%
Welfare	2.5%	2.5%	2.4%	2.5%	2.5%	2.1%	2.9%
B. Implementation of simple rule: percentage change of volatility from baseline							
Distortionary taxes							
Unemployment	-8.1%	-8.2%	-8.3%	-8.6%	-6.5%	-11.2%	-4.0%
Consumption	-11.7%	-11.9%	-12.1%	-11.9%	-12.9%	-12.8%	-9.1%
Inflation	-4.8%	-4.9%	-4.9%	-5.0%	-4.4%	-6.3%	-2.6%
Lump-sum taxes							
Unemployment	-2.9%	-2.9%	-3.0%	-3.2%	-1.4%	-4.5%	-0.8%
Consumption	-4.2%	-4.4%	-4.3%	-4.4%	-4.6%	-4.7%	-3.0%
Inflation	-0.3%	-0.3%	-0.3%	-0.4%	-0.3%	-0.4%	-0.1%

Note: model simulations under alternative calibrations: i) logistic distribution, ii) high search in public sector ($\bar{s} = 0.21$, $Std(s_t) = 0.06$); iii) low search in public sector ($\bar{s} = 0.07$, $Std(s_t) = 0.02$); iv) high heterogeneity in ability ($\bar{w}^{p,\bar{h}}/\bar{w}^{p,\underline{h}} = 1.46$, $\bar{w}^{p,\bar{\mu}}/\bar{w}^{p,\underline{\mu}} = 1.42$); v) low heterogeneity in ability ($\bar{w}^{p,\bar{h}}/\bar{w}^{p,\underline{h}} = 1.09$, $\bar{w}^{p,\bar{\mu}}/\bar{w}^{p,\underline{\mu}} = 1.08$); vi) high weight of skilled ($\omega^{\bar{h}} = \omega^{\underline{h}} = 0.20$) and vii) low weight of skilled ($\omega^{\bar{h}} = \omega^{\underline{h}} = 0.125$). In all cases the model was recalibrated as described in Section 3. Panel A reports the steady-state change of implementing a zero public sector wage premium for all workers relative to baseline of: unemployment rate (percentage points), consumption (percent) and welfare (percent of consumption equivalent variation). Panel B reports the percentage change of volatility of unemployment rate, consumption and inflation of implementing the simple rule given by equation (41), compared to the baseline case ($\iota = 0.58$).

Volatility of unemployment rate and consumption fall by 8 and 12 percent. With lump-sum taxes the reduction is only of three and four percent.

5 Conclusion and discussion

I construct a model of public sector employment with search and matching frictions and heterogeneous workers to evaluate a reform of public sector wages that links them to the behaviour of the private sector, both across workers and over time. In the model calibrated to the United Kingdom, setting the wage of all workers equal to those offered in the private sector reduces the unemployment rate by three percentage points. Implementing a simple rule that aims to stabilize the ratio of average wages in the two sectors in turn reduces the volatility of unemployment by three to eight percent.

Such a wage reform has several advantages. It guarantees parity between the two sectors and its maintenance over the business cycle. It reduces the government's scope to use wages for electoral purposes. It enables a low tax burden in recessions. It is simple and easy for economic agents to understand, and introduces some predictability in one of the most important decisions that the government takes annually.

The paper was motivated by the experience of several countries before and during the Eurozone crisis. The fiscal rule proposed to guide the wage growth would have avoided the sharp increase in public sector wages in the decade prior to the crisis. On the other hand, the principle of equating the distribution to the private sector could guide governments facing budgetary pressures regarding how to proceed with wage cuts. Instead of progressive cuts along the distribution, a review of pay by occupation and education is preferable to make the whole distribution of wages closer to those in the private sector.

Alesina *et al.* (2000) argue that politicians use public employment for redistributive policies, directing income towards disadvantaged groups. This might also justify why the distribution of wages in the public sector are so compressed and the wage premium at the bottom so high. This policy is self-defeating. On the one hand, I show that the wage compression increase the unemployment of workers with lowest skills. On the other hand, Wilson (1982) shows that, from a redistributive point of view, it is optimal for the government to increase the wage difference between skilled and unskilled worker in order to induce more individuals to obtain education. The wage compression does precisely the oppositive. Mitigation of inequality is a valid policy objective. But if governments want to reduce inequality, they should use suitable instruments such as income tax or minimum wage. Trying to deal with the problem of inequality by only protecting an arbitrary group of workers,

governments do not solve this problem and further distort the labour market.

The idea that the public sector wages should closely follow private wages is simple and intuitive, but it is not acknowledged by policy makers who view government wages as a stabilization tool. Holm-Hadulla *et al.* (2010) argue that the government should avoid mild procyclicality of wages, as increasing wages in expansions may boost aggregate demand, amplify the business cycle and create an inflationary spiral. However, I have demonstrated that such a policy has the opposite effect because it heavily distorts the labour market. If a government would commit to the proposed rule, it would lose one instrument, but for the purpose of stabilizing demand, it could use alternatives such as employment, purchases of intermediate goods, investments or transfers, which are arguably more effective.

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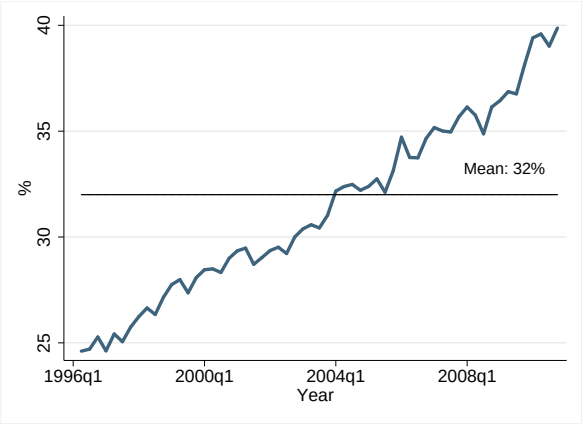
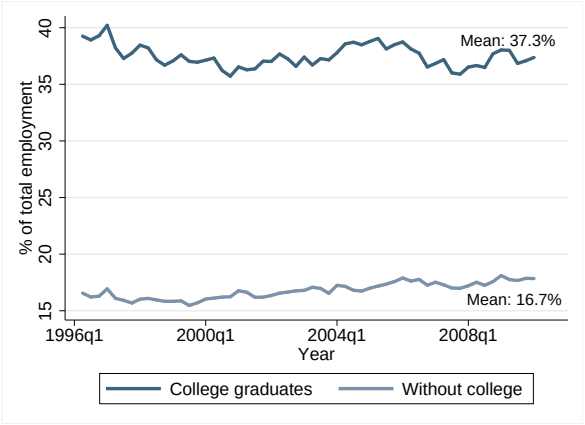
Appendix A: Data used in calibration

Figure A1: Share of skills in labour force and in the public sector



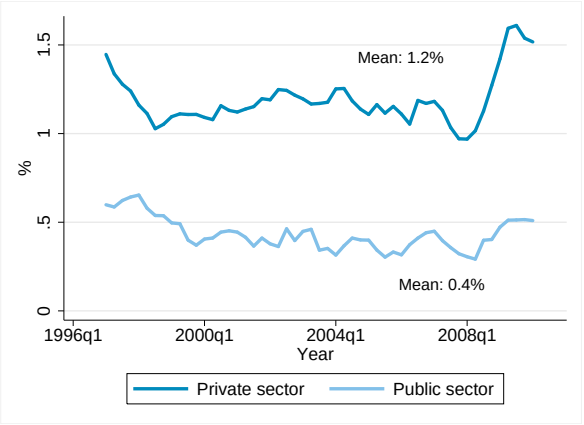
(a) Share of college graduates in labour force



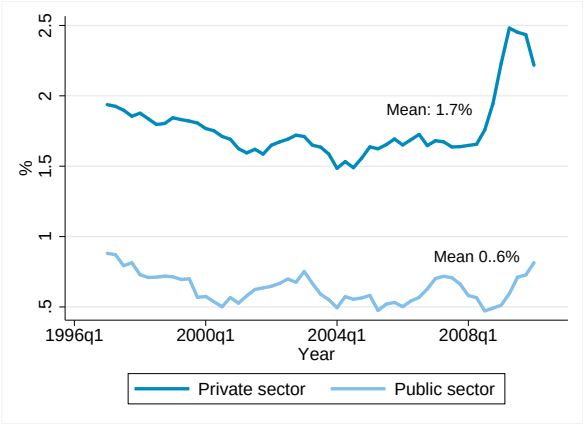
(b) Public sector employment by skill

Source: Labour Force Survey.

Figure A2: Job separation rates



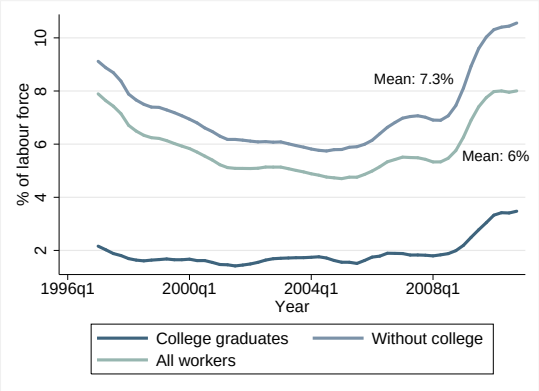
(a) College degree



(b) Without college

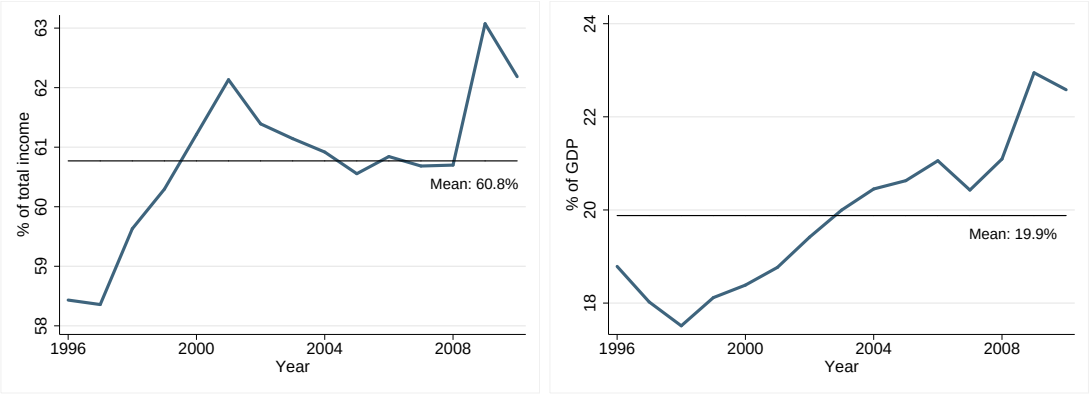
Source: Labour Force Survey.

Figure A3: Unemployment rate



Source: Labour Force Survey.

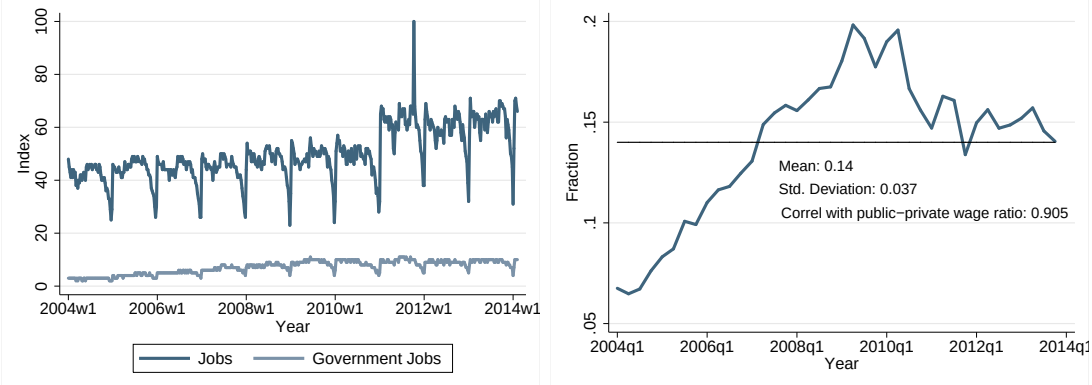
Figure A4: Labour share and government consumption



(a) Labour share (b) Government consumption

Source: AMECO.

Figure A5: Google indexes



(a) Original indexes (b) Search in public sector

Source: Google. The index of search in the public sector includes the following keywords with their relative importance in brackets: 'nhs jobs' (46%), 'council jobs' (32%), 'jobs in nhs' (5%), 'gov jobs' (4%), 'public jobs' (4%), 'direct gov jobs' (2%), 'government jobs' (2%), 'army jobs' (2%), 'local government jobs' (1%), 'raf jobs' (1%).

Table A1: Estimation of public sector wage premium

Education	Percentile	R-squared	Estimated Premium
College educated	75	0.375	0.016
Obs: 84236	25	0.456	0.039
Without college degree	75	0.488	0.037
Obs: 209740	25	0.595	0.071

Note: quantile regression of log net wages on several control variables and a dummy for public sector. Controls include: sex, industry and occupation dummies, status in previous quarter, tenure, age and its square, marital status, time and region dummies, average hours worked and its square. Labour Force Survey: sample from 1996 to 2006.

Table A2: Cost per hire and vacancy duration by sector and worker type

	Cost per hire (£)			Vacancy duration (weeks)		
Type of worker	Manufacturing	Services	Public	Manufacturing	Services	Public
Senior Managers - Directors	13396	18963	10451	16.8	16.5	18
Managers and professionals	8049	12392	6066	12.1	11.8	14.3
Administrative, Secretarial and Technical	3680	5628	1934	6	5.2	9.1
Services (costumer, personal and sales)	4564	1398	2326	6.7	5.6	9.9
Manual, craft workers	2498	2978	1898	5.2	4.5	8.3

Source: Chartered Institute of Personal Development*, "Recruitment, retention and turnover survey", 2008 (Survey of 800 organizations: Manufacturing, Services and Public sector). Vacancy duration in weeks.*

Table A3: Estimation of inter-quantile wage residual

Education	R-squared	Obs.	25-75 percentile residual difference		
			Total (100%)	Adjusted (80%)	Adjusted (20%)
College educated	0.600	44133	0.461	0.368	0.092
Without college degree	0.595	209740	0.416	0.332	0.083

Note: regression of the log of net wages on several control variables: sex, industry and occupation dummies, status in previous quarter, tenure, age and its square, marital status, time and region dummies, average hours worked and its square. Labour fource survey: sample from 1996 to 2006. The fourth column reports the 25-75 percentile difference of wage residuals.

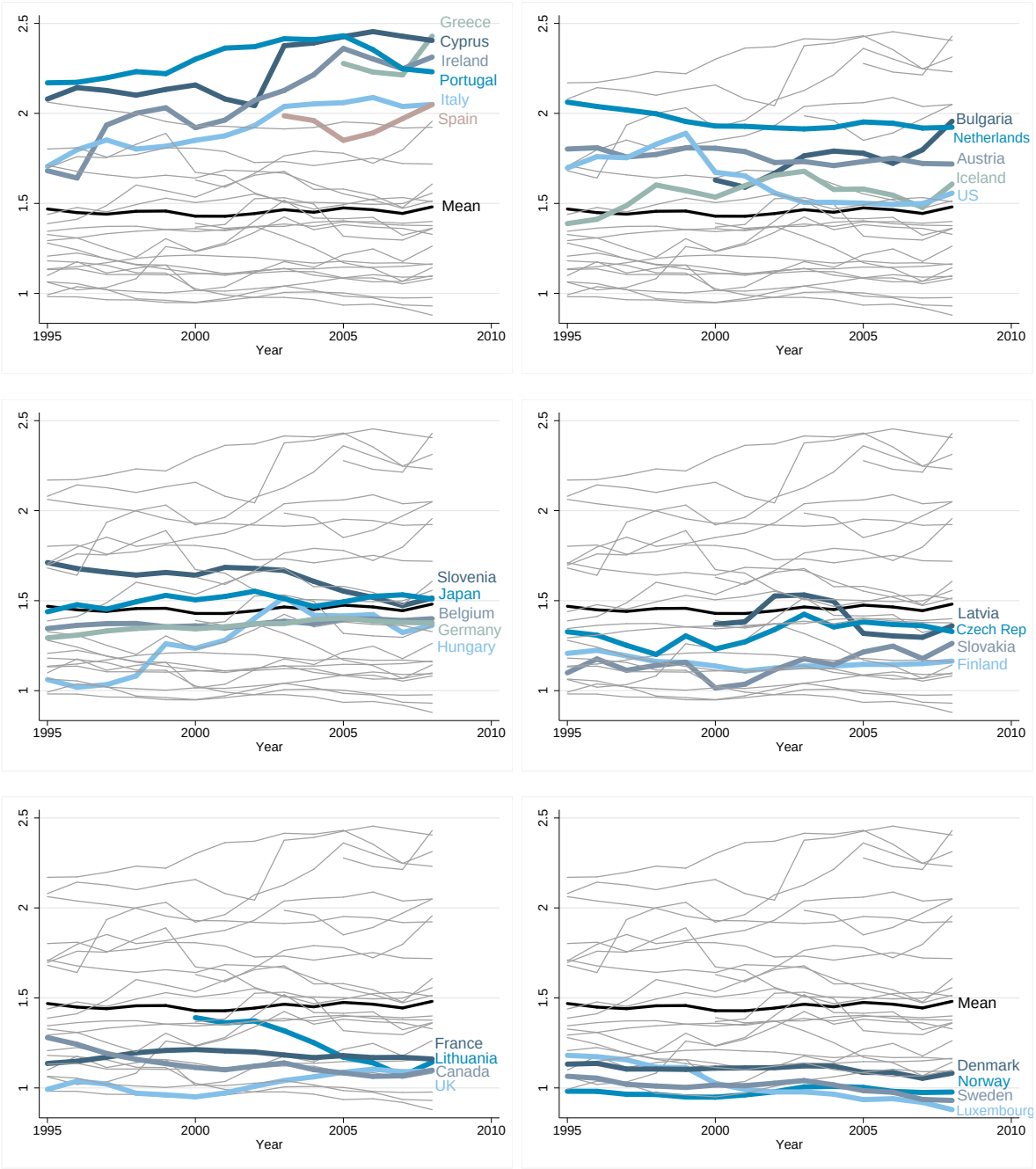
Table A4: Summary of baseline calibration

Fixed parameters fixed	**Source**	**Values**
Public-private wage ratio	LFS	$\frac{\bar{w}^{g,\bar{h}}}{\bar{w}^{p,\bar{h}}} = 1.016$, $\frac{\bar{w}^{g,\underline{h}}}{\bar{w}^{p,\underline{h}}} = 1.039$, $\frac{\bar{w}^{g,\bar{\mu}}}{\bar{w}^{p,\bar{\mu}}} = 1.037$, $\frac{\bar{w}^{g,\underline{\mu}}}{\bar{w}^{p,\underline{\mu}}} = 1.071$.
Job-separation rates	LFS	$\lambda^{g,h} = 0.004$, $\lambda^{p,h} = 0.012$, $\lambda^{g,\mu} = 0.006$, $\lambda^{p,\mu} = 0.018$.
Weights of skilled	LFS	$\omega^{\underline{h}} = 0.16$, $\omega^{\bar{h}} = 0.16$, $\omega^{\underline{\mu}} = 0.34$, $\omega^{\bar{\mu}} = 0.34$.
Matching elasticities w.r.t. unemployment	Gomes (2014)	$\eta^g = 0.15$, $\eta^p = 0.40$.
Substitution between skilled and unskilled	Krussel *et al.* (2000)	$\varsigma = 0.40$
Substitution between high and low ability		$\rho = 0.95$
Depreciation rate	Merz (1995)	$\delta = 0.02$
Discount factor	Galí (2008)	$\beta = 0.99$
Substitution between consumption goods	Galí (2008)	$\epsilon = 6$
Calvo parameter	Galí (2008)	$\gamma = 0.67$
Response of interest rate to inflation	Galí (2008)	$\phi = 1.5$
Inertia of interest rate		$\rho^m = 0.8$
Coefficient of relative risk aversion		$\sigma = 2$
Steady-state income tax		$\bar{\tau} = 0.2$
Productivity	Normalization	$z^{\underline{h}} = z^{\bar{\mu}} = \bar{a} = 1$
Ciclicality of public sector wages	OECD	$\iota = 0.58$
Process of public sector wage shock	OECD	$\rho^w = 0.83$, $\sigma^w = 0.025$
Process of public services shock	OECD	$\rho^g = 0.96$, $\sigma^g = 0.001$
Process of technology shock	OECD	$\rho^a = 0.74$, $\sigma^a = 0.010$
Other parameters	**Target (Source)**	**Values**
Matching efficiency	Vacancy duration (CIPD)	$\zeta^{g,h} = 0.70$, $\zeta^{p,h} = 0.57$, $\zeta^{g,u} = 0.99$, $\zeta^{p,u} = 0.98$
Cost of posting vacancies	Cost per hire (CIPD)	$\kappa^{g,h} = 0.90$, $\kappa^{p,h} = 1.35$, $\kappa^{g,u} = 0.13$, $\kappa^{p,u} = 0.14$
Unemployment benefits	Replacement rate (EC)	$\chi^g = 0.21$
Unemployment utility	Unemployment rate of unskilled (LFS)	$\chi^u = 0.33$
Bargaining power of workers	Unemployment rate (LFS)	$b = 0.28$
Weight of skilled in gov. production	Public employment of skilled (LFS)	$\Phi = 0.74$
Government services	Public employment of unskilled (LFS)	$\bar{g} = 0.13$
Weight of skilled in production	College premium (LFS)	$\Psi = 0.407$
Market ability	Residual wage dispersion (LFS)	$z^{\underline{\mu}} = 0.80$, $z^{\bar{h}} = 1.24$
Elasticity w.r.t private capital	Labour share (AMECO)	$\alpha = 0.35$
Gov. purchases	Gov. consumption (AMECO)	$\bar{g}^{int} = 0.033$
Distribution of preferences	Average search and volatility (*Google*)	$v_1 = -3.41$, $v_2 = 0.35$
Process of cost-push shock	Inflation (OECD)	$\rho^a = 0.7$, $\sigma^a = 0.072$

Note: in Section 4.4, the parameters in the top panel remain fixed and the parameters in the bottom panel are recalibrated to match the new targets.

Appendix B: Evidence for OECD countries

Figure A1: Evolution of average aggregate public-private wage ratio for different countries



Sources: compensation to government employees and compensation to employees in the overall economy (AMECO); government employment and total employment (Eurostat); employment data from Austria, Sweden, UK and Iceland (OECD). The average aggregate public-private wage ratio is calculated as $\frac{Government\ wage\ bill}{Private\ sector\ wage\ bill} / \frac{Government\ Employment}{Private\ sector\ Employment}$.