PUBLIC AND PRIVATE SECTOR WAGES INTERACTIONS IN A GENERAL EQUILIBRIUM MODEL

2009

Gonzalo Fernández-de-Córdoba, Javier J. Pérez and José L. Torres

Documentos de Trabajo
N.º 0924

BANCO DE **ESPAÑA**
Eurosistema

PUBLIC AND PRIVATE SECTOR WAGES INTERACTIONS IN A GENERAL EQUILIBRIUM MODEL

PUBLIC AND PRIVATE SECTOR WAGES INTERACTIONS IN A GENERAL EQUILIBRIUM MODEL (*)

Gonzalo Fernández-de-Córdoba

UNIVERSIDAD DE SALAMANCA

Javier J. Pérez

BANCO DE ESPAÑA

José L. Torres

UNIVERSIDAD DE MÁLAGA

(*) The views expressed in this paper are the authors' and do not necessarily reflect those of the European Central Bank, the Bank of Spain or the Eurosystem. Fernández de Córdoba and Torres thank the hospitality of the Fiscal Policies Division of the European Central Bank. We also thank M. J. Gutiérrez, L. Ljungqvist, M. Ljungqvist, D. Martínez, J. Rodríguez, T. van Rens, A. van Riet, participants in seminars at the European Central Bank, the University of Málaga, the University Pablo de Olavide, the University of Santiago de Chile, the II workshop "Advances in the analysis of labor markets with frictions", and the Editorial Board of the ECB Working Paper Series for helpful comments and suggestions. The authors acknowledge financial support from Proyecto de Excelencia Junta de Andalucía P07-SEJ-02479. Fernández de Córdoba acknowledges financial support from the Research Grant SA091/02 from Junta de Castilla y León.

Documentos de Trabajo. N.º 0924

2009

The Working Paper Series seeks to disseminate original research in economics and finance. All papers have been anonymously refereed. By publishing these papers, the Banco de España aims to contribute to economic analysis and, in particular, to knowledge of the Spanish economy and its international environment.

The opinions and analyses in the Working Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the INTERNET at the following website: http://www.bde.es.

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

© BANCO DE ESPAÑA, Madrid, 2009

ISSN: 0213-2710 (print)
ISSN: 1579-8666 (on line)
Depósito legal: M. 43904-2009
Unidad de Publicaciones, Banco de España

Abstract

This paper develops a dynamic general equilibrium model in which the public and the private sector interact in the labor market. Previous studies that analyze the labor market effects of public sector employment and wages have mostly assumed exogenous rules for public wage and public employment. We show that theories that equalize wages with marginal products in the private sector can rationalize the interaction of public and private sector wages when extended to accommodate a non-trivial government sector/public sector union that endogenously determines public employment and wages. Our model suggests a positive correlation between public and private sector wages. Any increase in tax revenues, coupled with the existence of a positive public-private sector wage gap, makes working in the public sector an attractive option. Thus, a positive neutral productivity shock increases public and private sector wages. More interestingly, even a private-sector specific productivity shock spills-over to the public sector, increasing public wages. These facts lend some support to the wage leading role of the private sector. Nevertheless, at the same time, a positive shock to public sector wages would lead to an increase in private sector wages, via the flow of workers from the private to the public sector.

Keywords: Public wages, public employment, labor market, trade unions.

JEL classification: C32, J30, J51, J52, E62, E63, H50.

Non-technical summary

The wage premium received by public sector employees relative to private sector employees has been positive in most OECD countries over the past four decades, with some variation in the size of the premium over time and some differences across countries. The standard theory by which labor in the public and the private sector are paid at their marginal products would predict that the ratio of wages in both sectors should be closely tied to the ratio of employees in the two sectors. In fact, models with free labor mobility imply that wages should be equalized across sectors for the same type of labor. In general a number of institutional, political and economic factors would also contribute to the determination of public/private sector wages. The literature on public sector labor markets reveals that the influence of public sector trade unions and the "vote producing" activities by civil servants are the potential reasons for the existence of the earnings differential.

Our paper develops a dynamic general equilibrium model in which the public and the private sectors interact in the labor market. Contrary to the extant literature we allow for labor flows between the private and the public sector to be endogenously determined in our model. We show that theories that equalize wages with marginal products in the private sector can rationalize the dynamic path of the public/private sector wage differential over the last four decades when extended to accommodate a non-trivial government sector/public sector union that endogenously determines public employment and wages. A key element of our model is that we consider an objective function for the government that results from a bargaining process between the government and a public sector union, leading to a public sector objective function that encompasses the maximization of public wages and public employment. The inclusion of the union is crucial to rationalize the observed existence of a wage premium. A standard model in which wages are equalized with marginal products would not be able to predict a positive wage premium under standard assumptions. Nevertheless a first message of our paper is that the literature has put an excessive weight on the role of unions and institutional factors in order to understand public-private sector wage dynamics.

We are able to simulate experiments that help us understanding the dynamic behavior of aggregate time series of public-private sector wages. In particular, we perform the following key exercises. First, we study the impact of an increase in total factor productivity (a positive neutral technological shock to the economy). This shock has a positive effect on output and on total employment, with both private and public employment experiencing an increase. Private labor increases due to the increased productivity, while given that the shock pushes up fiscal revenues the government is able to increase public employment. The effect on public employment is larger than on private employment. However, the flow of employment from the private sector to the public sector generates a larger effect on private wages than on public wages. Therefore, as a consequence of this shock, the ratio public/private wages decreases and the ratio public/private employment increases.

Next, we study the effects of a (positive) shock to private labor productivity. This shock generates an increase in the relative efficiency of private workers versus public workers, and displays

a positive effect on output and on total employment. As in the case of a neutral productivity shock both private and public employment increase. Interestingly, although the shock is specific to private employment, public employment increases in a larger proportion. As a consequence, the ratio public/private employment increases. The shock generates an increase in fiscal revenues which is transformed into more public workers in spite of the fact that the relative efficiency of private workers is larger. Both private and public wages increase, but the ratio of public/private wages decreases. The increase in private wages is clear, given the larger productivity. However, in spite of the fact that the relative productivity in the public sector decreases, also public wages increase. Therefore, the larger productivity in the private sector spills-over to the public sector, increasing also public wages.

Finally, we study the effect of a relaxation of the budget constraint of the government, implemented through an increase in taxes. As a consequence of this shock, both public wages and employment increase. However, there is a reduction in private labor, an increase in private wages, and also a decrease in total economy employment and total output. This shock increases both the public-private sector wage premium and the ratio public/private employment.

Our results are consistent with the evidence on the pro-cyclicality of public sector wages, as shown by the empirical results in the literature. In addition, and most importantly, the indicated responses of wages to overall and a private sector specific technology shock would be consistent with an observed positive correlation between public and private sector wages, while at the same time being consistent with a wage-leading role of the private sector, if on average technology shocks were the main drivers of business cycle fluctuations. At the same time, it also renders a rationale to public wages leading private wages in certain episodes. These predictions are in line with some recent empirical evidence on the causality of public and private wages. At the same time, our results about the existence of crowding out effects of public employment on private employment under quite general circumstances, are in line with the related, mostly empirical literature.

Our paper also has important implications for the recent debate on the effects of government spending shocks. Indeed, being the public sector wage bill (public wages times public employment) the main component of government consumption (some 60% for a representative OECD country), the strong crowding out effects on private sector employment described in our paper would advise against widespread use of public employment and wages policies as a device for short-term fiscal stimuli. If implemented, the negative effects on private sector employment arising from the labor market channel exploited in the paper might outweigh/counterbalance the positive direct demand impact traditionally present in most macroeconomic models.

1 Introduction

The wage premium received by public sector employees relative to private sector employees has been positive in most OECD countries over the past four decades, with some variation in the size of the premium over time and some differences across countries. The existence of such a positive premium is a well documented empirical fact of developed economies, as shown in the surveys of Ehrenberg and Schwarz (1986), Bender (1998), and Gregory and Borland (1999).[1] The size of the public wage premium has presented a degree of variation over time. As Figure 1 shows, the public/private sector wage premium in the aggregate of the euro area countries showed a compression from a maximum in the early 1970s to a minimum by the end of the 1980s, but then increased steadily again over the last twenty years. In the US the (positive) wage premium has remained more or less stable since the 1960s, while in the Nordic countries it has decreased steadily since the early 1970s, moving into negative territory since the 1980s.

The standard theory by which labor in the public and the private sector are paid at their marginal products would predict that the ratio of wages in both sectors should be closely tied to the ratio of employees in the two sectors. In fact, models with free labor mobility imply that wages should be equalized across sectors for the same type of labor. It is worth noticing that, as witnessed in Figure 1, this behavior of the public/private wage premium has had a somewhat parallel reflection in the dynamic evolution of the ratio of government sector employees to private sector employees. The ratio of public to private employees in the euro area reached a maximum in the second half of the 1980s, the same period in which the wage premium reached its minimum. A similar though less marked pattern is apparent for Sweden[2] while in the case of the US the link is less clear by simple inspection.

In general, as signalled by the survey papers of Bender (1998, 2003), a number of institutional, political and economic factors would also contribute to the determination of public/private sector wages. While there is little research on the determinants of the public wage premium, the literature on public sector labor markets reveals that the influence of public sector trade unions and the "vote producing" activities by civil servants are the potential reasons for the existence of the earnings differential.

There are a number of papers that touch upon the issue of public/private sector wage deter-

[1] The main findings from this, mainly microeconometric, literature can be summarized as follows: (i) most articles find a positive premium paid to central government workers, even after controlling for differences in the productive characteristics of workers; (ii) in developing countries, however, the premium is usually negative; (ii) women and minorities get higher wages in the public sector relative to their private sector counterparts. Following a related literature, Bender (2003) signals that the largest difference in public/private wages can be found in the low-skilled part of the distribution of earnings, while workers at the upper end earn less than their private sector counterparts. Domeij and Ljungqvist (2006) show that this argument is at the heart of the compression of the skill premia in Sweden as compared to the US. For the UK this argument does not seem to hold, though, as shown by Chatterji and Mumford (2007).

[2] Pedersen *et al.* (1990) document this issue for Denmark.

mination. Calmfors and Horn (1986) introduce public employment in a monopolistic union model, and assume that the union chooses the same wage rate for workers in the public and private sectors. Ardagna (2007), in a more general model assumes in the baseline specification that workers receive a different salary in the public and private sectors, but at the same time assumes that there is no mobility of workers among sectors, and thus closes the existence of potential job market flows.[3] Algan *et al.* (2002), rely on the latter assumption to justify the difference of private and public sectors' wages.[4] [5] Recent papers using models with search mechanisms perform welfare analysis under different exogenous rules for public wage and public employment wage setting (Quadrini and Trigari, 2008, Gomes, 2009).

Our paper develops a dynamic general equilibrium model in which the public and the private sectors interact in the labor market. Contrary to the extant literature we allow for labor flows between the private and the public sector to be endogenously determined in our model. We show that theories that equalize wages with marginal products in the private sector can rationalize the dynamic path of the public/private sector wage differential over the last four decades when extended to accommodate a non-trivial government sector/public sector union that endogenously determines public employment and wages. We take this latter feature from the standing literature as reported above. A key element of our model is that we consider an objective function for the government that results from a bargaining process between the government and a public sector union, leading to a public sector objective function that encompasses the maximization of public wages and public employment.[6] The inclusion of the union is crucial to rationalize the observed existence of a wage

[3] In an extension of the model she models the public sector labor market as the private sector one. Thus, she allows monopoly unions to unilaterally set wages of public sector workers at the firm level.

[4] On related grounds see the dynamic general equilibrium models of Ardagna (2001), Cavallo (2005), Finn (1998), Pappa (2004), Quadrini and Trigari (2007) and Forni et al. (2009), in which public employment is an exogenous variable and wages in both sector are equalized according to the standard arbitrage conditions.

[5] Oswald *et al.* (1984) develop a model in which public sector wages are determined by efficient bargaining between the government and a public sector union, assuming that the private sector labor market is perfectly competitive. Forni and Giordano (2003), in a somewhat related framework, rationalize the wage premium mainly as linked to the degree of coordination between unions in the economy (private and public sectors), along the lines of Holmlund (1997) that considers the impact of cash limits in the public sector in a static framework in which differences in the bargaining power of private and public sector unions might lead to a wage premium. Holmlund (1993) presents a model in which the public sector wage premium arises because of externalities: the public-sector union ignores that a wage increase will raise taxes for private-sector workers and reduce public consumption for all workers, including those in the private sector. Demekas and Kontolemis (2000) use a static model in which government and private sector employers compete for workers but make employment and wage decisions on the basis of different objective functions, and in which a public sector wage premium arises if the (exogenous) probabilities of moving from one sector to the other are higher in the public than in the private sector.

[6] As pointed out by Gregory and Borland (1999) trade unions are perhaps the most important part of the institutional environment in public sector labor markets. Simple union models predict that unionization will increase employees' wages at the expense of lower employment. Blanchflower (1991) shows that union density is larger in the public sector than in the private sector in most of developed countries (see also Freeman, 1988, and Robinson, 1995). Unionization also increases employment stability for public sector employees (Allen, 1988).

premium. A standard model in which wages are equalized with marginal products would not be able to predict a positive wage premium under standard assumptions. Nevertheless a first message of our paper is that the literature has put an excessive weight on the role of unions and institutional factors in order to understand public-private sector wage dynamics.

We consider a production function that relates output with three inputs: private labor, public labor and the capital stock. Our choice of the production function implies that a positive level of taxes is necessary to finance the public sector wage bill. In this framework we are able to simulate experiments that help us understanding the dynamic behavior of aggregate time series of public-private sector wages. In particular, we perform the following key exercises. First, we study the impact of an increase in total factor productivity (a positive neutral technological shock to the economy). This shock has a positive effect on output and on total employment, with both private and public employment experiencing an increase. Private labor increases due to the increased productivity, while given that the shock pushes up fiscal revenues the government is able to increase public employment. The effect on public employment is larger than on private employment. However, the flow of employment from the private sector to the public sector generates a larger effect on private wages than on public wages. Therefore, as a consequence of this shock, the ratio public/private wages decreases and the ratio public/private employment increases.

Next, we study the effects of a (positive) shock to private labor productivity. This shock generates an increase in the relative efficiency of private workers versus public workers, and displays a positive effect on output and on total employment. As in the case of a neutral productivity shock both private and public employment increase. Interestingly, although the shock is specific to private employment, public employment increases in a larger proportion. As a consequence, the ratio public/private employment increases. The shock generates an increase in fiscal revenues which is transformed into more public workers in spite of the fact that the relative efficiency of private workers is larger. Both private and public wages increase, but the ratio of public/private wages decreases. The increase in private wages is clear, given the larger productivity. However, in spite of the fact that the relative productivity in the public sector decreases, also public wages increase. Therefore, the larger productivity in the private sector spills-over to the public sector, increasing also public wages.

Finally, we study the effect of a relaxation of the budget constraint of the government, implemented through an increase in taxes. As a consequence of this shock, both public wages and employment increase. However, there is a reduction in private labor, an increase in private wages, and also a decrease in total economy employment and total output. This shock increases both the public-private sector wage premium and the ratio public/private employment.

Our results are consistent with the evidence on the pro-cyclicality of public sector wages, as shown by the empirical results of Lane (2003) and Lamo et al. (2007). In addition, and most importantly, the indicated responses of wages to overall and a private sector specific technology shock would be consistent with an observed positive correlation between public and private sector wages, while at the same time being consistent with a wage-leading role of the private sector, if on average technology shocks were the main drivers of business cycle fluctuations. At the same time, it also renders a rationale to public wages leading private wages in certain episodes. These predictions are in line with some recent empirical evidence on the causality of public and private wages (see Lamo et al., 2008, Lindquist and Vilhelmsson, 2007, and the references quoted therein). At the same time, our results about the existence of crowding out effects of public employment on private employment under quite general circumstances, are in line with the empirical results of Malley and Moutos (1996) and Algan et al. (2002), Lamo et al. (2008), or Afonso and Gomes (2008), and the theoretical results of Ardagna (2007).

Our paper also has important implications for the recent debate on the effects of government spending shocks, as in Cogan et al. (2009), Romer and Bernstein (2009) or Taylor (2009). Indeed, being the public sector wage bill (public wages times public employment) the main component of government consumption (some 60% for a representative OECD country), the strong crowding out effects on private sector employment described in our paper would advise against widespread use of public employment and wages policies as a device for short-term fiscal stimuli. If implemented, the negative effects on private sector employment arising from the labor market channel exploited in the paper might outweigh/counterbalance the positive direct demand impact traditionally present in most macroeconomic models.

The paper is organized as follows. Section 2 describes the empirical evidence on the relationship between public and private wages and employment. Sector 3 presents a standard general equilibrium model that distinguishes two types of labor: private and public. Section 4 shows the calibration exercise. Section 5 presents a quantitative analysis of shocks. Finally, Section 6 presents some conclusions.

2 Relative public/private sector wages and employment

We will have a first look at the data through the lens of the assumption that workers in both the public and the private sector are paid at their marginal products. Domeij and Ljungqvist (2006) and Katz and Autor (1999) take a similar approach to analyze different, though related problems. They break the work force into skilled (or high school equivalents) and unskilled (or college equivalents) workers in order to study the skill wage premium. Following their approach we consider a production function with a CES specification over labor inputs, which is nested inside a Cobb-Douglas specification with capital,

$$Y_t = A_t K_t^{\alpha} \left[\mu L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta} \right]^{\frac{(1-\alpha)}{\eta}} \tag{1}$$

where $L_{p,t}$ and $L_{g,t}$ denote private and public sector labor respectively, K_t is capital, Y_t is aggregate output and A_t is a measure of total-factor productivity. Time invariant production parameters are α that pins down the private capital share of income, μ that measures the weight of public employment relative to private employment, and $\sigma = 1/(1-\eta)$ that is a measure of the elasticity of substitution between public and private labor inputs. The elasticity of substitution measures the percentage change in factor proportions due to a change in relative factor prices. If $\sigma = 0$ there is no substitution between the two factors, while if $\sigma \to \infty$ public and private employment would be perfect substitutes.

Under the assumption that public and private sector workers are paid their marginal products, the problem of the firm is to find optimal values for the utilization of labor and capital given the presence of public inputs. Under the assumption that private and public workers are paid their marginal products, we obtain that wages are given by:

$$W_{p,t}^{comp} = \mu(1-\alpha)A_t K_t^{\alpha}\left[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}\right]^{(1-\alpha-\eta)/\eta} L_{p,t}^{\eta-1} \tag{2}$$

and

$$W_{g,t}^{comp} = (1-\mu)(1-\alpha)A_t K_t^{\alpha}\left[\mu L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}\right]^{(1-\alpha-\eta)/\eta} L_{g,t}^{\eta-1} \tag{3}$$

So that the ratio of public/private sectors wages turns out to be:

$$\frac{W_{g,t}^{comp}}{W_{p,t}^{comp}} = \frac{1-\mu}{\mu}\frac{L_{g,t}^{\eta-1}}{L_{p,t}^{\eta-1}} \tag{4}$$

Thus the public-private wage premium would depend on the relative employment level between the two sectors and on the value of the parameters η and μ. As the relative employment level of the private sector with respect to the public sector increases the public/private wage premium increases via job market flows. Applying logs we obtain that:

$$\log\left(\frac{W_{g,t}^{comp}}{W_{p,t}^{comp}}\right) = \log\left(\frac{1-\mu}{\mu}\right) + (\eta-1)\log\left(\frac{L_{g,t}}{L_{p,t}}\right) \tag{5}$$

We estimate by OLS the above equation for a number of OECD countries.[7] Table 1 shows the estimated parameters. To account for the endogeneity of $\frac{L_{g,t}}{L_{p,t}}$ in the regression, we instrument it using one lag of the ratio and one lag of the independent variable (shown in the Table) and two lags (not shown) and the results barely change. [8]

Of special interest is the parameter σ, an estimate of the degree of substitution between public and private sector employees. For all OECD countries the elasticity of substitution between public

[7]We estimate expression (5), extended with a time trend to account for the potential presence of technological progress over time (following Domeij and Ljungqvist, 2006). We take data for the period 1970-2006, from the OECD Economic Outlook Database.

[8]Standard tests of stationarity would tend to reject the null hypothesis of stationarity of both the ratio of wages per employee and the ratio of employment for most countries. While from a theoretical point of view this is not reasonable and would point to weaknesses of the empirical tests, it is also arguable that within the confines of the actual sample used this is a possibility. In the latter case, the OLS estimates drawn from of the equation would be superconsistent. To reinforce this point we provide standard unit root tests for the residuals of the regressions in the Table.

and private sector workers is greater than one with the only exception of Belgium. The numbers in the table range from a minimum of 0.6 in Belgium to perfect substitution ($\sigma \rightarrow \infty$) in the cases of Japan and Korea, and to a lesser extent the US. In fact, the elasticity of substitution for the average of the euro area is estimated at 1.4-1.6 – for the euro area aggregate and the pool of euro area countries – below the values of the Japan, the US, the UK (3.6), Sweden (3.8) and thus the OECD pool (range 1.9-2.3). Within the euro area, countries with lower degree of substitution are Italy (1.1), Netherlands (1.4), Belgium (0.6), Greece (1.1) and Portugal (1.0).

As shown by the information in Figure 2 for some selected countries, the fit of the estimated model is quite good in the case of all European countries. For the US the model only captures the average premium, even though the higher substitutability compared to EU countries might reflect a more competitive labor market (less segmented between public and private sector employees). In the case of Japan the apparent perfect substitution is related to the institutional setup of the country. As indicated by Ishida and Matsushima (2009), in Japan civil servants are typically not allowed to bargain collectively, and their wages are instead determined based on the advise of the National Personnel Authority, with its particular emphasis on the equalization between the private and public sectors. Although the advice formally covers only national employees, it typically sets the baseline and hence has strong implications for salaries of local government employees. Along the same lines, in the case of Korea perfect substitutability ($\sigma \rightarrow \infty$) stems from the institutional features of the country by which wages are equalized by law between workers of the same type working in different sectors (Song, 1999).

Overall, the results in Table 1 signal a high degree of substitutability between public and private sector workers, but also some heterogeneity across countries. The assumptions that public workers, on average, are paid their marginal products as private workers, and that there are job flows across sectors, as prescribed by the standard theory, have to be taken into account to model the interactions between public and private sector wages. Thus, we take the latter approach as a fair starting point for our modeling strategy as described in the following Section. Nevertheless, given that in this standard framework the existence of a (positive) wage premium is not possible, we extend it to accommodate a non-trivial government sector/public sector union that endogenously determines public employment and wages. This latter feature is also consistent with the standing literature as summarized above.

3 A general equilibrium model

In this section, we construct a dynamic general equilibrium model that includes explicitly the public sector in the labor market. The model economy has three agents: households, firms and the government. Households' behavior is modeled in a standard fashion. Firms have access to a technology that encompasses three inputs: capital, private labor and public labor. Thus, labor supply is divided into private and public labor. The government raises taxes to finance the public sector wage bill, and decides over public employment and public employees' wages.

3.1 Households

Consider a model economy where the decisions made by consumers are represented by a stand-in consumer, with preferences given by the following instantaneous utility function:

$$U(C_t, N_t\overline{H} - L_t) = \gamma \log C_t + (1-\gamma)\log(N_t\overline{H} - L_t) \tag{6}$$

Private consumption is denoted by C_t. Leisure is $N_t\overline{H} - L_t$, where $\overline{H}$ is total time endowment and it is calculated as the number of effective hours in the week times the number of weeks in a year times population in the age of taking labor-leisure decisions, N_t, minus the aggregated number of hours worked in a year, L_t. The parameter γ $(0 < \gamma < 1)$ is the fraction of private consumption on total private income. Households consume final goods and supply labor to the private and the public sectors,

$$L_t = L_{p,t} + L_{g,t} \tag{7}$$

where L_t is the aggregate level of employment, $L_{p,t}$ is private employment and $L_{g,t}$ is public employment. Public employment is chosen by the government and thus it is exogenously given to the households. At an aggregate level, the households can only choose the supply of private labor, $L_{p,t} = L_t - L_{g,t}$.

The budget constraint faced by the stand-in consumer is:

$$C_t + K_{t+1} - K_t = (1-\tau_t)\left[W_{p,t}L_{p,t} + W_{g,t}L_{g,t} + (R_t - \delta)K_t + \Pi_t\right] \tag{8}$$

where K_t is the private capital stock, $W_{p,t}$ is private compensation per employee, $W_{g,t}$ is public compensation per employee, R_t is the rental rate of capital, δ is the capital depreciation rate which is modelled as tax deductible, τ_t is an income tax and Π_t denotes profits from firms, to be defined later. The budget constraint states that consumption and investment cannot exceed the sum of labor and capital rental income net of taxes and profits.

Capital holdings evolve according to:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{9}$$

where I_t is household's gross investment.

The problem faced by the stand-in consumer is to maximize the value of her lifetime utility given by:

$$Max_{\{C_t,L_t\}_t^\infty} \sum_{t=0}^{\infty} \beta^t \left[\gamma \log C_t + (1-\gamma)\log(N_t\overline{H} - L_{p,t} - L_{g,t})\right] \tag{10}$$

subject to the budget constraint, where K_0 and the paths of public employment and taxes are given, and where $\beta \in (0,1)$, is the consumer's discount factor.

The first order conditions for the consumer maximization problem are:

$$
\begin{aligned}
\gamma \frac{1}{C_t} - \lambda_t &= 0, & (11)\\
-(1-\gamma)\frac{1}{N_t\overline{H} - L_{p,t} - L_{g,t}} + \lambda_t(1-\tau_t)W_{p,t} &= 0, & (12)\\
\beta^t \left[\lambda_{t+1}\left(1 + (1-\tau_{t+1})(R_{t+1}-\delta)\right)\right] - \lambda_t \beta^{t-1} &= 0. & (13)
\end{aligned}
$$

Note that the above expressions imply that the consumer can only choose the supply of private labor, given that public labor is determined inelastically by the government. This rests on the assumption that there is a positive public-private wage premium.

3.2 Firms

The problem of the firm is to find optimal values for the utilization of labor and capital given the presence of public inputs. The stand-in firm is represented by a nested CES with a standard Cobb-Douglas production function. The production of the final output, Y, requires labor services, L (both private and public) and capital, K. Goods and factor markets are assumed to be perfectly competitive. The firm rents capital and hire labor in order to maximize period profits, taking public inputs and factor prices as given. The technology exhibits constant returns to factors and thus, profits would be zero in equilibrium. Nevertheless, public employment is paid by the government via taxes, and thus there is a positive level of profits.

The technology is given by

$$
Y_t = A_t K_t^{\alpha}\left[\mu B_t^{\eta} L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta}\right]^{\frac{(1-\alpha)}{\eta}} \tag{14}
$$

where Y_t is aggregate output, A_t is a measure of total factor productivity, α is the private capital share of output, μ measures the weight of public employment relative to private employment and $\sigma = 1/(1-\eta)$ is a measure of the elasticity of substitution between public and private labor inputs. The parameter η indicates the elasticity of technical substitution between private and public labor. B_t is the relative efficiency level of private labor.[9]

Under the assumption that private workers are paid their marginal products, we obtain that wages are given by

$$
W_{p,t} = \mu(1-\alpha)A_t K_t^{\alpha}\left[\mu B_t^{\eta} L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta}\right]^{(1-\alpha-\eta)/\eta} B_t^{\eta} L_{p,t}^{\eta-1} \tag{15}
$$

while the rental rate of capital is

$$
R_t = \alpha A_t K_t^{\alpha-1}\left[\mu B_t^{\eta} L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta}\right]^{(1-\alpha)/\eta} \tag{16}
$$

From the above equations, we obtain that private factors income is

$$
W_{p,t}L_{p,t} = (1-\alpha)\frac{\mu B_t^{\eta} L_{p,t}^{\eta}}{\left[\mu B_t^{\eta} L_{p,t}^{\eta} + (1-\mu) L_{g,t}^{\eta}\right]} Y_t \tag{17}
$$

[9] In some empirical specifications like the one discussed in a previous section the term capturing relative efficiency, B_t^{η}, is proxied by a linear trend in the expression for the public wage premium, i.e., $B_t^{\eta} = e^t$.

and

$$R_t K_t = \alpha Y_t \tag{18}$$

The selected production function has three productive factors. However, the third factor, public employment, has no market price. This implies that the rent generated by public labor is not assigned to the private factors. As public labor is paid by the government, there is a positive level of profits, that turns out to be

$$\Pi_t = (1-\alpha)\frac{(1-\mu)L_{g,t}^{\eta}}{\left[\mu B_t^{\eta} L_{p,t}^{\eta} + (1-\mu)L_{g,t}^{\eta}\right]} Y_t \tag{19}$$

The government usually does not charge a price that covers the full cost of the services provided with the contribution of public labor. Therefore a rent is generated. We assume, without loss of generality that profits are paid out to households given that they are the owners of the firm.

3.3 The government

Finally, we turn to the description of the public sector and its interactions with the private sector. We consider a two-side role for the government: as a tax-levying entity and as a supplier of public labor input. The government levies distortionary tax revenues to finance spending, pays the public sector wage bill $W_{g,t}L_{g,t}$ and balances its budget period-by-period.

To provide an objective function to the government, we follow a standard text-book approach (for example see Oswald *et al.*, 1984 [10]) and pose an objective function for the government as the solution of a game between a public sector union, that cares about the wage of public sector employees, and a government that cares about the level of public employment given its budget constraint. Thus, the government wants to maximize the following objective function subject to a budget constraint:[11]

$$\max \left[\omega W_{g,t}^{\theta} + (1-\omega)L_{g,t}^{\theta}\right]^{1/\theta} \tag{20}$$

where ω is the weight given to wages and θ is a negative parameter indicating the curvature of the objective function of the government.[12] If ω is close to zero, then the main goal of the government is to maximize public employment (benevolent government preference), whereas if ω is close to one, the main goal of the government is to maximize public wages (public sector union's preferred option). This function implies that the government wants to maximize both public wages and employment.

[10] On related grounds Ardagna (2007) and Forni and Giordano (2003) consider the wage bill of the government, employment and wages, separately as arguments of the objective function of the government or the public sector union.

[11] This objective function for the government is similar to minimizing the following function: $[\omega W_{g,t} + (1-\omega)L_{g,t}]$ in the case in which $\theta = -1$.

[12] In order to ensure that a maximum is achieved, the parameter θ must be negative.

The government obtains resources from the economy by taxing income from labor and capital, where the effective average public wage bill tax is τ_t. The government budget constraint in each period is given by,

$$\tau_t \left[W_{p,t}L_{p,t} + W_{g,t}L_{g,t} + (R_t - \delta)K_t + \Pi_t\right] = W_{g,t}L_{g,t} \tag{21}$$

Thus, from this expression it is immediate to see that the public sector wage bill is constrained to be

$$W_{g,t}L_{g,t} = \frac{\tau_t}{(1-\tau_t)}\left[W_{p,t}L_{p,t} + (R_t - \delta)K_t + \Pi_t\right] \tag{22}$$

Maximizing the government objective function subject to the government budget constraint we obtain that public wages and employment are equal to:

$$W_{g,t} = \left(\frac{\omega}{1-\omega}\right)^{-1/2\theta}\left[\frac{\tau_t}{(1-\tau_t)}(W_{p,t}L_{p,t} + (R_t - \delta)K_t + \Pi_t)\right]^{1/2} \tag{23}$$

$$L_{g,t} = \left(\frac{\omega}{1-\omega}\right)^{1/2\theta}\left[\frac{\tau_t}{(1-\tau_t)}(W_{p,t}L_{p,t} + (R_t - \delta)K_t + \Pi_t)\right]^{1/2} \tag{24}$$

It is worth noticing that for a wage premium to exist, $W_{g,t}$ must be larger than $W_{g,t}^{comp}$ (the competitive wage, as defined in equation 4).

This formulation implies that the wage-setting process in the private sector is totally different to the one in the public sector. Whereas in the private sector wages are determined in terms of their marginal products, in the public sector a given amount given by the budget constraint is distributed between public wages and public employment. This distribution of the public resources depends on government preferences. However, it is also true that both private and public sectors are competing for the same labor input and as a consequence there is a relationship between public sector and private sector wages.

3.4 Definition of equilibrium

Definition. A competitive equilibrium for this economy is a sequence of consumption, leisure, and private investment $\{C_t, N_t\overline{H} - L_t, I_t\}_{t=0}^{\infty}$ for households, a sequence of capital and labor utilization for the firm $\{K_t, L_{p,t}\}_{t=0}^{\infty}$, and a sequence of public employment and public wages $\{L_{g,t}, W_{g,t}\}_{t=0}^{\infty}$, such that, given a sequence of prices, $\{W_{p,t}, R_t\}_{t=0}^{\infty}$ and taxes, $\{\tau_t\}_{t=0}^{\infty}$:

(i) The optimization problem of the consumer is satisfied.

(ii) Given prices for capital and private labor, and given a sequence for public labor, the first-order conditions of the firm are satisfied with respect to capital and private labor.

(iii) Given a sequence of taxes, the government maximizes its utility function and the government budget constraint is satisfied.

(iv) The feasibility constraint of the economy is satisfied.

4 Data and calibration

We calibrate the model to replicate certain features of an economy of reference. For our exercise we choose the euro area aggregate as our economy of reference given the importance of the public sector in the labor market of the euro area. In calibrating the model presented in the previous section we need information on the tax rate (τ_t), technological parameters, $(\alpha, \delta, \mu, \eta)$ and preference parameters, $(\beta, \gamma, \theta, \omega)$. Following Kydland and Prescott (1982) we set in advance as many parameters as possible based upon *a priory* information. Thus, before simulating the model, numerical values must be assigned to the parameters of the model: $(\alpha, \beta, \gamma, \delta, \tau, \mu, \eta, \theta, \omega)$.

4.1 Data

The data is taken from two different sources: the OECD Economic Outlook Database and the EU-Klems Database. Output, wages and employment figures are taken from the OECD database. The capital stock is taken from the EU-Klems database. The frequency of the data is annual. We calibrate the model to the data of the euro-area for the last year in our sample (year 2006). The public wage premium $(\overline{W}_g/\overline{W}_p)$ is set to be 1.27, and the ratio of public/private employment $(\overline{L}_g/\overline{L}_p)$ to 0.20, where an upper bar denotes a steady state value. On the other hand, the ratio of capital to output $(\overline{K}/\overline{Y})$ is fixed to be 3.5.

4.2 Tax rate (τ)

In our model economy the government has to obtain fiscal revenues to finance public employment. Our stylized model implies that all fiscal revenues are used to pay the public wage bill. Therefore, we use an implicit tax rate that guarantees that the government budget constraint holds. Given expression (21), the implicit tax rate in steady state is defined as

$$\tau = \frac{\overline{W}_g \overline{L}_g}{\left[\overline{W}_p \overline{L}_p + \overline{W}_g \overline{L}_g + (\overline{R} - \delta)\overline{K} + \overline{\Pi}\right]}. \tag{25}$$

The value of this particular tax rate has been calculated as the ratio of the public wage bill over total output, and turns out to be 0.1428 for our calibration. This implies that, in order to finance public employment, the income tax rate must be at least 14%.

4.3 Technological parameters $(\alpha, \delta, \mu, \eta)$

In order to calibrate the technological parameters we use data from the euro area national income and product accounts. First, the disposable effective time endowment of individuals, $N_t\overline{H}$ (i.e. non-sleeping hours of the working-age population) is taken to be 96 hours a week ($\overline{H} = 96$). The fraction of disposable effective hours that households spends working is equal to 0.25.

We take a standard value for the aggregate labor income share, $(1 - \alpha)$, of 0.65. This implies a value for α of 0.35. The capital stock and the depreciation rate are taken from the EU-Klems database. The capital depreciation rate is set to be 0.06.

Regarding parameters μ and η, we take the estimated values shown in Table 1. This would imply that wages are determined by their marginal productivity in both, the public and the private sector. Indeed, the fit shown in Figure 2 hint this assumption as a reasonable one, in particular in the case of the euro area aggregate. For the euro area aggregate, the estimated value for μ is 0.698, and the estimated value of η is 0.336.

4.4 Preference parameters $(\beta, \gamma, \theta, \omega)$

Finally, following the standard practice, (some) preference parameters are calibrated using actual data. From the first order conditions we can obtain the following value of β and γ as a function of data observations:

$$\beta = \frac{1}{1 + (1 - \tau)(\alpha \overline{Y} / \overline{K} - \delta)} \tag{26}$$

$$\gamma = \frac{\overline{C}}{(1 - \tau)\overline{W}(\overline{N}_t \overline{H} - \overline{L}) + \overline{C}} \tag{27}$$

The resulting values are a β of 0.96, an a value for γ of 0.32. More complicated is the calibration of the government preference parameters as we have no previous information about them. Given this restriction, preference parameters for the government, (θ, ω) are obtained as follows. First, we choose arbitrarily a value of θ equal to -1.[13] This implies that the maximization of the objective function for the government is equivalent to the minimization of a weighted average of public wages and employment. Second, the value of the parameter ω is obtained calibrating the first order conditions of the government maximization problem (expressions (20) and (21)). Therefore, given our previous calculations about fiscal revenues and the data about wages and labor, we use the model equations to obtain the resulting value for the weight given to wages in the government objective function. The value of this parameter reflects how the government allocate its fiscal revenues between public wages and public employment. The calculated value for the euro area aggregate is 0.526, very close to one half, indicating that a similar weigh is given to wages and employment in the government objective function. Table 2 summarizes the values of the calibrated parameters.

5 Quantitative analysis of shocks

The calibration exercise conducted in the previous section enables us to conduct simulation experiments with the log-linearized version of our model. In this section we present some simulations to show the dynamics of the model via impulse-response functions. We consider two different shocks:

[13] A sensitivity analysis have been done for values of θ ranging from -0.5 to -2. For the analyzed range model results remained almost unchanged. This can be explained by the fact that this parameter only affects the curvature of the objective function of the government with little importance on the resulting equilibrium.

a total factor productivity shock (neutral technological shock) and a private labor efficiency shock (a specific shock to private labor). Additionally, we study the effects of an increase in the implicit tax rate.

5.1 Total factor productivity shock

Our first exercise considers the case of an exogenous positive neutral shock to the economy, that is, an increase in Total Factor Productivity, A_t. This is a standard shock in most real business cycle models. We assume that TFP follows a first order autoregressive, AR(1), process:

$$\ln A_t = \mu + \rho_A \ln A_{t-1} + \varepsilon_t^A \tag{28}$$

where $\varepsilon_t^A \sim N(0, \sigma_A)$. Selected values are $\rho_A = 0.95$ and $\sigma_A = 0.01$. We assume that the TFP increases by 1% standard deviation on impact. As expected, this shock raises output on impact, as more output is produced for given factor inputs. Hours worked also increase as the return to work increases, rising output further. Additionally, due to the direct effect of the shock on output, private labor productivity increases on impact. Capital stock also increases given the rise in its productivity. Thus, overall, the effects of this shock in our theoretical framework are the same than in a standard real business cycle model without the distinction between private and public sector employment.

The inclusion of the distinction between private and public employment in our model, allows us to move beyond the standard results, and to provide the separate effects on the private and the public labor markets. The impact of an increase in TFP on the relevant variables is summarized in Figure 3. We plot deviations in percentage points from steady state values. The shock has a positive effect on output and on total employment, as expected, and described above. Both private and public employment increase on impact but through different channels. Private labor increases, as a consequence of the higher productivity. On the other hand, the shock increases fiscal revenues and therefore, the government can increase the public wage bill and thus rises public employment and public wages. The effect on public employment is larger than on private employment and as time goes on, the effect on private employment turns even negative. Nevertheless, it is true that this negative effect is relatively small. In summary, a TFP shock produces a "crowding-out" effect as there is a substitution of private employment by public employment.

As regards wages, there is an increase in private wages as a consequence of the gains in productivity. Additionally, given the parameterization of the objective function of the government, the increase in public revenues, leads to an increase in public wages. However, given the flow of employees from the private sector to the public sector there is a larger effect on private wages than on public wages.

Thus, our model prescribes additional insights on the effect of a TFP shock on total employment as compared with the standard model. The crowding-out effect on private employment entail that private wages do not only increases as a consequence of the rise in labor productivity after the shock, but also as a consequence of the transfer of labor from the private sector to the public sector. Therefore, in this case the response of public employment puts pressure into both public and private wages and thus reduces the effect of the shock on total economy employment. This effect is missing in the standard model without a public labor sector.

Figure 4 plots the effects on the public/private wage premium and the ratio of public and private employment in percentage deviations with respect to the calibrated one (year 2006 for the euro-area). As a consequence of this shock, the ratio of public and private wages decreases. On the other hand, the ratio public/private employment increases.

The important conclusion we obtain from our model is that a total factor productivity shock can have a negative effect on private employment. The effect would depend, though, on the preferences of the government regarding public employment. If the preferences of the government are such that $\omega = 1$, then public employment remains constant and the crowding-out mechanism does not hold. In this case, all the change in public revenues is addressed to finance public wages, increasing the public wage premium. However, the effect on private labor is the same as in a standard neoclassical model. As the value of this parameter departs from one and approaches zero, the crowding-out mechanism starts to work, moving employment from the private sector to the public one and putting pressure on private wages. All in all, the results in this subsection imply that when accounting for the effect of a TFP shock on total employment one must pay attention to the behavior of public employment.

5.2 Private labor productivity shock

Next, we study the effects of a positive private labor productivity shock, i.e., an increase in B_t. This perturbation can be interpreted as a rise in efficiency in the private labor sector of the economy compared to the public labor sector. The analysis of this shock can be very interesting as one can observe the effects a productivity shock in the private labor market has on the public labor market. As in the case of the TFP shock, we also assume that private labor productivity follows a first order autoregressive process:

$$\ln B_t = \mu + \rho_B \ln B_{t-1} + \varepsilon_t^B \tag{29}$$

where $\varepsilon_t^B \sim N(0, \sigma_B)$. Selected values are the same as for the TFP process, i.e., $\rho_B = 0.95$ and $\sigma_B = 0.01$.

We consider the case of a 1% standard deviation positive shock. In a standard model, the effects of this shock would be qualitatively similar to the effects derived from an aggregate productivity shock. However, in our context, this shock generates a rise in the relative efficiency of private workers versus public workers affecting the overall behavior of aggregate variables.

At an aggregate level, this shock has a positive effect on output and on total employment as in the case of an aggregate productivity shock (Figure 5). However, as total output increases it is also true that government tax revenues will rise, which in turn will expand public wages and employment.

Interestingly, although the shock is specific to private employment, public employment increases in a larger proportion in the short-run, generating also a crowding-out effect. The explanation is simple. Despite the fact that this productivity shock is specific to the private labor market, the rise in public revenues gets translated into a higher level of public wages and employment. Again, there is a movement of workers from the private sector to the public sector. As a consequence, the ratio public/private employment increases (Figure 6). The shock generates an increase in fiscal revenues which is transformed into more public workers in spite of the fact that the relative efficiency of private workers is larger. This is an important feature of our model.

The effects on wages are as follows. Both private and public wages increase, but the ratio of public/private wages decreases as the rise in private wages is larger than in public wages. The increase in private wages is obvious, given the larger productivity provoked by the shock. However, in spite of the fact that the relative productivity in the public sector decreases, also public wages increase. Thus, the larger productivity in the private sector translates to the public sector, increasing also public wages.

This result supports the wage-leading role hypothesis of the private sector. Our model predicts that a positive productivity shock in the private sector increases wages and employment in the public labor sector. This is important to explain the dynamic relationship between wages in both sectors.

5.3 Public sector wage bill shock

Finally, we study the effect of an increase in the available resources to the public sector via an increase in taxes to finance the public sector wage bill. We consider the case of a 1 percentage point increase in the tax rate.

The effects of this government decision on the economy are negative, as both output and total employment decrease. The negative effect on output increases as time elapses given the convergence to a lower steady-state value (Figure 7). The negative effect on total employment derives from the effect on the private labor market. The increase in the public wage bill provokes a reduction in private employment that come from two sources. First, the rise in the tax rate has a negative effect on output, and then on private employment. Second, there is a flow of employment from the private labor sector to the public one. Again, there is a crowding-out effect from the public labor market to the private one. The increase of the public wage bill implies a rise in public wages and a rise in public employment of about the same proportion, given the calibrated parameters of the government utility function. Therefore, total employment decreases as a consequence of the negative impact on output and on the movement of workers to the public labor market.

As a consequence of this shock, both public wages and public employment increase in the short-run. However, as the adjustment takes place we observe a reduction in both public wages and employment. The rise in the tax to finance public wage will provokes a reduction in total output in the economy, and then, a reduction of government revenues, reducing the budget constraint of the government. In the private sector the adjustment implies a reduction in wages and a slight recovery in employment. The total effect on private employment and total employment is negative

Figure 8 plots the percentage change in both the public/private employment and the public/private wage premium. This shock increases both the public/private sector wage premium and the ratio public/private employment. These effects are the outcome of, on the one hand, the overall rise of public employment and the reduction on private employment and, on the other hand, the larger increase in public wages compared to private wages. In the adjustment process we observe that the public/private labor ratio decreases whereas the public/private wage ratio increases, as a consequence of the reduction in public revenues.

6 Conclusions

This paper develops a dynamic general equilibrium model in which the public and the private sector interact in the labor market. We show that theories that equalize wages with marginal products in the private sector can rationalize the dynamic path of the public/private sector wage differential over the last four decades when extended to accommodate a non-trivial government sector/public sector union that endogenously determines public employment and wages. We take this latter feature from the standing literature as reported above. The inclusion of the union is key to account for the observed existence of a wage premium. Nevertheless a first message of our paper is that the literature has put an excessive weight on the role of unions in order to understand public-private sector wage dynamics.

In this framework we are also able to simulate experiments that help us understanding the dynamic behavior of aggregate time series of public-private sector wages. Our model would prescribes a positive correlation between public and private sector wages, while at the same time being consistent with a wage-leading role of the private sector. These predictions are in line with some recent empirical evidence.

Finally, we study the effects of several shocks. The behavior of the economy at an aggregate level is qualitatively similar to the one generated by a standard dynamic general equilibrium model with only one labor input. This is a proof of the robustness of our model. However, we can also account for the effects on both the private and the public sectors, conducting a richer analysis missing in standard models. The most important result derived from our analysis is the existence of a crowding-out effect that causes that a positive productivity shock may have a negative effect on private employment.

References

AFONSO, A., and P. GOMES (2008). *Interaction between private and public sector wages,* ECB Working Paper, No. 971, November.

ALGAN, Y., P. CAHUC and A. ZYLBERBERG (2002). "Public employment. Does it increase unemployment?", *Economic Policy,* April, pp. 9-65.

ALLEN, S. (1988). *Can Union Labor Ever Cost Less?,* NBER Working Papers, No. 2019.

ARDAGNA, S. (2001). "Fiscal Policy Composition, Public Debt and Economic Activity", *Public Choice,* 109, pp. 301-325.

— (2007). "Fiscal policy in unionized labor markets", *Journal of Economic Dynamics and Control,* 31, pp. 1498-1534.

BENDER, K. (1998). "The central government-private sector wage differential", *Journal of Economic Surveys,* 12, pp. 177-220.

— (2003). "Examining equality between public- and private-sector wage distribution", *Economic Inquiry,* 41, pp. 62-79.

BLANCHFLOWER, D. (1991). "Fear, Unemployment and Pay Flexibility", *Economic Journal,* 101, pp. 483-496.

CALMFORS, L., and H. HORN (1986). "Employment Policies and Centralized Wage-Setting", *Economica,* August, pp. 281-302.

CAVALLO, M. (2005). *Government employment expenditure and the effecs of fiscal policy shocks,* Federal Reserve Bank of San Francisco Working Paper, No. 2005-16.

CHATTERJI, M., and K. MUMFORD (2007). *The Public-Private Sector Wage Differential for Full-Time Male Employees in Britain: A Preliminary Analysis,* IZA Discussion Papers No. 2781, Institute for the Study of Labor (IZA).

COGAN, J., T. CWIK, J. B. TAYLOR and V. WIELAND (2009). *New Keynesian versus Old Keynesian government spending multipliers,* NBER Working Paper, No. 14782.

DEMEKAS, D., and Z. KONTOLEMIS (2000). "Government employment and wages and labour market performance", *Oxford Bulletin of Economics and Statistics,* 62, pp. 391-415.

DOMEIJ, D., and L. LJUNGQVIST (2006). *Wage structure and public sector employment: Sweden versus the United States 1970-2000,* CEPR Discussion Paper, No. 5921.

EHRENBERG, R. D., and J. L. SCHWARZ (1986). "Public-sector labor markets", in O. Ashenfelter and R. Leyard (eds.), *Handbook of Labor Economics,* Vol. 2, North-Holland.

FINN, M. G. (1998). "Cyclical effects of government's employment and goods purchases", *International Economic Review,* 39, pp. 635-657.

FORNI, L., L. MONTEFORTE and L. SESSA (2009). "The general equilibrium effects of fiscal policy: estimates for the euro area", *Journal of Public Economics,* 93, pp. 559-585.

FORNI, L., and R. GIORDANO (2003). *Employment in the public sector,* CESIFO Working Paper, No. 1085.

FREEMAN, R. (1988). "Union density and economic performance: An analysis of U.S. States", *European Economic Review,* 32, pp. 707-716.

GOMES, P. (2009). *Labour market effects of public sector employment and wages,* mimeo, London School of Economics.

GREGORY, R., and J. BORLAND (1999). "Recen developments in public sector labor markets", in O. Ashenfelter and D. Card (eds.), *Handbook of Labor Economics,* edition 1, Vol. 3, chapter 53, pp. 3573-3630 Elsevier.

ISHIDA, J., and N. MATSUSHIMA (2009). "Should civil servants be restricted in wage bargaining? A mixed-duopoly approach", *Journal of Public Economics,* 93, pp. 634-646.

HOLMLUND, B. (1993). "Wage setting in private and public sectors in a model with endogenous government behavior", *European Journal of Political Economy,* 9, 149-162.

— (1997). "Macroeconomic implications of cash limits in the public sector", *Economica,* 64, pp. 49-62.

JACOGSON, T., and H. OHLSSON (1994). "Long-run relations between private and public sector wages in Sweden", *Empirical Economics,* 19, pp. 343-360.

KATZ, L., and D. AUTOR (1999). "Changes in the wage structure and earnings inequality", in O. Ashenfelter and D. Card (eds.), *Handbook of Labor Economics,* edition 1, Vol. 3, chapter 26, pp. 1463-1555.

KYDLAND, F., and E. PRESCOTT (1982). “Time to built and aggregate fluctuations”. *Econometrica,* 50, pp. 1345-1370.

LAMO, A., J. J. PÉREZ and L. SCHUKNECHT (2007). *The cyclicality of consumption, wages and employment of the public sector in the euro area,* ECB Working Paper, No. 757, May.

— (2008). *Public and private sector wages: co-movement and causality,* ECB Working Paper, No. 937, November.

LANE, P. (2003). “The cyclical behaviour of fiscal policy: evidence from the OECD”, *Journal of Public Economics,* 87, pp. 2661-2675.

LINDQUIST, M., and R. VILHELMSSON (2004). *Is the Swedish central government a wage leader?,* Stockholm University Working Paper, No. 8/2004.

MALLEY, J., and T. MOUTOS (1996). “Does Government Employment Crowd-out Private Employment: The Swedish Case”, *Scandinavian Journal of Economics,* 98, pp. 289-302.

OSWALD, A. J., P. A. GROUT and D. T. ULPH (1984). *Uncertainty, unions and the theory of public sector labor markets,* Working Paper, No. 176, Industrial Relations Section, Princeton University.

PAPPA, E. (2004). “Do the ECB and the fed really need to cooperate? Optimal monetary policy in a two-country world”, *Journal of Monetary Economics,* 51, pp. 753-779.

PEDERSEN, P. J., J. B. SCHMIDT-SØRENSEN, N. SMITH and N. WESTERGARD-NIELSEN (1990). “Wage differentials between the public and private sectors”, *Journal of Public Economics,* 41, pp. 125-145.

QUADRINI, V., and A. TRIGARI (2007). “Public Employment and the Business Cycle”, *Scandinavian Journal of Economics,* 109, pp. 723-742.

ROBINSON, C. (1995). “Union Incidence in the Public and Private Sectors”, *Canadian Journal of Economics,* 28, pp. 1056-1076.

ROMER, C., and J. BERNSTEIN (2009). *The job impact of the American recovery and reinvestment plan,* mimeo, January.

SONG, H. (1999). *Labour unions in the Republic of Korea: Challenge and choice,* Discussion Papers, No. 107/1999, International Institute for Labour Studies.

TAYLOR, J. B. (2009). “The lack of an empirical rationale for a revival of discretionary fiscal policy”, *American Economic Review, Papers and Proceedings,* 99, pp. 550-555.

Figure 1: The wage premium received by public sector employees with respect to private sector employees, and ratio of public sector employees to private sector employees (%), selected OECD countries.

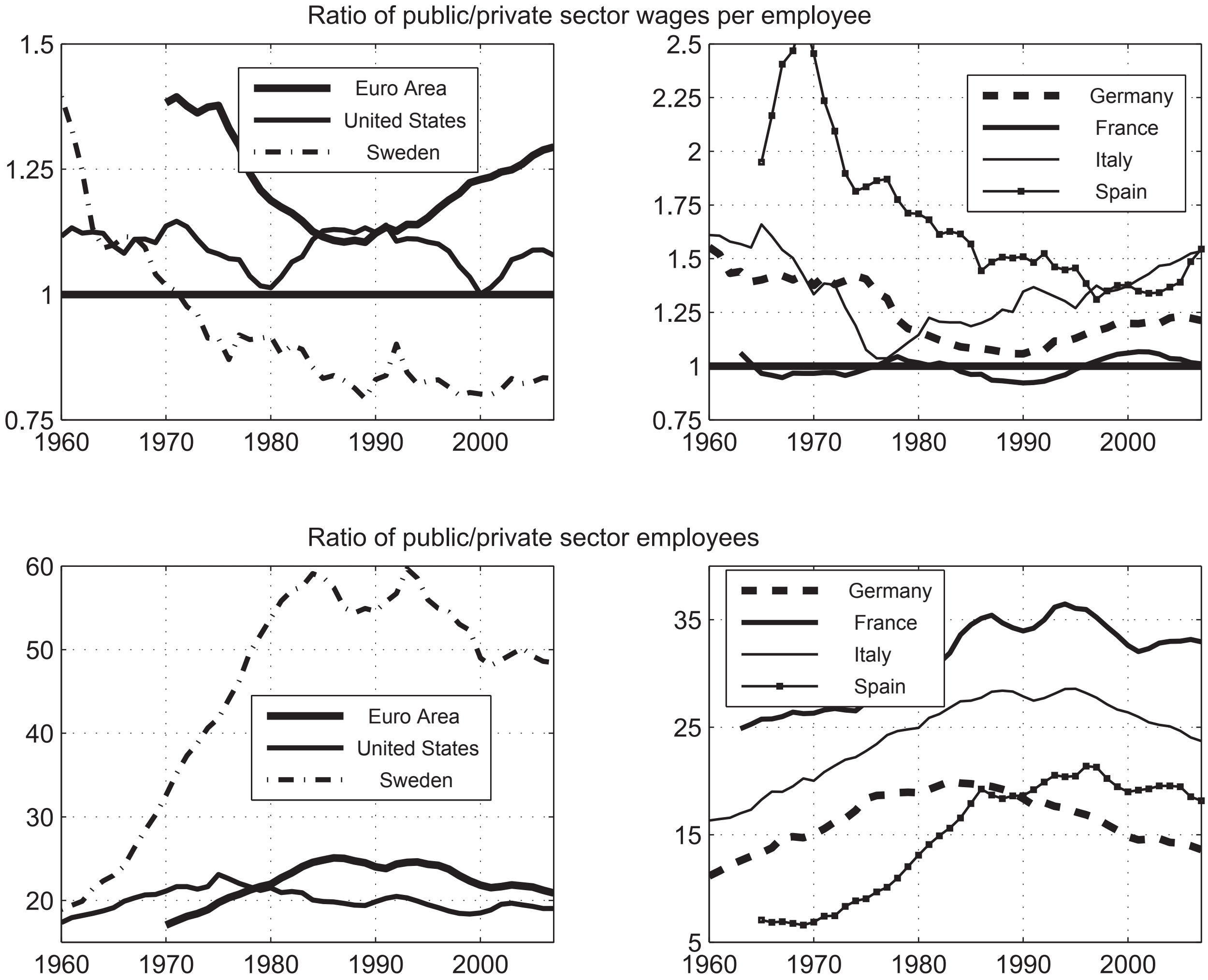

Figure 2: Relative public/private sector wages and employment: actual data (solid lines) and the prescription of a model in which public and private sector workers were paid their marginal products (dotted lines), selected OECD countries.

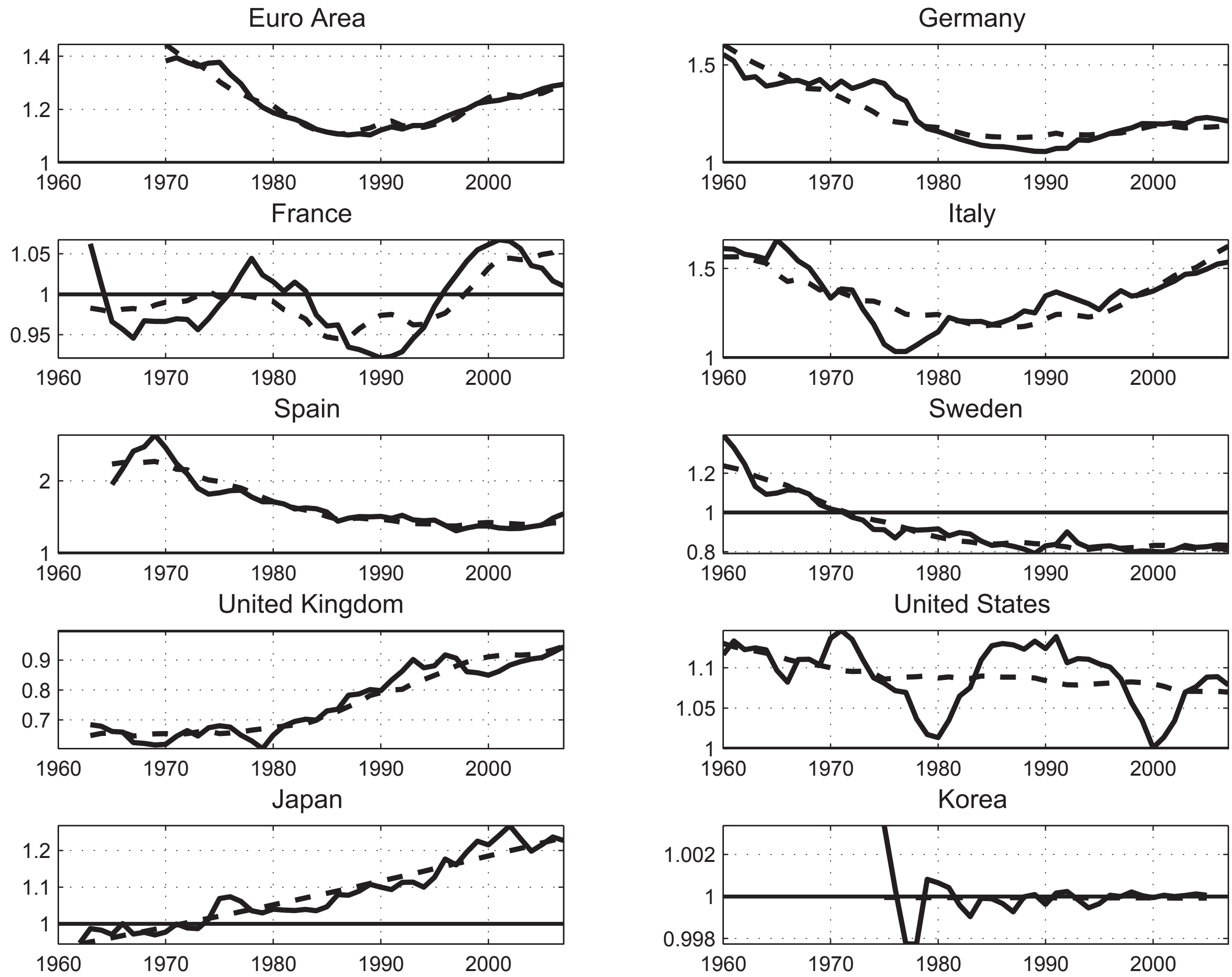

Figure 3: Total factor productivity shock (1/2).

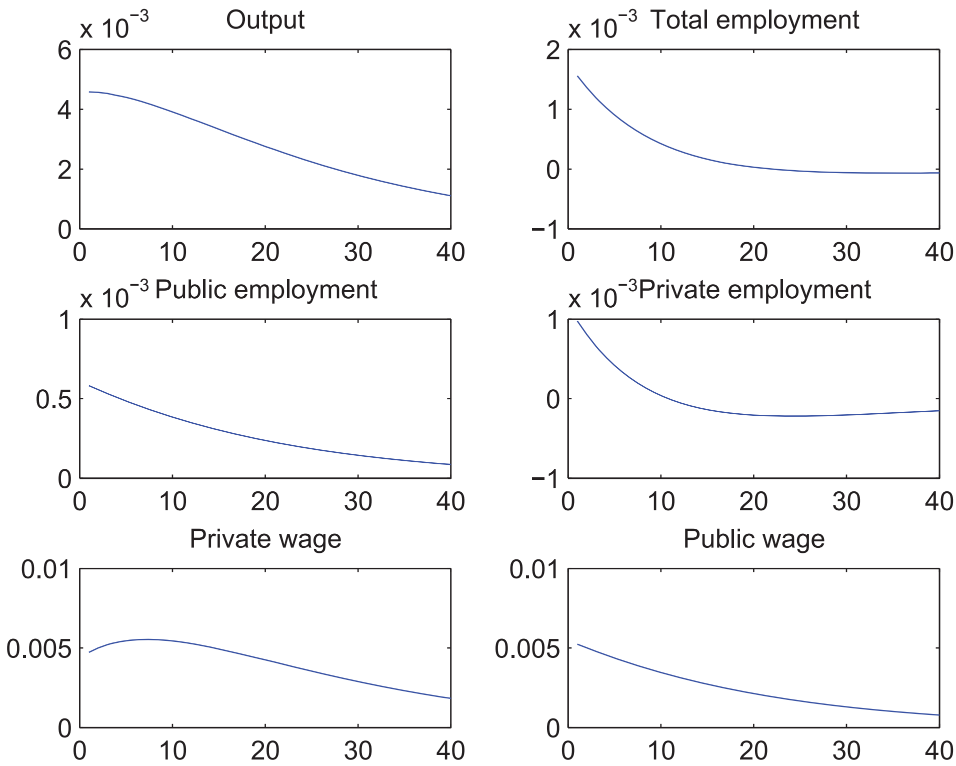

Figure 4: Total factor productivity shock (2/2).

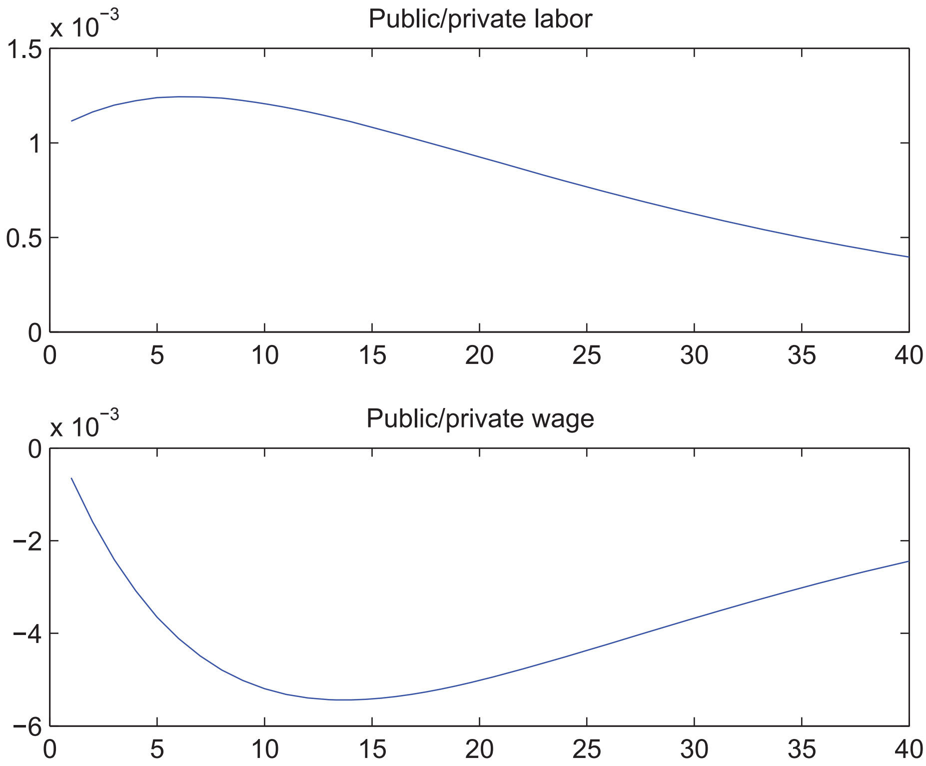

Figure 5: Private sector employment productivity shock (1/2).

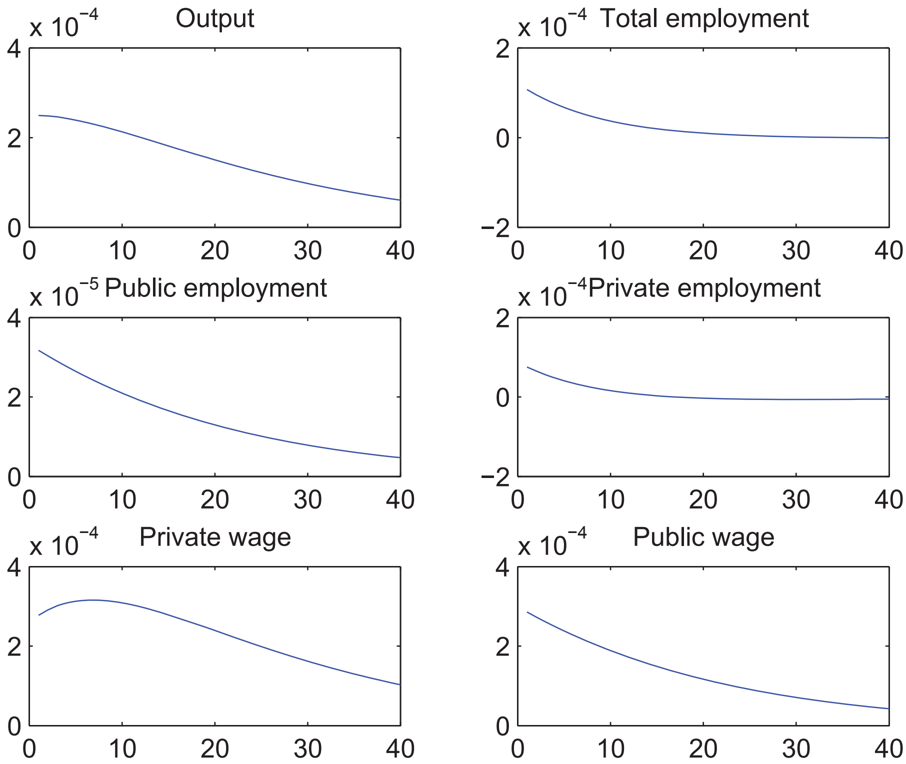

Figure 6: Private sector employment productivity shock (2/2).

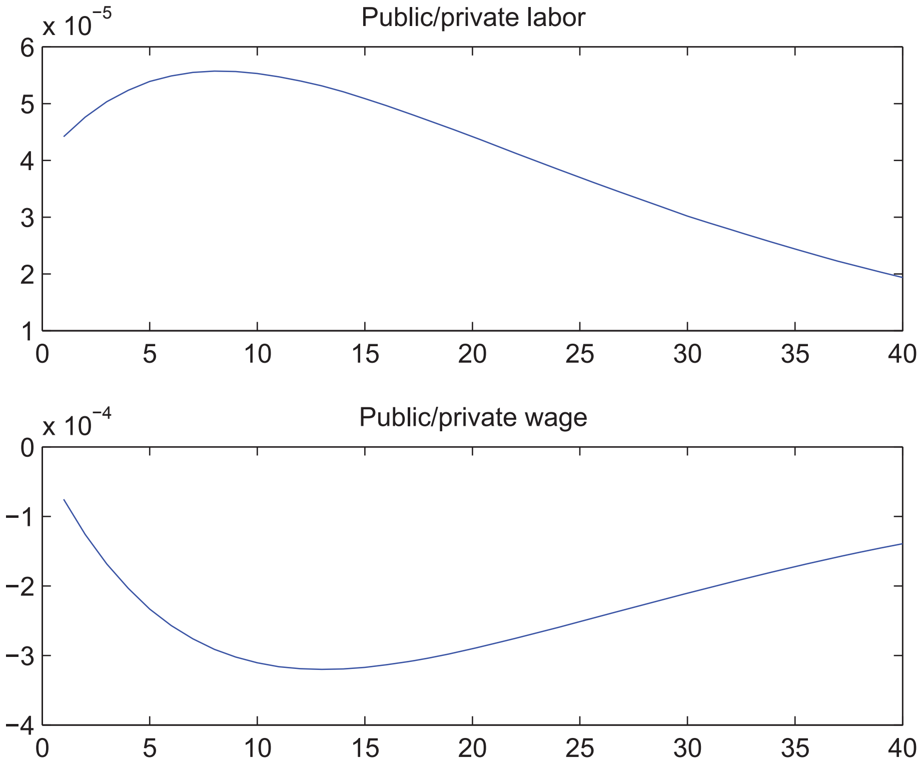

Figure 7: Public sector wage bill shock (1/2).

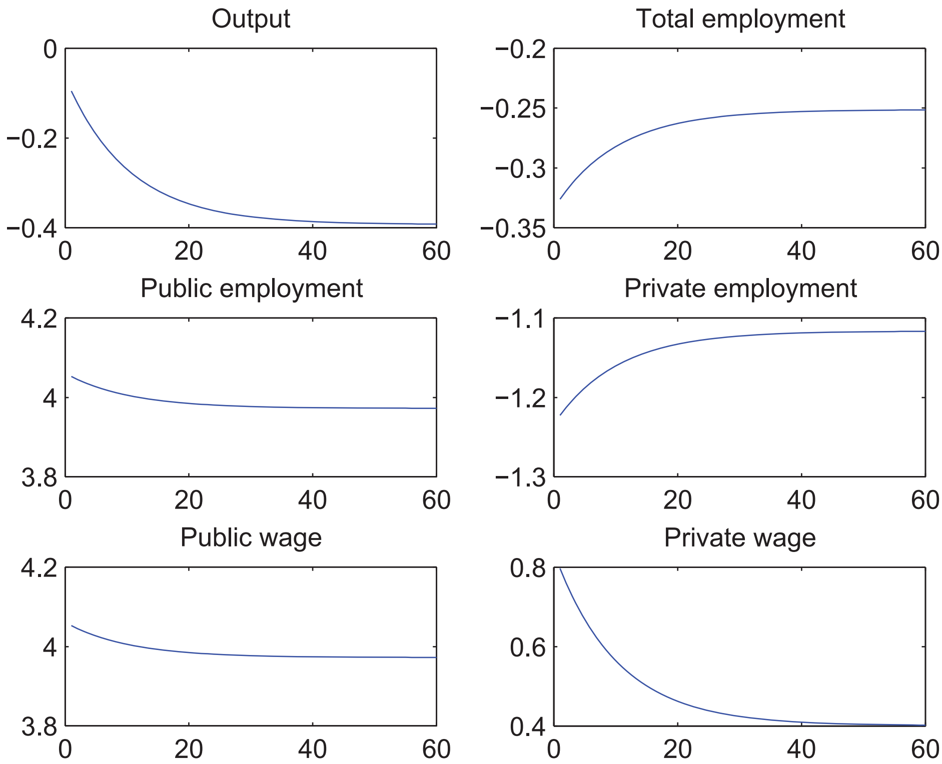

Figure 8: Public sector wage bill shock (2/2).

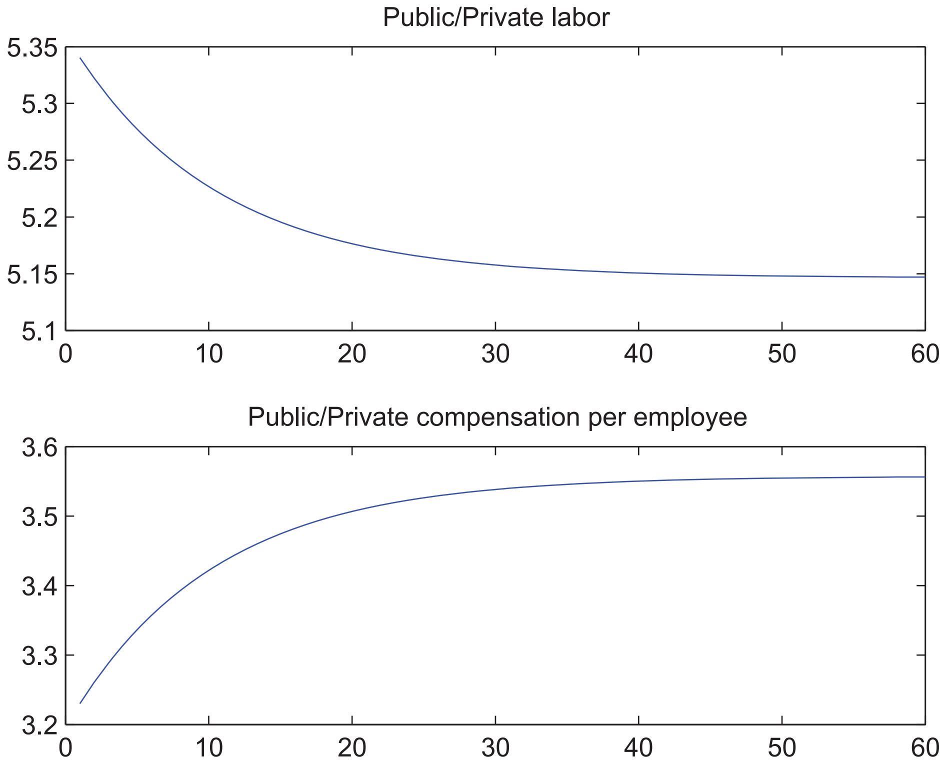

Table 1: Job market flows and some determinants of the public/private wage premium. The estimated equation is: $\log\left(\frac{W_{g,t}}{W_{p,t}}\right) = constant + linear\ trend + (\eta - 1)\log\left(\frac{L_{g,t}}{L_{p,t}}\right)$, where $L_{p,t}$ and $L_{g,t}$ denote private and public sector labor respectively, and $W_{p,t}$ and $W_{g,t}$ private and public sector wages per employee.

	OLS estimation			IV estimation		
	$\sigma = -\frac{1}{\eta-1}$	$\eta - 1$	*U-root p-val*	$\sigma = -\frac{1}{\eta-1}$	$\eta - 1$	*U-root p-val*
Euro area aggregate	1.4	-0.73 (0.03)	0.000	1.8	-0.56 (0.09)	0.000
Euro area pool ($n = 443$)	1.4	-0.70 (0.03)	0.000	1.4	-0.70 (0.03)	
Euro area pool (weighted)	1.6	-0.62 (0.02)	0.000	1.6	-0.61 (0.02)	
Germany	2.5	-0.41 (0.05)	0.004	2.4	-0.42 (0.05)	0.007
France	2.5	-0.39 (0.07)	0.007	2.5	-0.39 (0.07)	0.027
Italy	1.1	-0.93 (0.11)	0.032	1.1	-0.93 (0.11)	0.028
Spain	2.7	-0.37 (0.05)	0.004	2.7	-0.37 (0.06)	0.046
Netherlands	1.4	-0.71 (0.03)	0.017	1.4	-0.73 (0.03)	0.000
Austria	3.1	-0.32 (0.06)	0.000	3.1	-0.32 (0.06)	0.004
Belgium	0.6	-1.73 (0.12)	0.026	0.5	-1.98 (0.11)	0.004
Greece	1.1	-0.89 (0.08)	0.025	1.1	-0.89 (0.09)	0.008
Ireland	1.8	-0.57 (0.05)	0.004	1.9	-0.53 (0.05)	0.009
Portugal	1.0	-1.03 (0.08)	0.058	1.0	-0.99 (0.10)	0.001
Finland	2.2	-0.46 (0.06)	0.001	2.0	-0.49 (0.07)	0.001
Sweden	3.8	-0.26 (0.03)	0.000	4.0	-0.25 (0.03)	0.000
Denmark	1.8	-0.57 (0.04)	0.000	1.9	-0.53 (0.04)	0.001
Norway	2.9	-0.35 (0.03)	0.000	2.6	-0.38 (0.03)	0.000
United Kingdom	3.6	-0.28 (0.05)	0.001	4.7	-0.21 (0.05)	0.009
United States	> 10	-0.09 (0.08)	0.005	> 10	-0.08 (0.08)	0.004
Japan	$\gg 10$	-0.00 (0.00)	0.002	$\gg 10$	-0.01 (0.10)	0.003
Korea	$\gg 10$	-0.00 (0.00)	0.000	$\gg 10$	0.00 (0.00)	0.000
OECD pool ($n = 863$)	1.9	-0.53 (0.01)		1.9	-0.53 (0.02)	
OECD pool (weighted)	2.3	-0.44 (0.01)		2.3	-0.43 (0.01)	

Notes: Pool estimates include fixed effects and country-specific linear trends. Weighted estimates account for cross-section heteroskedasticity. The OECD pool includes all the countries listed in the table plus Island, Canada, and New Zealand. The euro area pool includes Austria, Belgium, Germany, Spain, Finland, France, Ireland, Netherlands, Portugal and Greece.

IV estimation: lagged log $\frac{L_{g,t}}{L_{p,t}}$ and lagged log $\frac{W_{g,t}}{W_{p,t}}$ used as instruments.

Unit root tests' null hypothesis is H0: the residual of the regression has a unit root. Lag-length selection using the SIC criterion.

Table 2: Calibrated parameters.

Parameter	Value
α	0.350
β	0.960
γ	0.320
δ	0.060
τ	0.143
μ	0.698
η	0.336
θ	-1.000
ω	0.526

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS[1]

0821 GABRIEL JIMÉNEZ, JOSÉ A. LÓPEZ AND JESÚS SAURINA: Empirical analysis of corporate credit lines.
0822 RAMÓN MARÍA-DOLORES: Exchange rate pass-through in new Member States and candidate countries of the EU.
0823 IGNACIO HERNANDO, MARÍA J. NIETO AND LARRY D. WALL: Determinants of domestic and cross-border bank acquisitions in the European Union.
0824 JAMES COSTAIN AND ANTÓN NÁKOV: Price adjustments in a general model of state-dependent pricing.
0825 ALFREDO MARTÍN-OLIVER, VICENTE SALAS-FUMÁS AND JESÚS SAURINA: Search cost and price dispersion in vertically related markets: the case of bank loans and deposits.
0826 CARMEN BROTO: Inflation targeting in Latin America: Empirical analysis using GARCH models.
0827 RAMÓN MARÍA-DOLORES AND JESÚS VAZQUEZ: Term structure and the estimated monetary policy rule in the eurozone.
0828 MICHIEL VAN LEUVENSTEIJN, CHRISTOFFER KOK SØRENSEN, JACOB A. BIKKER AND ADRIAN VAN RIXTEL: Impact of bank competition on the interest rate pass-through in the euro area.
0829 CRISTINA BARCELÓ: The impact of alternative imputation methods on the measurement of income and wealth: Evidence from the Spanish survey of household finances.
0830 JAVIER ANDRÉS AND ÓSCAR ARCE: Banking competition, housing prices and macroeconomic stability.
0831 JAMES COSTAIN AND ANTÓN NÁKOV: Dynamics of the price distribution in a general model of state-dependent pricing.
0832 JUAN A. ROJAS: Social Security reform with imperfect substitution between less and more experienced workers.
0833 GABRIEL JIMÉNEZ, STEVEN ONGENA, JOSÉ LUIS PEYDRÓ AND JESÚS SAURINA: Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking?
0834 ENRIQUE ALBEROLA AND JOSÉ MARÍA SERENA: Sovereign external assets and the resilience of global imbalances.
0835 AITOR LACUESTA, SERGIO PUENTE AND PILAR CUADRADO: Omitted variables in the measure of a labour quality index: the case of Spain.
0836 CHIARA COLUZZI, ANNALISA FERRANDO AND CARMEN MARTÍNEZ-CARRASCAL: Financing obstacles and growth: An analysis for euro area non-financial corporations.
0837 ÓSCAR ARCE, JOSÉ MANUEL CAMPA AND ÁNGEL GAVILÁN: asymmetric collateral requirements and output composition.
0838 ÁNGEL GAVILÁN AND JUAN A. ROJAS: Solving Portfolio Problems with the Smolyak-Parameterized Expectations Algorithm.
0901 PRAVEEN KUJAL AND JUAN RUIZ: International trade policy towards monopoly and oligopoly.
0902 CATIA BATISTA, AITOR LACUESTA AND PEDRO VICENTE: Micro evidence of the brain gain hypothesis: The case of Cape Verde.
0903 MARGARITA RUBIO: Fixed and variable-rate mortgages, business cycles and monetary policy.
0904 MARIO IZQUIERDO, AITOR LACUESTA AND RAQUEL VEGAS: Assimilation of immigrants in Spain: A longitudinal analysis.
0905 ÁNGEL ESTRADA: The mark-ups in the Spanish economy: international comparison and recent evolution.
0906 RICARDO GIMENO AND JOSÉ MANUEL MARQUÉS: Extraction of financial market expectations about inflation and interest rates from a liquid market.
0907 LAURA HOSPIDO: Job changes and individual-job specific wage dynamics.
0908 M.ª DE LOS LLANOS MATEA AND JUAN S. MORA: La evolución de la regulación del comercio minorista en España y sus implicaciones macroeconómicas.
0909 JAVIER MENCÍA AND ENRIQUE SENTANA: Multivariate location-scale mixtures of normals and mean-variance-skewness portfolio allocation.
0910 ALICIA GARCÍA-HERRERO, SERGIO GAVILÁ AND DANIEL SANTABÁRBARA: What explains the low profitability of Chinese banks?
0911 JAVIER MENCÍA: Assessing the risk-return trade-off in loans portfolios.
0912 MAXIMO CAMACHO AND GABRIEL PEREZ-QUIROS: Ñ-STING: España Short Term INdicator of Growth.
0913 RAQUEL VEGAS, ISABEL ARGIMÓN, MARTA BOTELLA AND CLARA I. GONZÁLEZ: Retirement behaviour and retirement incentives in Spain.

---

1. Previously published Working Papers are listed in the Banco de España publications catalogue.

0914 FEDERICO CINGANO, MARCO LEONARDI, JULIÁN MESSINA AND GIOVANNI PICA: The effect of employment protection legislation and financial market imperfections on investment: Evidence from a firm-level panel of EU countries.

0915 JOSÉ MANUEL CAMPA AND IGNACIO HERNANDO: Cash, access to credit, and value creation in M&As.

0916 MARGARITA RUBIO: Housing market heterogeneity in a monetary union.

0917 MAXIMO CAMACHO, GABRIEL PEREZ-QUIROS AND HUGO RODRÍGUEZ MENDIZÁBAL: High-growth Recoveries, Inventories and the Great Moderation.

0918 KAI CHRISTOFFEL, JAMES COSTAIN, GREGORY DE WALQUE, KEITH KUESTER, TOBIAS LINZERT, STEPHEN MILLARD AND OLIVIER PIERRARD: Wage, inflation and employment dynamics with labour market matching.

0919 JESÚS VÁZQUEZ, RAMÓN MARÍA-DOLORES AND JUAN-MIGUEL LONDOÑO: On the informational role of term structure in the U.S. monetary policy rule.

0920 PALOMA LÓPEZ-GARCÍA AND SERGIO PUENTE: What makes a high-growth firm? A probit analysis using Spanish firm-level data.

0921 FABIO CANOVA, MATTEO CICCARELLI AND EVA ORTEGA: Do institutional changes affect business cycles? Evidence from Europe.

0922 GALO NUÑO: Technology, convergence and business cycles.

0923 FRANCISCO DE CASTRO AND JOSÉ LUIS FERNÁNDEZ: The relationship between public and private saving in Spain: does Ricardian equivalence hold?

0924 GONZALO FERNÁNDEZ-DE-CÓRDOBA, JAVIER J. PÉREZ AND JOSÉ L. TORRES: Public and private sector wages interactions in a general equilibrium model.

BANCO DE ESPAÑA
Eurosistema

Unidad de Publicaciones
Alcalá, 522; 28027 Madrid
Telephone +34 91 338 6363. Fax +34 91 338 6488
E-mail: publicaciones@bde.es
www.bde.es