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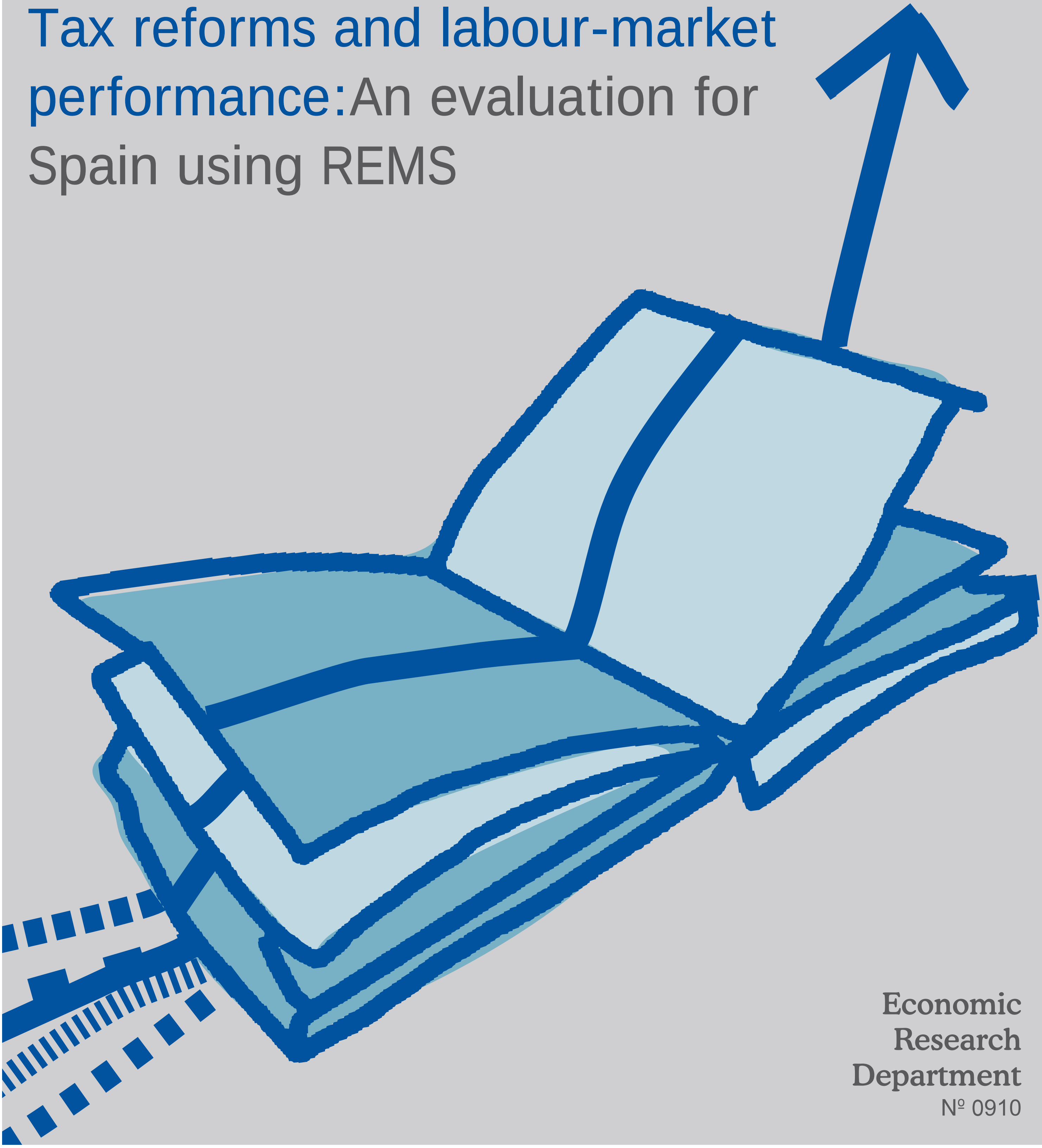

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Tax Reforms and Labour-market Performance: An Evaluation for Spain using REMS*

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Abstract

This paper uses REMS, a **R**ational **E**xpectations **M**odel of the **S**panish economy designed by Boscá et al (2007), to analyse the effects of lowering the overall tax wedge to the level prevailing in the US. Our results partially confirm previous findings in the literature: a reduction in the overall tax wedge of 19.5 points, in order to reach the US levels, has a positive effect in the long run, increasing total hours by about 7 per cent and GDP by about 8 percentage points. In terms of GDP per adult, these results account for 1/4 of the gap with respect to the US, but imply a reduction of only one percentage point in the labour productivity gap. The rise in total hours per adult is explained by a similar increase in both hours per employee and the employment rate of about 3.5 percentage points, allowing hours per adult to converge to levels only slightly lower than those in the US.

Keywords: general equilibrium, tax wedge, tax reforms, fiscal policy, labour market.
JEL Classification: E32, E62.

1. Introduction

Despite the integration of Spain in the European Union and its high growth levels from 1995 to 2007, the relative per capita income of the Spanish economy with respect to the US was 69 per cent in 2007, even slightly lower than the levels reached in the mid seventies. As many other European countries, it seems that Spain faces a 'glass ceiling' which constrains complete convergence with the United States. Although the lower level of GDP per hour

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worked accounts for 3/4 of the gap with the US, a lower use of labour at both the intensive (hours per employed) and extensive (employment) margins also explains a significant part of it. For these reasons, in order to understand the macroeconomic performance of the Spanish economy, relative to the United States, it is very important to take into account the differences in labour utilization between countries.

During the last years, fiscal policy and, in particular, taxes have attracted a lot of attention in explaining the differences in labour utilization and macroeconomic performance between European countries and the US. Although the argument that taxes were one of the culprits of the worse performance of labour markets in Europe than in the US has been at stake since the mid nineties (see, for example, European Commission, 2004, and Nickell, 2006, for a survey of the empirical literature), the evidence offered by Prescott (2004) that taxes explain the bulk of the difference between the US and Europe in the evolution of hours per adult has generated a renewed interest in the effects of the tax structure on the labour performance of advanced economies. A recent exemplary contribution on this literature has been made by Coenen, McAdam and Straub (2008). Using a New Area-Wide Model (NAWM) for the EMU, these authors find that lowering tax distortions in the EMU to the levels prevailing in the US would increase hours worked per adult and output by more than 10 per cent.

In this paper we follow a similar approach to Coenen, McAdam and Straub (2008) and use REMS, a Rational Expectations Model of the Spanish economy designed by Boscá et al (2007), to analyse the effects of lowering the overall tax wedge to the same level as in the US. REMS builds on recent advances in DGE models, sharing many features of NAWM, such as nominal and real rigidities or the presence of constrained households, but departs from NAWM in two important aspects. First, REMS models a small open economy (Spain) in a monetary union (EMU), whereas NAWM is a two-country model calibrated for the EMU and the US. Second, it includes a richer and deeper characterization of the labour market, distinguishing between the intensive and extensive margin in a search and matching model.

In the analysis of the effects of taxation on the labour market, as in many previous contributions, we decompose the overall tax wedge into consumption and labour income taxes, and social security contributions. As shown in the second section, although the overall tax wedge is between the levels prevailing in the EU and the US, there are also some significant differences in its composition, since social contributions in Spain are higher than in the EU whereas labour income taxes are even below the level of the US.

Our results partially confirm previous findings in the literature, as a reduction in the overall tax wedge of 19.5 points, in order to reach US levels, has a positive effect in the long run, increasing total hours by about 7 per cent and GDP by about 8 percentage points.

In terms of GDP per adult, these results account for 1/4 of the gap with respect to the US, but imply a reduction of only one percentage point in the labour productivity gap. The rise in total hours per adult is explained by a similar increase in both hours per employee and the employment rate of about 3.5 percentage points, allowing hours per adult to converge to levels only slightly lower than those in the US.

The rest of the paper is organized as follows. In the second section we document the differences between the US, the EU and Spain in terms of GDP per adult, employment and participation rates, hours and taxes, evaluating this evidence in terms of previous contributions to the literature. In the third section, we describe the main characteristics of REMS and the details of its calibration are presented in the fourth section. In the fifth section we present the main results of the paper, both in terms of the long-run effects and the transitional dynamics of the main variables. In section 6, we carry out a sensitivity analysis of the results. Finally, section 7 summarizes our conclusions.

2. Macroeconomic performance, taxes and the labour market.

A very convenient and useful way of analyzing the empirical evidence on macroeconomic and labour market performance and the tax wedge in the Spanish economy is to use the following identity as a starting point:

$$\frac{GDP}{L^{16-64}} \equiv \frac{GDP}{H}\frac{H}{L^d}\frac{L^d}{L^s}\frac{L^s}{L^{16-64}} \tag{1}$$

where the GDP over the working-age population (L^{16-64}) is decomposed as the product of labour productivity (GDP per hours, H), the average number of annual hours worked per employee (H/L^d), the employment rate (the ratio of the employed over total workers, L^d/L^s) and the participation rate (the ratio of total workers over the working-age population). As the employment rate is equal to one minus the unemployment rate (u), then we can then rewrite equation (1) as

$$\frac{GDP}{L^{16-64}} \equiv \frac{GDP}{H}\frac{H}{L^d}(1-u)\frac{L^s}{L^{16-64}} \tag{2}$$

In other words, per capita income (measured in terms of the working-age population) depends on the labour productivity, the unemployment and participation rates and the average number of hours per employee.

In Figure 1 we have represented the evolution of GDP over the working-age population in Spain and the UE15 in relative terms to the United States.[1] As we can see, relative

[1] Data for the EU15 refers to the 15 initial members of the European Union, excluding Luxembourg (due to the lack of data) and Spain (for a better comparison as it represents 10.6 per cent of the EU15 GDP in 2006).

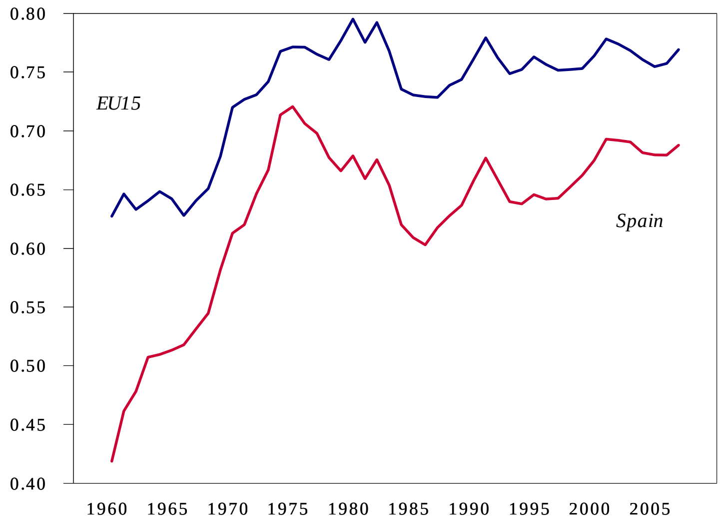

Figure 1: *GDP over working-age population, relative to the US. Source: OECD and National Accounts.*

per capita income peaked in 1975 (72.0 per cent), decreased significantly until the mid eighties (60 per cent) and then, with some cyclical fluctuations, started to increase until the end of the sample, when relative income was 69 per cent in 2007. In the EU15, after the increase in the sixties and seventies, relative per capita income has been fluctuating between 75 and 80 per cent, with no trend over the last two decades. Despite the international integration of many markets and the process of technology diffusion, it seems that European countries face a 'glass ceiling' that constrains complete convergence with the United States.

The decomposition provided by equation (1) is very illustrative of the factors behind this 'glass ceiling'. In Figure 2 we have represented the evolution of the four variables that determine per capita income. Spanish labour productivity reached 90 per cent of the US level in mid nineties, but has decreased over the last ten years as a result of the increase in productivity growth in the United States and the significant reduction in the unemployment rate in the Spanish economy, which implied the entry of a lot of workers in low productivity jobs. As a result, relative Spanish labour productivity in 2007 was 76 per cent (85 per cent in the EU15). Hours per employee were higher in the EU15 and in Spain than in the US until the mid eighties. In the case of the EU15, the downward trend has been highly persistent from since (reaching 92 per cent in 2007), whereas in the case of Spain, relative hours per employee remained rather constant from 1985 to 2000 and experienced a slight decline over the last few years, reaching 96,4 per cent in 2007. The employment rate $(1 - u_t)$ was higher in Spain and the EU15 than in the US until the beginning of the eighties. However, with the increase in structural unemployment in European countries, particularly in Spain, the relative employment rate fell below 100 per cent. In the Spanish economy, the relative employment rate dropped to 84 per cent in 1994 to later recover to 96 per cent in 2007. Dew-Becker and Gordon (2008) have documented the trade-off between labour productivity and the employment rate both in raw data and in regressions that control for the two-way causality between productivity and employment growth, showing that there is a robust negative correlation between productivity and employment growth in European countries from 1980 onwards. This evidence is the opposite in the case of the US. Ball and Mankiw (2002) found that the correlation between productivity growth and the structural unemployment rate has been positive in the United States. The last panel in Figure 2 shows that the correlation between the participation rate and the employment rate has been positive both in Spain and the EU15.

One key result of Figure 2 is that in order to understand the macroeconomic performance of Spain and the EU15, relative to the United States, it is very important to take into account the changes in both the intensive (hours per employed) and extensive (employment) margins of the labour market. In fact, Alesina and Giavazzi (2006) use these pieces of empirical evidence, together with other facts, to document their expectations about the economic and political eclipse of Europe. According to these authors, Europe has much to learn from the market liberalism in America to handle its worker productivity, labour market regulations, the support for higher education, its technology research efforts and its fiscal policy.

Over the last few years, fiscal policy and, in particular, taxes have attracted a lot of attention in explaining the differences in labour utilization on both sides of the Atlantic. The argument that taxes is one of the main culprits of the lower labour utilization in Europe than in the US is based on the observation that the tax wedge (the difference between the effective consumption wage received by workers and the total effective cost paid by firms) is lower in the latter than in the former. In Figure 3 we have represented the evolution of consumption taxes (τ^c), labour income taxes paid by workers (τ^l), social security contributions paid by employers (τ^{ss}) and the total tax wedge (τ) approximated as:

$$\tau = 1 - \frac{(1 - \tau^l)}{(1 + \tau^c)(1 + \tau^{ss})} \simeq \tau^l + \tau^c + \tau^{ss} \tag{3}$$

We have updated the information from Boscá, García and Taguas (2005), using their methodology and have computed EU15 averages using GDP in PPP as weights. As we can see, both in Spain and, particularly, in the EU15 taxes are higher than in the US, with the only exception of income taxes, which are lower in Spain. Additionally, these figures show that

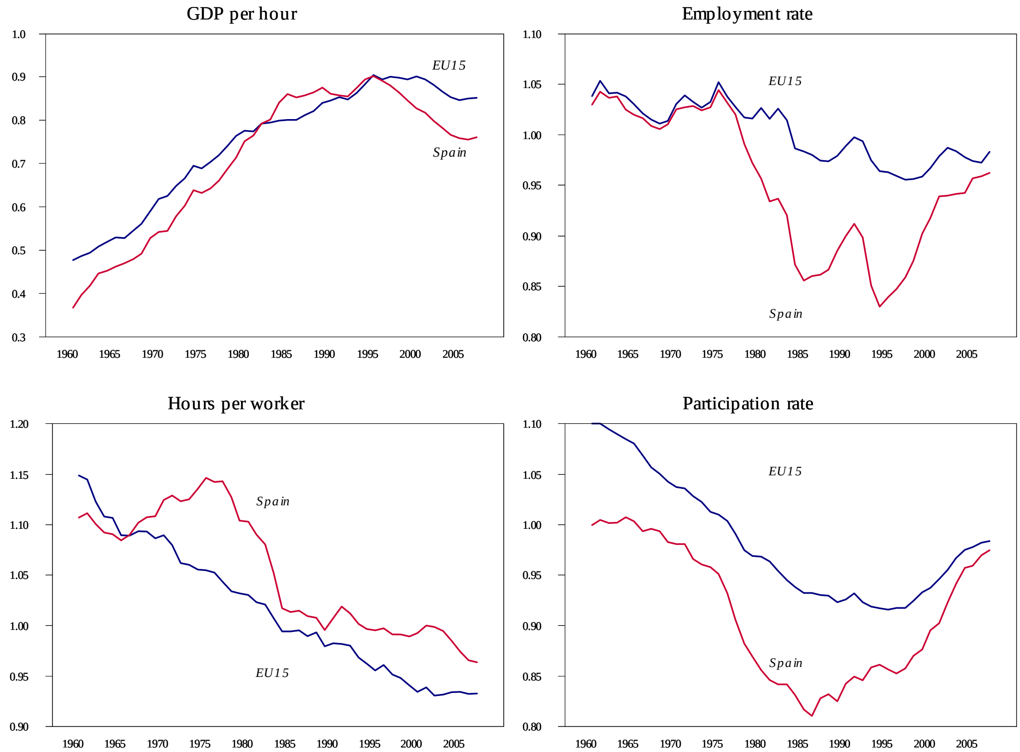

Figure 2: *Productivity, hours worked per employe, and employment and participation rates in relative terms to the Unites States. Source: OECD, National Accounts and GGDC (2008).*

European countries exhibit a trend in the overall tax rate, which is more pronounced in the case of Spain.

Several papers have investigated the effects of taxes on hours worked, but with no distinction between the intensive and extensive margin, that is, focusing in the ratio of total hours over the working-age population (see Causa, 2008, for a review of this literature). Prescott (2004) has argued that the differences in the tax wedge can explain the differences between the US and several European countries in the evolution of hours worked per adult. Rogerson (2006 and 2008) has shown that both technology and taxes can account for the evolution of hours per adult in the US and several continental European countries. Pissarides (2007) has pointed out that the effects of taxes on hours per adult are sensitive to the specification of the model, which may be appropriate for some countries (the US and Continental Europe) but not for others (Scandinavian countries), a result also stressed by

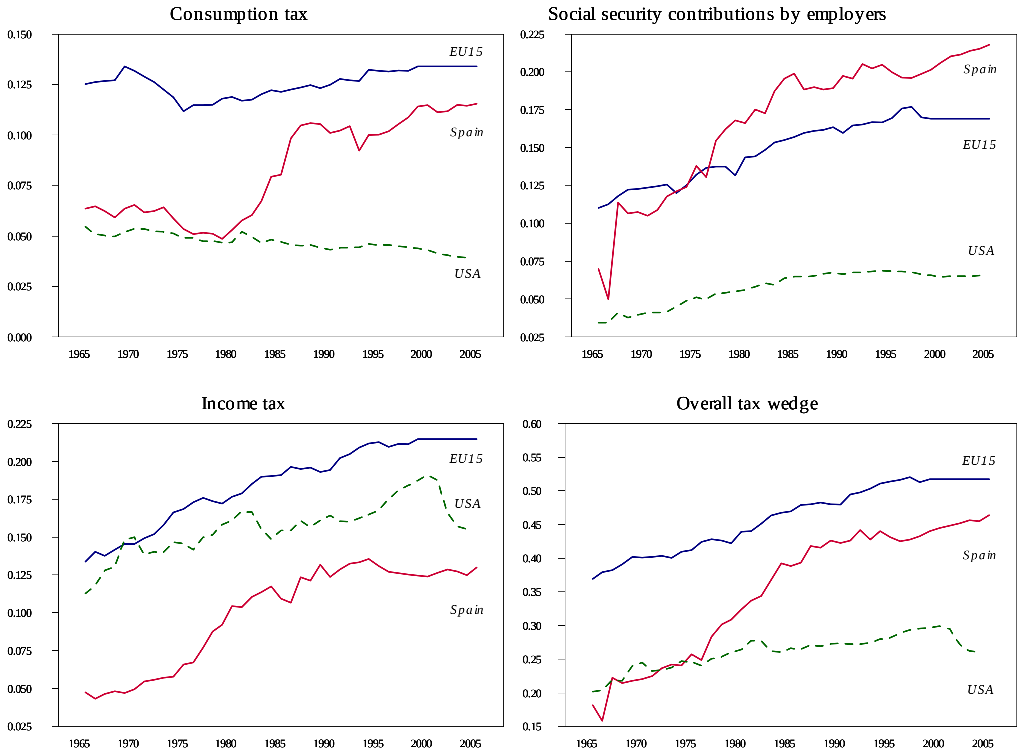

Figure 3: *Taxes on consumption and labour income, social security contributions and the overall tax wedge in Spain, EU15 and the USA, 1965-2005.*

Rogerson (2007). Ohanian, Raffo and Rogerson (2008) present economic evidence in which changes in labour taxes account for a large share of the trend differences in hours per adult in a sample of 21 OECD countries from 1956 to 2004, even accounting for other explanatory variables, such as the duration of unemployment benefits or measures of employment protection regulation. In the case of the Spanish economy, Conesa and Kehoe (2005) have found that taxes can account for the level of hours per adult in 1970 and 2000 but not, simultaneously, for the fall in the first part of the sample and the increase in the last years.[2]

Of the two margins, the effects of taxes on the employment rate has received much more attention than in the case of hours worked per employee. Although summarizing this empirical literature is beyond the scope of this paper (interested readers may turn to

[2] Fernández de Córdoba and Torregrosa (2005), and Doménech and Pérez (2006) have also analized the effects of changes in fiscal structure on labour and output in the Spanish economy.

Nickell, 2006, and Causa, 2008) and the empirical research offers a wide range of results, as alleged by Doménech and Garcia (2008), whereas the cross-section evidence (e.g.: Jackman, Layard and Nickell, 1996, Nickell, 1997 and Nickell and Layard, 1999) shows a null or low correlation between labour taxes and unemployment rates, the time series or panel data correlation (e.g.: Bean, Layard and Nickell, 1986, Elmeskov, Martin and Scarpetta, 1998, Blanchard and Wolfers, 2000, Nickell, Nunziata and Ochel, 2005, Planas, Roeger and Rossi, 2007) is usually positive and, in many cases, statistically significant.[3]

The effects of taxes on average hours worked by the employed (the intensive receive) has been analyzed by a shorter list of authors. Using a sectorial database of rich countries in the mid 1990s, Davis and Henrekson (2004) found that higher taxes lower the number of hours worked. Similar results were found by Faggio and Nickell (2007), in a sample of OECD countries, from 1981 to 1999, although their results are sensitive to the inclusion of variables that control for the distribution of earnings. More recently, Causa (2008) has found that high marginal tax rates on second household earners are a significant disincentive on the intensive margin of labour supply, whereas the labour supply of men is insensitive to taxation.

The empirical evidence on the relative performance of labour markets supports the relevance of analyzing the effects of taxes on both margins. As shown in Figure 2 and also pointed out by Fang and Rogerson (2008), there are important differences between countries in the contribution of the intensive and extensive margins in explaining the number of hours worked per adult. In Figure 4 we have represented the evolution of the three components of hours worked per adult in relative terms to the United States, using the following decomposition in logs:

$$\begin{aligned}\ln \frac{H_{it}}{L_{it}^{15-64}} - \ln \frac{H_{USt}}{L_{USt}^{15-64}} &= \left(\ln \frac{H_{it}}{L_{it}^{d}} - \ln \frac{H_{USt}}{L_{USt}^{d}} \right) + \left(\ln \frac{L_{it}^{d}}{L_{it}^{s}} - \ln \frac{L_{USt}^{d}}{L_{USt}^{s}} \right) \\ &\quad + \left(\ln \frac{L_{it}^{s}}{L_{it}^{15-64}} - \ln \frac{L_{USt}^{s}}{L_{USt}^{15-64}} \right) \qquad (4)\end{aligned}$$

As we can see, most of the volatility of hours per adult comes from the changes in the employment and participation rates, particularly in the eighties and nineties. As shown in Figure 4, hours per adult in the sixties were approximately 15 per cent higher in Spain than in the US and 10 per cent lower in 2007, the greatest difference being -35 per cent in 1986. This figure also shows that the fall in the relative number of hours per adult between

3 As surveyed by González-Páramo and Melguizo (2008), an alternative research area in the empirical literature has analysed the effects of taxes on wages instead that on unemployment. According to their results, in the long run workers bear between three quarters of the tax burden in Continental and Anglo-Saxon economies, and the whole tax burden in the Nordic ones.

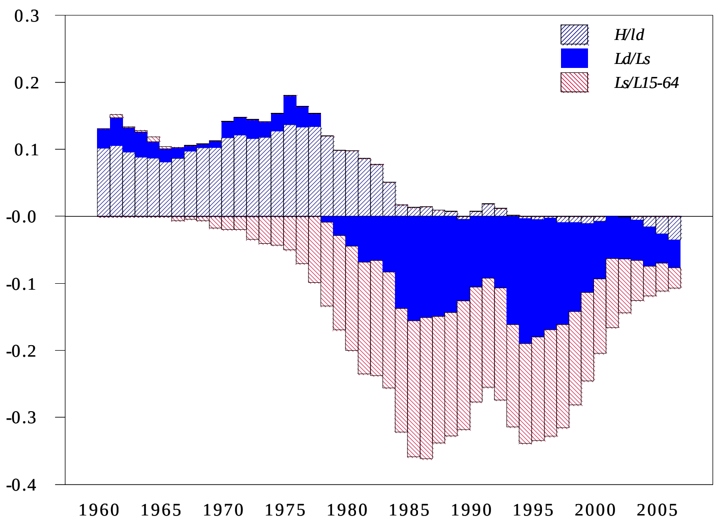

Figure 4: *Intensive (hours per employed) and extensive margins (employed per adult population) in Spain, relative to the USA.*

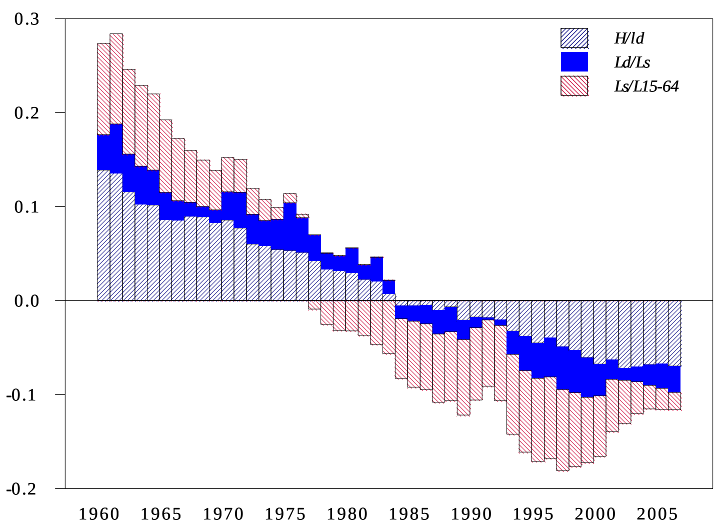

Figure 5: *Intensive (hours per employed) and extensive margins (employed per adult population) in EU15, relative to the USA.*

1975 and 1985 was only partially explained by hours per employee (25 per cent of the total fall), and its contribution was even negative in explaining the recovery from 1995 to 2007. However, the relevance of the intensive margin in explaining the relative performance of the EU15 with respect to the US has been much greater and similar to the relevance of the participation rate, as can be seen in Figure 5, whereas the contribution of the employment rate has been smaller.

3. A Model of the Spanish Economy (REMS)

REMS is a decentralized, small open economy model, where households, firms, policy-makers and the external sector actively interact each period by trading one final good, two financial assets and three production factors[4]. In order to produce gross output, firms employ physical capital (public and private), labour and an intermediate input (energy). While private physical capital and energy are exchanged in a context of perfect competition, the labour market is not Walrasian. Households possess the available production factors. They also own all the firms operating in the economy. In such a scenario, each representative household rents physical capital and labour services out to firms, for which they are paid income in the form of interest and wages. New jobs are created after investing in search activities. The fact that exchange in the labour market is resource and time-consuming generates a monopoly rent associated with each job match. It is assumed that the worker and the firm bargain over these monopoly rents in Nash fashion.

Each period the government faces a budget constraint where expenditure items are financed by means of public debt and various distortionary taxes. Intertemporal sustainability of fiscal balance is ensured by a conventional policy reaction function, whereby a lump-sum tax transfer responds to the deviation of the debt to GDP ratio from its long-term target level.

Monetary policy is geared by the European Central Bank (ECB) by means of interest rates movements, which target EMU inflation in which the weight of the Spanish economy is approximately 10 per cent.

Each household is made up of working-age agents who may be active or inactive. In turn, active workers participating in the labour market may either be employed or unemployed. If unemployed, agents are actively searching for a job. Firms' investment in vacant posts is endogenously determined and so are job inflows. Finally, job destruction is taken as exogenous.

[4] In this section we will present a brief description of the main characteristics of the model. For a complete account of the model, see Boscá et. al (2007).

3.1 Households

Following Galí et al. (2007), liquidity-constrained consumers are incorporated into the standard Keynesian model. There are two types of representative households. One representative household enjoys unlimited access to capital markets, so its members substitute consumption intertemporally in response to changes in interest rates. We will refer to these households as "Ricardian or optimizing consumers". Another representative household does not have access to capital markets, so its members can only consume out of current labour income. We will refer to these liquidity-constrained consumers as "rule-of-thumb (RoT) consumers".

Both types of households maximize intertemporal utility by selecting streams of consumption and leisure. Household members may be either employed or unemployed, but are able to fully insure each other against fluctuations in employment, as in Andolfatto (1996) or Merz (1995). For the sake of simplicity, we assume that only optimizing consumers hold money balances, as well as foreign and domestic bonds. However, taxes are levied on both Ricardian and the liquidity-constrained consumers.

Optimizing households

Ricardian households face the following maximization programme:

$$\max_{\substack{c_t, n_t, j_t, k_t, \\ b_t^o, b_t^{o,emu}, m_t^o}} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln\left(c_t^o - hc_{t-1}^o\right) + n_{t-1}^o \phi_1 \frac{(T - l_{1t})^{1-\eta}}{1-\eta} + (1 - n_{t-1}^o)\phi_2 \frac{(T - l_{2t})^{1-\eta}}{1-\eta} + \chi_m \ln\left(m_t^o\right) \right] \quad (5)$$

subject to

$$\left(r_t(1-\tau_t^k) + \tau_t^k \delta\right) k_{t-1}^o + w_t \left(1 - \tau_t^l\right) \left(n_{t-1}^o l_{1t} + rr_t s \left(1 - n_{t-1}^o\right) l_{2t}\right) + \left(\left(1 - \tau_t^l\right) g_{st} - trh_t\right) + \frac{m_{t-1}^o}{1+\pi_t^c} + \left(1 + r_{t-1}^n\right) \frac{b_{t-1}^o}{1+\pi_t^c} + (1 + r_{t-1}^{emu}) \frac{b_{t-1}^{o,emu}}{1+\pi_t^c} - (1+\tau_t^c) c_t^o \frac{P_t^c}{P_t} - \frac{P_t^i}{P_t} j_t^o \left(1 + \frac{\phi}{2}\left(\frac{j_t^o}{k_{t-1}^o}\right)\right) - \gamma_A \gamma_N \left(m_t^o + b_t^o + \frac{b_t^{o,emu}}{\phi_{bt}}\right) = 0 \quad (6)$$

$$\gamma_A \gamma_N k_t^o = j_t^o + (1-\delta) k_{t-1}^o \quad (7)$$

$$\gamma_N n_t^o = (1-\sigma) n_{t-1}^o + \rho_t^w s (1 - n_{t-1}^o) \quad (8)$$

All variables in the maximisation problem above are stationary[5]. In our notation, variables

[5] Thus, variables are expressed in efficiency units per persons of a working age.

indexed by r and o respectively denote RoT and optimizing households. Non-indexed variables apply indistinctly to both types of households. Thus, c_t^o,n_{t-1}^o and $s(1-n_{t-1}^o)$ represent, consumption, the employment rate and the unemployment rate of Ricardian households. s is the share of the non-employed searching for a job, which is assumed to be exogenous.[6] T, l_{1t} and l_{2t} are the time endowment, hours worked per employee, and hours devoted to job searching by the unemployed. Note that, while the household decides over l_{1t}, the same cannot be said of l_{2t}: time devoted to job searching is assumed to be a function of overall economic activity, so that individual households take it as given[7].

Several parameters are presented in the utility function of Ricardian households. Future utility is discounted at a rate of $\beta \in (0,1)$. The parameter $-\frac{1}{\eta}$ measures the negative of the Frisch elasticity of labour supply. As consumption is subject to habits, the parameter h takes a positive value. In general $\phi_1 \neq \phi_2$, i.e., the subjective value of leisure imputed by workers may vary across employment statuses. For simplicity, we adopt the money-in-the-utility function approach to incorporate money into the model.

Maximization of (5) is constrained as follows. First, the budget constraint (6) describes the various sources and uses of income. The term $w_t\left(1-\tau^l\right)n_{t-1}^o l_{1t}$ captures net labour income earned by the fraction of employed workers, where w_t stands for hourly real wages. The product $rr_t w_t\left(1-\tau^l\right)s\left(1-n_{t-1}^o\right)l_{2t}$ measures unemployment benefits accruing to the unemployed, where rr_t denotes the (exogenous) replacement rate of the unemployment subsidy to the market wage. There are four assets in the economy, namely private physical capital (k_t^o), domestic and Euro-zone bonds (b_t^o and b_t^{ow}) and money balances (m_t^o). All assets are owned by Ricardian households. Barring money, the remaining assets yield some remuneration. Net return on capital is captured by $r_t k_{t-1}^o(1-\tau^k) + \tau^k\delta k_{t-1}^o$, where r_t represents the gross return on physical capital. Note that depreciation is tax-deductible as reflected in $\tau^k\delta k_{t-1}^o$. Interest payments on domestic and foreign debt are respectively captured by $r_{t-1}^n\frac{b_{t-1}^o}{1+\pi_t^c}$, and $r_{t-1}^{emu}\frac{b_{t-1}^{ow}}{1+\pi_t^c}$, where r^n and r^{emu} represent the nominal interest rates on domestic and EMU bonds, which may differ because of a risk premium. The other two expenditure categories are lump-sum transfers, trh_t, and other government transfers, g_{st}.

Total revenues can either be invested in private capital or spent on consumption. The household's consumption and investment are respectively given by $(1+\tau^c)\frac{P_t^c}{P_t}c_t^o$ and $\frac{P_t^i}{P_t}j_t^o\left(1+\frac{\phi}{2}\left(\frac{j_t}{k_{t-1}}\right)\right)$, where τ^c is the consumption income tax. Note that total investment outlays are affected by the increasing marginal costs of installation $j_t^o\left(1+\frac{\phi}{2}\left(\frac{j_t}{k_{t-1}}\right)\right)$. Also,

[6] For simplicity, we assume that the leisure utility of the unemployed searching for a job is the same as for the non-active.

[7] We assume for empirical reasons that the search effort undertaken by unemployed workers varies along the cycle depending positively on the GDP growth rate.

the presence in the model of the relative prices P_t^c/P_t and P_t^i/P_t implies that a distinction is made between the three deflators of consumption, investment and aggregate output.

The remaining constraints faced by Ricardian households concern the laws of motion for capital and employment. Each period the private capital stock k_t^o depreciates at the exogenous rate δ and is accumulated through investment, j_t^o. Thus, it evolves according to (7). Employment obeys the law of motion (8), where n_{t-1}^o and $s(1-n_{t-1}^o)$ respectively denote the fraction of employed and unemployed optimizing workers in the economy at the end of period $t-1$. Each period jobs are lost at the exogenous rate σ. Likewise new employment opportunities come at the rate ρ_t^w, which represents the probability that one unemployed worker will find a job. Although the job-finding rate ρ_t^w is taken as exogenous by individual workers, at aggregate level it is endogenously determined according to the following Cobb-Douglas matching function:

$$\rho_t^w(1-n_{t-1}) = \vartheta_t\left(v_t, n_{t-1}\right) = \chi_1 v_t^{\chi_2}\left[s\left(1-n_{t-1}\right) l_{2t}\right]^{1-\chi_2}. \tag{9}$$

The solution to the optimization programme above generates first order conditions for consumption, employment, investment, capital stock, government debt, foreign debt and money holdings.

According to the first order condition for consumption (10) the current-value shadow price of income is equal to the difference between the marginal utility of consumption in two consecutive periods t and $t+1$.

$$\lambda_{1t}^o = \frac{1}{(P_t^c/P_t)(1+\tau_t^c)}\left(\frac{1}{c_t^o - hc_{t-1}^o} - \beta\frac{h}{c_{t+1}^o - hc_t^o}\right) \tag{10}$$

The marginal utility of consumption evolves according to the following expression (11), which is obtained by deriving the Lagrangian with respect to domestic government bonds b_t^o.

$$\gamma_A \gamma_N E_t \frac{\lambda_{1t}^o}{\lambda_{1t+1}^o} = \beta E_t \frac{1+r_t^n}{1+\pi_{t+1}^c} \tag{11}$$

In the same way, the first order condition for employment (12) ensures that the intertemporal reallocation of labour supply cannot improve the household's life-cycle utility. This optimizing rule distinguishes search models from the competitive framework, as it replaces the conventional labour supply. It tells us that as search is a costly process, there is a premium on being employed, λ_{3t}^o, which measures the marginal contribution of a newly created job to household utility.

$$\gamma_N \lambda_{3t}^o = \beta E_t \left\{ \begin{array}{c} \phi_1 \frac{(T-l_{1t+1})^{1-\eta}}{1-\eta} - \phi_2 \frac{(T-l_{2t})^{1-\eta}}{1-\eta} + \lambda_{1t+1}^o w_{t+1} \left(1-\tau_{l+1}^l\right)(l_{1t+1} - rr_{t+1} s l_{2t}) \\ +\lambda_{3t+1}^o \left[(1-\sigma) - \chi_1 \rho_{t+1}^w\right] \end{array} \right\} \tag{12}$$

Making some algebra we can obtain from the first order condition the optimal allocation of capital over time:

$$q_t = \frac{1+\pi_{t+1}^c}{1+r_t^n} \left[r_{t+1}(1-\tau_{t+1}^k) + \tau_{t+1}^k \delta + \frac{\phi}{2} \frac{j_{t+1}^2}{k_t^2} + q_{t+1}(1-\delta) \right] \tag{13}$$

where q_t is Tobin's q, that is obtained from the first order condition for investment:

$$q_t = \frac{P_t^i}{P_t} \left[1 + \phi \left(\frac{j_t^o}{k_{t-1}^o} \right) \right] \tag{14}$$

Deriving the Lagrangian with respect to foreign debt $b_t^{o,emu}$ and combining with with (11) yields

$$1 + r_t^n = \phi_{bt}(1 + r_t^{nw}) \tag{15}$$

implying that the interest parity condition holds between domestic and EMU bonds to the extent that they are perfect substitutes. Note that (15) slightly differs from the standard uncovered interest parity condition in that there is no risk associated with exchange rate movements, as both domestic and foreign bonds are expressed in the same currency. Note that the specification above assumes that Ricardian households incur in a risk premium when buying foreign bonds (ϕ_{bt}). Specifically, the risk premium is made up of a function of net foreign asset holdings in the following way

$$\ln \phi_{bt} = -\phi_b \left(\exp\left(b_t^{o,emu}\right) - 1 \right) \tag{16}$$

Finally, it is easy to show that the first order condition for money can be rewritten as a money demand function by using the current-value shadow price of income (10)

$$m_t^o = \frac{1}{\gamma_A \gamma_N} \chi_m \left(1 + \tau_t^c\right) \frac{P_t^c}{P_t} \frac{1 + r_t^n}{r_t^n} \frac{1}{\left(\frac{1}{c_t^o - h c_{t-1}^o} - \beta \frac{h}{c_{t+1}^o - h c_t^o} \right)} \tag{17}$$

Rule-of-thumb households

RoT households do not benefit from access to capital markets and also do not hold money, so they face the following maximization programme[8]:

$$\max_{c_t^r, n_t^r} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln\left(c_t^r - hc_{t-1}^r\right) + n_{t-1}^r \phi_1 \frac{(T - l_{1t})^{1-\eta}}{1-\eta} + (1 - n_{t-1}^r)\phi_2 \frac{(T - l_{2t})^{1-\eta}}{1-\eta} \right]$$

subject to the law of motion of employment (8) and the specific liquidity constraint whereby each period's consumption expenditure must be equal to current labour income and government transfers, as reflected in:

$$w_t \left(1 - \tau_t^l\right) \left(n_{t-1}^r l_{1t} + rr_t s \left(1 - n_{t-1}^r\right) l_{2t}\right) + g_{st} \left(1 - \tau_t^l\right) - trh_t - (1 + \tau_t^c) c_t^r \frac{P_t^c}{P_t} = 0 \quad (18)$$

$$\gamma_N n_t^r = (1 - \sigma) n_{t-1}^r + \rho_t^w s (1 - n_{t-1}^r) \quad (19)$$

Note that RoT consumers do not save and, as a result, they do not hold any assets. This feature of RoT consumers considerably simplifies the solution to the optimization programme, which is characterized by the following equations concerning optimal consumption, c_t^r, and optimal employment, n_t^r:

$$\lambda_{1t}^r = \frac{1}{(P_t^c / P_t) c_t^r (1 + \tau_t^c)} \left(\frac{1}{c_t^r - hc_{t-1}^r} - \beta \frac{h}{c_{t+1}^r - hc_t^r} \right) \quad (20)$$

$$\gamma_N \lambda_{3t}^r = \beta E_t \left\{ \begin{array}{c} \phi_1 \frac{(T - l_{1t+1})^{1-\eta}}{1-\eta} - \phi_2 \frac{(T - l_{2t})^{1-\eta}}{1-\eta} + \lambda_{1t+1}^r w_{t+1} \left(1 - \tau_{l+1}^l\right) \left(l_{1t+1} - rr_{t+1} s l_{2t}\right) \\ + \lambda_{3t+1}^r \left[(1 - \sigma) - \chi_1 \rho_{t+1}^w\right] \end{array} \right\} \quad (21)$$

Aggregation

Aggregate consumption and employment can be defined as a weighted average of the corresponding variables for each household type[9]:

$$c_t = (1 - \lambda^r) c_t^o + \lambda^r c_t^r \quad (22)$$

$$n_t = (1 - \lambda^r) n_t^o + \lambda^r n_t^r \quad (23)$$

[8] Alternatively, Coenen, McAdam and Straub (2008) allow these households to smooth consumption by changing money holdings.

[9] $1 - \lambda^r$ and λ^r denote the constant fractions in the working-age population of Ricardian and RoT consumers.

For the variables that exclusively concern Ricardian households, aggregation is merely performed as:

$$k_t = (1 - \lambda^r)\, k_t^o \tag{24}$$

$$j_t = (1 - \lambda^r)\, j_t^o \tag{25}$$

$$b_t = (1 - \lambda^r)\, b_t^o \tag{26}$$

$$b_t^{emu} = (1 - \lambda^r)\, b_t^{oemu} \tag{27}$$

$$m_t = (1 - \lambda^r)\, m_t^o \tag{28}$$

3.2 Factor demands

Production in the economy takes place at two different levels. At the lower level, an infinite number of monopolistically competing firms produce differentiated intermediate goods (y_i), which imperfectly substitute each other in the production of the final good. These differentiated goods are then aggregated by competitive retailers into a final domestic good (y) using a CES aggregator.

Intermediate producers solve a two-stage problem. In the first stage, each firm faces a cost minimization problem which results in optimal demands for production factors. When choosing optimal streams of capital, energy, employment and vacancies intermediate producers set prices by varying the mark-up according to demand conditions. Variety producer $i \in (0,1)$ uses three inputs: a composite input of private capital and energy, labour and public capital, so that technological possibilities are given by:

$$y_{it} = z_{it} \left\{ \left[a k_{it-1}^{-\rho} + (1-a) e_{it}^{-\rho} \right]^{-\frac{1}{\rho}} \right\}^{1-\alpha} (n_{it-1} l_{i1t})^{\alpha} \left(k_{it-1}^{p} \right)^{\zeta} \tag{29}$$

where all variables are scaled by the trend component of total factor productivity and z_t represents a transitory technology shock. Each variety producer rents physical capital, k_{t-1}, and labour services, $n_{t-1} l_{1t}$, from households, and uses public capital services, k_{t-1}^p, provided by the government. Intermediate energy inputs e_t can be either imported from abroad or produced at home. The technical elasticity of substitution between private capital and energy is given by $\frac{1}{1+\rho}$. $\alpha \in (0,1)$ is a distribution parameter: it determines relative factor shares in the steady state. Furthermore, it is convenient to denote capital services by k_{iet} as:

$$k_{iet} = \left[ak_{it-1}^{-\rho} + (1-a)e_{it}^{-\rho}\right]^{-\frac{1}{\rho}} \tag{30}$$

Factor demands are obtained by solving the cost minimization problem faced by each variety producer (we drop the industry index i when no confusion arises)

$$\min_{k_t,n_t,v_t,e_t} E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{1t+1}^o}{\lambda_{1t}^o} \left(r_t k_{t-1} + w_t \left(1+\tau^{sc}\right) n_{t-1} l_{1t} + \kappa_v v_t + \frac{P_t^e}{P_t} e_t \left(1+\tau^e\right) \right) \tag{31}$$

subject to

$$y_t = z_{it} \left(\left[ak_{t-1}^{-\rho} + (1-a)e_t^{-\rho}\right]^{-\frac{1}{\rho}} \right)^{1-\alpha} \left(n_{t-1}l_{1t}\right)^{\alpha} \left(k_{t-1}^{p}\right)^{\zeta} - \kappa_f \tag{32}$$

$$\gamma_N n_t = (1-\sigma)n_{t-1} + \rho_t^f v_t \tag{33}$$

where, in accordance with the ownership structure of the economy, future profits are discounted at the household relevant rate β. κ_v captures recruiting costs per vacancy, κ_f is an entry cost which ensures that extraordinary profits vanish in imperfectly-competitive equilibrium, τ^{sc} is the social security tax rate levied on gross wages[10], and ρ_t^f is the probability that a vacancy will be filled in any given period t. It is worth noting that the probability of filling a vacant post ρ_t^f is exogenous from the firm's perspective. However, from the perspective of the overall economy, this probability is endogenously determined according to the following Cobb-Douglas matching function:

$$\rho_t^w(1-n_{t-1}) = \rho_t^f v_t = \chi_1 v_t^{\chi_2} \left[s\left(1-n_{t-1}\right)l_{2t}\right]^{1-\chi_2} \tag{34}$$

Under the assumption of symmetry, the solution to the optimization programme above generates the following first order conditions for private capital, employment, energy and the number of vacancies

$$r_{t+1} = (1-\alpha)mc_{t+1}\frac{y_{t+1}}{k_{et+1}}a\left(\frac{k_{et+1}}{k_t}\right)^{1+\rho} \tag{35}$$

10 Note that, in our specification, firms bear the statutory incidence of social security contributions.

$$\gamma_N \lambda_t^{nd} = \beta E_t \frac{\lambda_{1t+1}^o}{\lambda_{1t}^o} \left(\alpha mc_{t+1} \frac{y_{t+1}}{n_t} - w_{t+1}(1+\tau_{t+1}^{sc}) l_{1t+1} + \lambda_{t+1}^{nd}(1-\sigma) \right) \tag{36}$$

$$(1-\alpha)(1-a) mc_t \frac{y_t}{ke_{t-1}} \left(\frac{ke_t}{e_t} \right)^{1+\rho} = \frac{P_t^e}{P_t}(1+\tau_t^e) \tag{37}$$

$$\kappa_v v_t = \lambda_t^{nd} \chi_1 \chi_2 v_t^{\chi_2} (s(1-n_{t-1}) l_{2t})^{1-\chi_2} \tag{38}$$

where the real marginal cost (mc_t) corresponds to the Lagrange multiplier associated with the first restriction (32), whereas λ_t^{nd} denotes the Lagrange multiplier associated with the second restriction (33).

3.3 Pricing behavior of intermediate firms: the New Phillips curve

Intermediate firms enjoy market power and are, therefore, price setters. Each intermediate firm produces a variety y_i and faces a downward-sloping demand curve that takes the form below:

$$y_{it} = y_t \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} \tag{39}$$

where $\left(\frac{P_{it}}{P_t}\right)$ is the relative price of variety y_i, ε can be expressed in terms of the elasticity of substitution between intermediate goods, $\varsigma \geq 0$, as $\varepsilon = (1+\varsigma)/\varsigma$, and y_t represents the production of the final product as defined by

$$y_t = \left(\int_0^1 y_{it}^{1/1+\varsigma}\, di \right)^{1+\varsigma} \text{ and } P_t = \left(\int_0^1 P_{it}^{-\frac{1}{\varsigma}}\, di \right)^{-\varsigma} \tag{40}$$

Variety producers act as monopolists and choose prices when allowed. We use the well-known Calvo hypothesis (Calvo, 1983), thereby assuming some overlapping adjustment in prices. Those firms that do not reset their prices optimally at a given date adjust them according to a simple indexation rule to catch up with lagged inflation. Thus, each period a proportion θ of firms simply set $P_{it} = (1+\pi_{t-1})^{\varkappa} P_{it-1}$ (with $\varkappa$ representing the degree of indexation), while only a measure $1-\theta$ of firms set their prices, $\widetilde{P}_{it}$, to maximize the present value of expected profits. Consequently, $1-\theta$ represents the probability of adjusting prices each period, whereas θ can be interpreted as a measure of price rigidity. Thus, the maximization problem of the representative variety producer generates a first order condition given by:

$$\widetilde{P}_{it} = \frac{\varepsilon}{\varepsilon - 1} \frac{\sum_{j=0}^{\infty} (\beta\theta)^j E_t \left[\rho_{it,t+j} P_{t+j}^{\varepsilon+1} mc_{it+j} y_{t+j} \overline{\pi}_{t+j}^{-\varepsilon} \right]}{\sum_{j=0}^{\infty} (\beta\theta)^j E_t \left[\rho_{it,t+j} P_{t+j}^{\varepsilon} y_{t+j} \overline{\pi}_{t+j}^{(1-\varepsilon)} \right]} \tag{41}$$

where $\rho_{t,t+j}$ is a price kernel which captures the marginal utility of an additional unit of profits accruing to optimizing households at $t + j$. The corresponding aggregate price index is equal to

$$P_t = \left[\theta \left(\pi_{t-1}^{\varkappa} P_{t-1} \right)^{1-\varepsilon} + (1-\theta) \widetilde{P}_t^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{42}$$

As is standard in the literature[11], equation (42) can be used to obtain an expression for aggregate inflation in the form below:

$$\pi_t = \frac{\beta}{1 + \varkappa\beta} E_t \pi_{t+1} + \frac{(1-\beta\theta)(1-\theta)}{\theta(1+\varkappa\beta)} \widehat{mc}_t + \frac{\varkappa}{1+\varkappa\beta} \pi_{t-1} \tag{43}$$

where $\widehat{mc}_t$ measures the deviation of the firm's marginal cost from the steady state, i.e., $mc_t = \frac{\varepsilon-1}{\varepsilon}(1 + \widehat{mc}_t)$. Equation (43) is known in the literature as the New Phillips curve. It participates of the conventional Phillips-curve philosophy that inflation is influenced by activity in the short run, emphasizing real marginal costs as the relevant variable to the inflation process, which is seen as a forward-looking phenomenon. The reduced form of the New Phillips curve can be simplified as:

$$\pi_t = \beta^f E_t \pi_{t+1} + \lambda \widehat{mc}_t + \beta^b \pi_{t-1} \tag{44}$$

3.4 Trade in the labour market: the labour contract

The key departure of search models from the competitive paradigm is that trading in the labour market is subject to transaction costs. Each period, the unemployed engage in search activities in order to find vacant posts spread over the economy. Costly search in the labour market implies that there are simultaneous inflows into and outflows out of the state of employment, so that an increase (reduction) in the stock of unemployment results from the predominance of job destruction (creation) over job creation (destruction). Stable unemployment occurs whenever inflows and outflows cancel out one another, i.e.,

$$\rho_t^f v_t = \rho_t^w (1 - n_{t-1}) = \chi_1 v_t^{\chi_2} \left[(1 - n_{t-1}) \, l_{2t} \right]^{1-\chi_2} = (1-\sigma) n_{t-1} \tag{45}$$

[11] See, for example, Galí, Gertler and López-Salido (2001).

Because it takes time (for households) and real resources (for firms) to make profitable contacts, some pure economic rent emerges with each new job, which is equal to the sum of the expected transaction (search) costs the firm and the worker will further incur if they refuse to match. The emergence of such rent gives rise to a bilateral monopoly framework.

Once a representative job-seeking worker and vacancy-offering firm match they negotiate a labour contract in hours and wages. We therefore stick to the efficient-bargaining hypothesis instead of the right-to-manage hypothesis (see Trigari, 2006, for further details about the implications of these two different hypotheses).

Several wage and hours determination schemes can be applied to a bilateral monopoly framework. In particular, we will assume that firms and workers negotiate by means of a Nash bargain, so the outcome of the bargaining process maximizes the product

$$\max_{w_{t+1},\, l_{1t+1}} \left[\lambda^r \frac{\lambda^r_{3t}}{\lambda^r_{1t}} + (1-\lambda^r)\frac{\lambda^o_{3t}}{\lambda^o_{1t}}\right]^{\lambda^w} \left(\lambda^{nd}_t\right)^{(1-\lambda^w)} \tag{46}$$

where $\lambda^w \in (0,1)$ reflects the worker's bargaining power. The first term in brackets represents the representative worker surplus while the second is the firm surplus. More specifically, $\lambda^o_{3t}/\lambda^o_{1t}$ and $\lambda^r_{3t}/\lambda^r_{1t}$ respectively denote the earning premium (in terms of consumption) of employment over unemployment for a Ricardian and a *RoT* worker. Similarly, λ^{nd}_t represents the profit premium of a filled over an unfilled vacancy for the representative firm. Note that this bargaining scheme features the same wage for all workers, irrespective of whether they are Ricardian or *RoT*.

Optimal real wage and hours worked (46) satisfy the following conditions (see Boscá et. al, 2007 for further details):

$$\begin{aligned}(1+\tau^{sc}_t)w_t l_{1t} = {} & \frac{\lambda^w}{\left[1-(1-\lambda^w)\, rr_t s \frac{l_{2t}}{l_{1t}}\right]}\left[\alpha mc_t \frac{y_t}{n_{t-1}} + (1-\sigma)\frac{\kappa_v}{\rho^f_t}\right] \\ & + \frac{(1-\lambda^w)}{\left[1-(1-\lambda^w)\, rr_t s \frac{l_{2t}}{l_{1t}}\right]}\frac{(1+\tau^{sc}_t)}{(1-\tau^l_t)}\left[\frac{\widetilde{\left(\frac{\lambda_{3t}}{\lambda_{1t-1}}\right)}}{\widetilde{\left(\frac{\lambda_{1t}}{\lambda_{1t-1}}\right)}}\left[\rho^w_t-(1-\sigma)\right] - \frac{\widetilde{\left(\frac{1}{\lambda_{1t-1}}\right)}}{\widetilde{\left(\frac{\lambda_{1t}}{\lambda_{1t-1}}\right)}} u_t\right]\end{aligned} \tag{47}$$

$$\widetilde{\left(\frac{\lambda_{1t}}{\lambda_{1t-1}}\right)} \alpha mc_t \frac{y_t}{n_{t-1} l_{1,t}} = \widetilde{\left(\frac{1}{\lambda_{1t-1}}\right)} \frac{(1+\tau^{sc}_t)}{(1-\tau^l_t)} \phi_1 \left[1-l_{1t}\right]^{-\eta} \tag{48}$$

where:

$$u_t = \frac{P_t^c}{P_t} c_t \left(1+\tau_t^c\right) \left[\phi_1 \frac{(T - l_{1t+1})^{1-\eta}}{1-\eta} - \phi_2 \frac{(T - l_{2t})^{1-\eta}}{1-\eta}\right] \tag{49}$$

$$\left(\widetilde{\frac{\lambda_{1t}}{\lambda_{1t-1}}}\right) = \left[\lambda^r \frac{\lambda_{1t}^r}{\lambda_{1t-1}^r} + (1-\lambda^r) \frac{\lambda_{1t}^o}{\lambda_{1t-1}^o}\right]$$

$$\left(\widetilde{\frac{1}{\lambda_{1t-1}}}\right) = \left[\lambda^r \frac{1}{\lambda_{1t-1}^r} + (1-\lambda^r) \frac{1}{\lambda_{1t-1}^o}\right]$$

$$\left(\widetilde{\frac{\lambda_{3t}}{\lambda_{1t-1}}}\right) = \left[\lambda^r \frac{\lambda_{3t}^r}{\lambda_{1t-1}^r} + (1-\lambda^r) \frac{\lambda_{3t}^o}{\lambda_{1t-1}^o}\right]$$

Unlike the Walrasian outcome, the wage prevailing in the search equilibrium is at some point between the marginal rate of substitution of consumption for leisure and the marginal productivity of labour, depending on worker bargaining power λ^w. Put differently, the wage is a weighted average between the highest feasible wage (i.e., the marginal productivity of labour plus the cost of posting a vacancy corrected by the probability that the vacancy will be filled) and the lowest acceptable wage (i.e., the reservation wage as given by the disutility from work corrected by the probability of finding a job). Consequently, the equilibrium wage depends on a number of policy parameters and institutional variables describing labour market performance. Notice that when $\lambda^r = 0$, all consumers are Ricardian, and, therefore, the solutions for the wage rate and hours simplify to the standard ones.

3.5 Government

Each period the government decides the size and composition of public expenditure and the mix of taxes and new debt holdings required to finance total outlays. It is assumed that government purchases of goods and services (g_t^c) and public investment (g_t^i) follow an exogenously given pattern. Conversely, interest payments on government bonds $(1 + r_t)b_{t-1}$, unemployment benefits $g_{ut}(1 - n_{t-1})$, and government social transfers g_{st} are assumed to be endogenous. The two latter expenditure categories are given by

$$g_{ut} = rr_t w_t \tag{50}$$

$$g_{st} = tr_t gdp_t \tag{51}$$

whereby g_{ut} and g_{st} are made proportional to the level of real wages, w_t,and activity, gdp_t, through rr_t and tr_t.

Government expenditure is financed by direct taxation, levied on either labour income (personal labour income tax, τ_t^l, and social security contributions, τ_t^{sc}) or capital income (τ_t^k), as well as indirect taxation, represented by consumption (τ_t^c) and energy taxes (τ_t^e). Government revenues are therefore given by

$$\begin{aligned} t_t &= (\tau_t^l + \tau_t^{sc}) w_t (n_{t-1} l_{1t}) + \tau_t^k (r_t - \delta) k_{t-1} \\ &\quad + \tau_t^c \frac{P_t^c}{P_t} c_t + \tau_t^e \frac{P_t^e}{P_t} e_t + trh_t + \tau_t^l \overline{rr} w_t (1 - n_{t-1}) l_{2t} + \tau_t^l g_{st} \end{aligned} \tag{52}$$

where trh_t stands for lump-sum transfers as defined below.

Each period total receipts and outlays are made consistent by means of the government's budget constraint

$$\gamma_A \gamma_N b_t = g_t^c + g_t^i + g_{ut}(1 - n_{t-1}) + g_{st} - t_t + \frac{(1 + r_t^n)}{1 + \pi_t} b_{t-1} \tag{53}$$

Equation (53) reflects that the gap between total receipts and outlays is financed by variations in lump-sum transfers to households, trh_t (which enter the fiscal budget rule through the term t_t), and/or the issue of domestic bonds $(b_t - b_{t-1})$. As it stands, equation (53) has an intertemporal dynamic nature. Note that government income from seniorage is nil.

Dynamic sustainability of public debt requires the introduction of a debt rule that makes one or several fiscal categories an instrument for debt stabilization. In order to enforce the government's intertemporal budget constraint, the following fiscal policy reaction function is imposed

$$trh_t = trh_{t-1} + \psi_1 \left[\frac{b_t}{gdp_t} - \overline{\left(\frac{b}{gdp} \right)} \right] + \psi_2 \left[\frac{b_t}{gdp_t} - \frac{b_{t-1}}{gdp_{t-1}} \right] \tag{54}$$

where $\overline{\left(\frac{b}{gdp} \right)}$ is the long-run target for the debt-to-GDP ratio and $\psi_1 > 0$ captures the speed of adjustment from the current ratio towards the desired target. The value of $\psi_2 > 0$ will be chosen to ensure a smooth adjustment of actual debt towards its steady-state level. Note that while in the baseline specification debt stabilization is accomplished through variations in lump-sum transfers, nothing precludes other receipt or spending categories from playing this role.

Government investment augments public capital, which in turn depreciates at the rate δ^p and thus follows the law of motion:

$$\gamma_A \gamma_N k_t^p = g_t^i + (1 - \delta^p) k_{t-1}^p \tag{55}$$

3.6 Monetary policy

Monetary policy is geared by the European Central Bank (ECB), which targets EMU inflation by means of movements in interest rates. More specifically, short-term interest rates are governed by the following reaction function

$$\ln \frac{1+r_t^{emu}}{1+\overline{r^{emu}}} = \rho^r \ln \frac{1+r_{t-1}^{emu}}{1+\overline{r^{emu}}} + \rho^\pi (1-\rho^r) \ln(\pi_t^{emu} - \overline{\pi^{emu}}) + \rho^y (1-\rho^r) \ln \Delta \ln y_t^{emu} \quad (56)$$

where all the variables indexed by *emu* refer to EMU aggregates. Thus, r_t^{emu} and π_t^{emu} are the Euro-zone nominal short-term interest rate and consumption price deflator (to which the Spanish economy contributes according to its relative size), and $\Delta \ln y_t^{emu}$ measures the deviation of GDP growth from its trend. As explained in Woodford (2003), (56) is the optimal outcome of a rational central bank facing and objective function under general equilibrium conditions.

Finally, the disappearance of national currencies since the inception of the monetary union means that the intra-euro-area real exchange rate is simply given by the ratio of relative prices between the domestic economy and the remaining EMU members, so real appreciation/depreciation developments are driven by the inflation differential vis-à-vis the euro area:

$$\frac{rer_{t+1}}{rer_t} = \frac{1+\pi_{t+1}^{emu}}{1+\pi_{t+1}} \quad (57)$$

3.7 The External Sector

The small open economy hypothesis adopted in REMS implies that world prices and world demand are taken as given. It also means that feedback linkages between the domestic economy, EMU and the rest of the world are ignored. Another simplifying assumption concerns the nature of final and intermediate goods produced at home, which are all considered to be tradable.

The allocation of consumption and investment between domestic and foreign produced goods

Let us think of aggregate consumption (investment) as a composite basket of home and foreign produced goods. There is a representative consumption (investment) distributor whose role is to determine the share of aggregate consumption (investment) to be satisfied with home produced goods c_h (i_h) and foreign imported goods c_f (i_f). This is carried out on the basis of CES technology:

$$c_t = \left((1-\omega_{ct})^{\frac{1}{\sigma_c}} c_{ht}^{\frac{\sigma_c-1}{\sigma_c}} + \omega_{ct}{}^{\frac{1}{\sigma_c}} \left(c_{ft} \right)^{\frac{\sigma_c-1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c-1}} \quad (58)$$

$$i_t = \left((1 - \omega_{it})^{\frac{1}{\sigma_i}} i_{ht}^{\frac{\sigma_i - 1}{\sigma_i}} + \omega_{it}^{\frac{1}{\sigma_i}} \left(i_{ft} \right)^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}} \tag{59}$$

where σ_c (σ_i) is the consumption (investment) elasticity of substitution between domestic and foreign goods.

Each period, the representative consumption distributor chooses c_{ht} and c_{ft} so as to minimize production costs subject to the technological constraint given by (58). The solution of this problem provides the optimal allocation of aggregate consumption between domestic and foreign goods, c_{ht} and c_{ft}:

$$c_{ht} = (1 - \omega_c) \left(\frac{P_t}{P_t^c} \right)^{-\sigma_c} c_t \tag{60}$$

$$c_{ft} = \omega_c \left(\frac{P_t^m}{P_t^c} \right)^{-\sigma_c} c_t \tag{61}$$

where P_t and P_t^m are respectively the prices of home and foreign produced goods. P_t^c represents both the price of the consumption good borne by households and the shadow cost of production borne by the aggregator.

Proceeding in the same manner as with the investment distributor problem, similar expressions can be obtained regarding the optimal allocation of aggregate investment between domestic and foreign goods, i_{ht} and i_{ft}

$$i_{ht} = (1 - \omega_i) \left(\frac{P_t}{P_t^i} \right)^{-\sigma_i} i_t \tag{62}$$

$$i_{ft} = \omega_i \left(\frac{P_t^m}{P_t^i} \right)^{-\sigma_i} i_t \tag{63}$$

Price formation

In the preceding analysis, the price of domestically produced consumption and investment goods is equal to the GDP deflator, P_t. In order to obtain the consumption price deflator, one needs to further incorporate the demand schedules provided by (60) and (61) for home and foreign consumption goods into the cost of producing one unit of aggregate consumption goods ($P_t c_{ht} + P_t^m c_{ft}$). Bearing in mind that the production cost per unit equates to the price of production, it is straightforward to express the consumption (investment) price deflator as a function of the GDP and import deflators

$$P_t^c = \left((1-\omega_{ct})P_t^{1-\sigma_c} + \omega_{ct}P_t^{m1-\sigma_c}\right)^{\frac{1}{1-\sigma_c}} \tag{64}$$

$$P_t^i = \left((1-\omega_{it})P_t^{1-\sigma_i} + \omega_{it}P_t^{m1-\sigma_i}\right)^{\frac{1}{1-\sigma_i}} \tag{65}$$

The exogenous world price is a weighted average calculated on the basis of final good and intermediate good prices, $\overline{PFM}$ and $\overline{P}^e$, both expressed in terms of the domestic currency. Given the small open economy assumption, the relevant foreign price is defined as:

$$P_t^m = \left(\widetilde{\alpha}_e P_t^e + (1-\widetilde{\alpha}_e)\overline{PFM}_t\right) \tag{66}$$

where $\widetilde{\alpha}_e$ stands for the ratio of energy imports to overall imports.

Let us consider that export prices charged by Spanish firms deviate from prices charged by competitors in foreign markets, at least temporarily. This well-known pricing-to-market hypothesis is consistent with a model of monopolistic competition among firms where each firm regards its influence on other firms as negligible. We may define the Spanish export price deflator as

$$P_t^x = P_t^{(1-ptm)}\left(\overline{PFM}_t\right)^{ptm} \tag{67}$$

where P_t^x is the export price deflator, $\overline{PFM}_t$ is a competitors price index expressed in euros and the parameter ptm determines the extent to which there is pricing-to-market.

Exports and Imports

Aggregate imports include two final goods, foreign consumption and investment, and one intermediate commodity, energy:

$$im_t = c_{ft} + i_{ft} + \alpha_e e_t \tag{68}$$

where α_e represents the ratio of energy imports over total energy consumption.

Exports demand can be defined in terms of aggregate consumption and investment from abroad, $\overline{y}_t^w$, and the ratio of the export price deflator to the competitors price index expressed in euros, $P_t^x/\overline{PFM}_t$:

$$ex_t = s_t^x \left(\frac{P_t^x}{\overline{PFM}_t} \right)^{-\sigma_x} \overline{y}_t^w \tag{69}$$

Plugging (67) into (69) yields the exports demand under the small open economy assumption and the pricing-to-market hypothesis:

$$ex_t = s_t^x \left(\frac{\overline{PFM}_t}{P_t} \right)^{(1-ptm)\sigma_x} \overline{y}_t^w \tag{70}$$

Stock-flow interaction between the current account balance and the accumulation of foreign assets

In the model, the current account balance is defined as the trade balance plus interest rate receipts/payments from net foreign assets:

$$ca_t = \frac{P_t^x}{P_t} ex_t - \frac{P_t^m}{P_t} im_t + \left(r_t^{emu} - \pi_t \right) b_{t-1}^{oemu} \tag{71}$$

Following standard practice in the literature (see, for example, Obstfeld and Rogoff, 1995, 1996), net foreign assets are regarded as a stock variable resulting from the accumulation of current account flows. This is illustrated by the following dynamic equation:

$$\frac{\gamma_A \gamma_N b_t^{oemu}}{\phi_{bt}} = \frac{(1 + r_t^{emu})}{1 + \pi_t^c} b_{t-1}^{oemu} + \frac{P_t^x}{P_t} ex_t - \frac{P_t^m}{P_t} im_t \tag{72}$$

(72) is obtained by combining the Ricardian households' budget constraint (assuming a zero net supply for domestic bonds and money), the government's budget constraint and the economy's aggregate resource constraint.

3.8 Accounting identities in the economy

Gross output can be defined as the sum of (final) demand components and the (intermediate) consumption of energy:

$$y_t = c_{ht} + i_{ht} + g_t + \frac{P_t^x}{P_t} ex_t + \kappa_v v_t + \frac{P_t^e}{P_t} (1 - \alpha_e) e_t + \kappa_f \tag{73}$$

whereas value added generated in the economy is given by:

$$gdp_t = y_t - \frac{P_t^e}{P_t} e_t - \kappa_f - \kappa_v v_t \tag{74}$$

Note that, in accordance with previous definitions, c_{ht} and i_{ht} are equal to overall domestic consumption and investment minus consumption and investment goods imported from abroad. Thus, c_{ht} and i_{ht} are consistent with the definitions above for gross output and value added.

4. Model calibration

Model parameters have been fixed using a hybrid approach of calibration and estimation. Some parameter values are taken from different related DGE models. Several other parameters are calculated from the sample average counterpart of long-run conditions. The remaining parameters have been estimated on the basis of selected model's equations. Altogether, these parameters produce a baseline solution that accurately resembles the behaviour of the Spanish economy over the last two decades.

The data used in the calibration come from the REMSDB database. All series cover the period 1985:3 2006:4. At the beginning of the sample, the third quarter of 1985 displays adequate cyclical properties for most of the endogenous variables (see Puch and Licandro, 1997, and Boscá et al, 2007b). Several variables included in the model have no direct statistical counterpart from official sources. Such variables include consumption and employment of RoT and optimizing consumers, Lagrange multipliers, Tobin's q, composite capital stock, marginal cost and total factor productivity. In order to sidestep the lack of data availability affecting these variables, we use the model's related behavioural equations to compute them.

Table 1 lists the values of parameters and exogenous variables. The implied steady state values of the endogenous variables are given in Table 2[12]. Roughly speaking, the calibration strategy follows a sequence in which one starts by setting the value of a number of parameters which are subsequently used to obtain a measure of the level of total factor productivity. This makes it possible to express all variables in the model in terms of efficiency units. The remaining parameters are then fixed on the basis of the model's equations with variables measured in efficiency units (see Boscá et. al., 2007 for further details).

5. Tax reform and economic performance in Spain

In this section we run some simulations to illustrate how changing the tax distortions in Spain to levels prevailing in the United States affects the performance of the labour market and output. In all cases, fiscal shocks are considered unexpected and permanent. In order

12 The model has been programmed in relative prices. This means that all prices are relative to the deflator price index, P_t, and the real exchange rate is defined as $rer_t = \frac{\overline{PFM}_t}{P_t}$.

Table 1 — Parameter Values

$\overline{g}$	0.0905	$\overline{l_2}$	0.2183	β^b	0.5035	$\overline{\pi^{emu}}$	0.0000
τ^c	0.1069	ϕ_1	2.9483	$\overline{\left(\frac{b}{gdp}\right)}$	2.4000	T	1.3690
τ^l	0.1107	η	2.0000	$\overline{rr}$	0.3832	λ^w	0.4274
τ^k	0.2080	σ_c	1.2063	τ_t^e	0.2000	ω_i	0.1381
$\overline{tr}$	0.1381	ϕ_b	0.0060	ψ_1	0.0100	σ_i	0.9305
τ^{sc}	0.2215	ϕ_2	2.2389	ψ_2	0.2000	λ^r	0.5000
P^e	0.8620	ρ	0.9571	σ_x	1.3000	h	0.6000
β	0.9908	a	0.9985	$\overline{r^{emu}}$	0.0158	α_e	0.4980
α	0.5938	χ_m	0.1987	ζ	0.0600	$\widetilde{\alpha}_e$	0.1049
δ	0.0141	$\overline{mc}$	0.7961	γ_A	1.0018	ω_c	0.0930
ϕ	5.5000	γ	1.7500	γ_N	1.0047	κ_f	0.2730
κ_v	1.4966	s	0.2600	δ^p	0.0105	s^x	0.0142
σ	0.0180	ρ^r	0.7500	ptm	0.5767	ρ^w	0.7600
χ_1	0.6115	λ	0.2006	ω_c	0.0930	ϕ_e	25.000
χ_2	0.5725	β^f	0.4965	$\overline{y}^w$	7.7855	ρ_e	0.8500

to highlight the comparability with respect to Coenen, McAdam and Straub (2008), we choose the same selected variables but, given the presence of search and matching in the labour market in our model, we separate the extensive and intensive margin of labour utilisation also adding information on the reaction of vacancies. In all the experiments we will assume that the loss in government revenues is financed by an increase in a lump-sum tax charged to households such that public investment and consumption and the government debt-to-output ratio remain constant in the long run.

5.1 Long run effects

Table 3 reports the long-run effects for each individual component of the overall tax wedge, the first column representing a reduction in the consumption tax wedge, the second column an increase in the labour tax wedge and the third column a reduction in firms' social security contributions. In the last column the overall tax wedge is displayed. Figures in the table represent percentage changes with respect to the initial steady state.

According to our results, the reduction in the overall tax wedge would have an unequivocally positive effect on the Spanish economy in the long run that would be summarized by an increase in total hours per adult of about 7 per cent and in GDP of about 8 percentage points. Consequently, there is a reduction of only one percentage point out of the 24 points in the labour productivity gap with respect to the US. Although these results represent a significant effect in terms of hours per capita and output, in terms of per capita

Table 2 − Steady State

b_t	1.3951	i_{ht}	0.0987	$\widetilde{\left(\frac{\lambda_{1t+1}}{\lambda_{1t}}\right)}$	1.0000	r_t	0.0335
b_t^o	1.3951	im_t	0.1565	$\widetilde{\left(\frac{\lambda_{3t+1}}{\lambda_{1t}}\right)}$	0.2539	r_t^n	0.0142
c_t	0.3192	j_t	0.1582	λ_{3t}^o	0.1997	g_{st}	0.0803
c_{ft}	0.0542	j_t^o	0.3163	λ_{3t}^r	1.4439	trh_t	0.0067
c_{ht}	0.2659	k_t	7.5943	λ_t^{nd}	0.4648	t_t	0.2024
c_t^o	0.3570	ke_t	6.3208	λ_{1t}^o	2.6355	U_t^n	-1.258
c_t^r	0.2814	k_t^o	15.189	λ_{1t}^r	3.3428	g_{ut}	0.0600
e_t	0.0477	l_{1t}	0.4487	$\frac{p_t^c}{p_t}$	0.9734	v_t	0.0595
rer_t	0.8390	m_t	2.6116	π_t	0.0000	w_t	1.2830
ex_t	0.1431	$\widehat{mc}_t$	0.0000	gdp_t	0.5813	y_t	0.9861
b_t^w	0.0000	m_t^o	5.2232	π_t^c	0.0000	ϕ_{bt}	1.0000
b_t^{ow}	0.0000	n_t	0.6102	$\frac{p_t^i}{p_t}$	0.9228	k_t^p	1.1131
g_t^c	0.0905	n_t^o	0.6102	$\frac{p_t^m}{p_t}$	0.8267	l_{2t}	0.2183
i_t	0.1672	n_t^r	0.6102	$\frac{p_t^x}{p_t}$	0.9037	g_t^i	0.0173
i_{ft}	0.0785	$\widetilde{\left(\frac{1}{\lambda_{1t}}\right)}$	0.3393	q_t	1.0285		

GDP they account only for one third of the gap with respect to the US, and for a very small fraction in the case of labour productivity.

The rise in total hours per capita is explained by an equal increase in both hours per worker and the employment rate of about 3.5 percentage points. These figures are in line with the empirical evidence. According to Nickell's (2004) discussion of the panel data estimations for the main OECD countries, a reduction equivalent to our 19.5 percentage points in the tax wedge would rise the employment rate by between 3 and 5.3 percentage points. This effect is significat but modest, implying for the Spanish economy around one third of the average difference in the employment rate since 1985 between Spain and the US. However, the increase in hours per employee would imply the convergence of this variable to US levels.

The results in Table 3 are also very similar to those obtained by Coenen, McAdam and Straub (2008). In general, the effects in our simulation represent approximately 2/3 of the effects estimated by these authors, a difference which is consistent with the fact that the relative tax wedge in the Spanish economy with the US is smaller than in the case of the EU15. The most important difference, albeit with a very limited quantitative effect, is that GDP per hour increases in our simulation, whereas it decreases in the results provided by

Coenen, McAdam and Straub (2008), since output increases by 11.89 per cent and hours worked by 13.72 per cent.

Higher labour input pushes up the marginal productivity of capital and therefore its rate of return, thus positively affecting Tobin's q and, hence, investment. Given the long run level of labour and capital the supply side of domestic goods is determined. On the demand side, the increase in the rental rate of capital, together with higher wages and more working hours, induce a boost in household's income and therefore in consumption (especially that for RoT households)[13]. In order to equilibrate the demand and the supply side of domestic goods, the terms of trade (p^x/p^m) fall to improve the external position. Because Spanish export prices deviate from international prices due to the pricing-to-market assumption, the increase in relative export prices (P^x/P) is lower than in relative import prices (P^m/P), thus provoking a fall in the terms of trade. Finally, the increase in output per worker and the decrease in firms' effective labour costs push up the marginal value of a new worker, driving firms to post more vacancies.

Moving on to the steady state effects of changes in the different components of the tax wedge, the first thing to note is that, as expected, the signs and individual contributions of the tax variations are in line with the reduction of the total tax wedge in the last column of Table 3. Notice that in the case of Spain, the labour tax rate has to be increased to reach US levels ($\Delta\tau^l > 0$). This means that, in general the effects are the opposite to those of the other tax components. For example, hours per worker are determined by the bargaining condition (48). In that condition firms' social security contributions, labour income tax and consumption tax (through the shadow price of income) affect hours per employee negatively. Given this mechanism, the increase in consumption tax and in firms' social security contributions increases the number of hours per worker, but the augment in the labour tax rate decreases them.

The only qualitative difference across the different components of the tax wedge has to do with the effects on real wages, after tax real wages and effective labour costs. In our model the real wage is a bargained variable that depends on the three components of the overall tax wedge: the consumption tax rate (that affects consumption prices and, hence, the shadow price of income), the labour income tax rate (that directly influences bargained wages and indirectly through the marginal utility of newly created jobs) and firms' social security contributions (that directly influence negotiated wages). In the case of a reduction in consumption taxes, the after tax real wage increases because the direct effect on consumption prices prevails. However, real wages and effective labour costs are reduced, mainly because the decrease in consumption prices increases the marginal

[13] These results are due to the assumption in our model that lump-sum taxes are borne only by optimizing consummers. Obviously, a different assumption would imply other redistributive effects. We will come back to this issue in the next section.

Table 3 − Long Run Benefits of Lowering Tax Wedges in Spain

	Components of overall tax wedge			Overall wedge
	$\Delta\tau^c = -7.5$	$\Delta\tau^l = 3.0$	$\Delta\tau^{sc} = -15.0$	$\Delta\tau = -19.5$
GDP	3.29	-1.61	6.31	8.04
Consumption	4.55	-2.23	8.71	11.08
Investment	0.74	-0.36	1.43	1.82
Exports	1.58	-0.78	3.00	3.81
Imports	0.36	-0.18	0.69	0.87
Tot. hours per adult	2.83	-1.39	5.39	6.85
Hours per employed	1.35	-0.65	2.61	3.35
Employment rate	1.48	-0.74	2.78	3.50
Real wage	-0.87	0.44	12.22	11.73
After tax real wage*	5.85	-2.81	11.35	14.56
Effective labour cost	-0.87	0.44	-1.64	-2.06
Terms of trade	-1.24	0.59	-2.38	-3.03
Vacancies	4.37	-2.13	8.40	10.71

(∗) Deflated with the price of consumption good

shadow value of household income. This in turn makes households more sensitive to accept lower real wages (measured in terms of the overall price deflator). In the case of changes in labour income tax, similar reasoning applies: an increase in labour taxes reduces after-tax labour wages, pushing up real wages in the bargaining. With respect to the decrease in social security contributions, as expected, this is the only case where the effect on real wages is the opposite to reductions in consumption and labour taxes. This can be easily explained, because a reduction in social security contributions lowers effective labour costs, making firms more able to accept higher real wages in the bargining process.

5.2 Transitional dynamics

Looking at the transitional dynamics produced by the unexpected permanent reduction in the overall tax wedge in Figure 6, we can appreciate similar behaviour on behalf of both the real wage (deflated by the price of the production good) and total hours per capita. Both magnitudes increase on impact and follow each other very closely over the medium term, although the impluse in hours dies off before that in wages. Interestingly, the decomposition of hours between hours per employee and the unemployment[14] rate shows that, over the medium term, the increase in labour income comes mainly from more

[14] It is convenient to recall that unemployment in our model is an equilibrium unemployment. Thus, it can only consider involuntary unemployment due to frictions in search, and not disequilibrium unemployment due for example to hysteresis in the labour market or other types of long term-unemployment.

employment, rather than from these employees spending more hours at the work place.

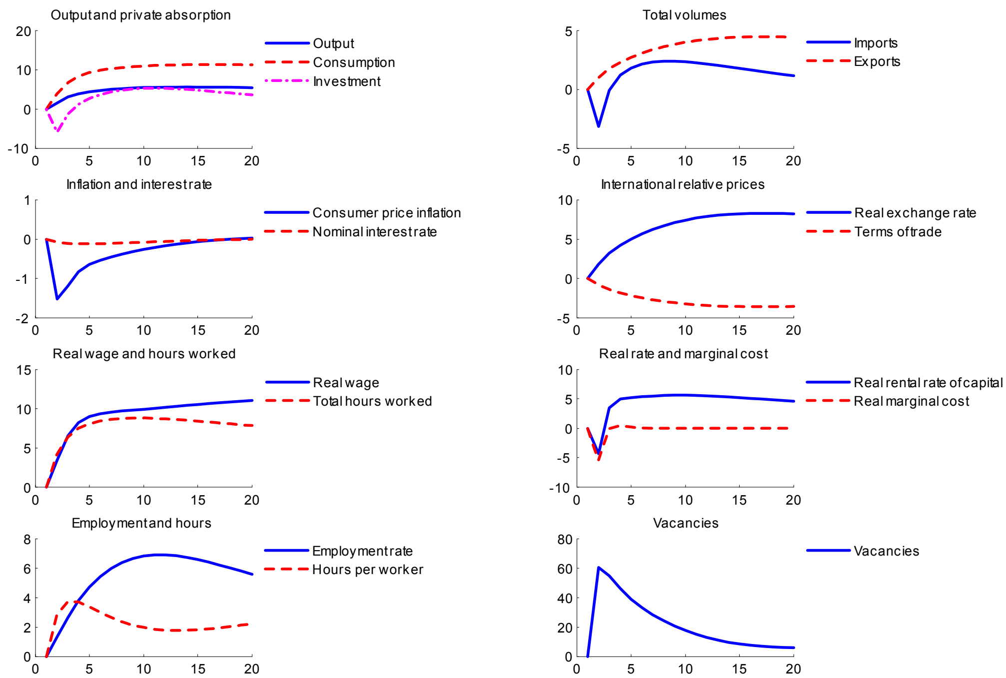

Figure 6: *Transitional dynamics after a permanent reduction in overall tax wedge*

Our model also features a rapid decline in vacancies after a very pronounced initial jump, due to the steady reduction in the search effort and an augment in market tightness.

Another interesting fact has to do with the short run dynamics of investment. As can be seen, investment falls in the first few quarters and recovers afterwards. The initial fall in investment is related to the initial fall in marginal cost, due to the reduction in effective labour costs. As marginal costs go down, consumption inflation dampens provoking a fall in Tobin's q, and consequently a reduction in investment. After some quarters, given that the rental rate of capital recovers due to an increase in the productivity of capital, investment experiences a steady increase towards its new higher long run level.

With respect to the foreign sector variables, the change in the overall tax wedge generates a continuous increase in exports, driven by both real depreciation and the fall in the terms of trade. Given that our model is a small open economy, the rest of the world is exogenous and there are no spillovers across countries that induce additional effects.

However, imports fall on impact because the negative effect of the initial increase in the relative price of imports more than compensates the positive income effect produced by the increase in aggregate demand.

In the Appendix, the transitional dynamics for each individual component are depicted. The temporal path of the variables is, in all the cases, very similar to that commented above for the overall tax wedge. However, contrary to the general case, the consumption tax rate reduction causes wages to begin to fall sharply during the first year to recover slightly in the long run.

The dynamics of aggregate consumption depicted in Figure 6 hides the distinctive behaviour of optimizing and RoT consumption. The distribution of the lump-sum endogenous transfers among both type of agents affects their consumption possibilities. In Figure 7 we have depicted the deviation (in percentage points) with respect to the steady state of total aggregate consumption (left panel), consumption of Ricardian households (central panel) and of restricted households (right panel). The solid line corresponds to the case in which the whole burden is borne by optimizing households, while the dotted line depicts the opposite situation where RoT consumers are the only burdened. Finally, the dashed line corresponds to an intermediate situation where both agents share the burden of lump-sum taxation. Given that in our model the reduction in the overall tax wedge, requires a negative lump-sum transfer (i. e. a lump-sum tax), the distibution of this burden has quite pronnounced effects on the dynamics of individual consumption. On impact, consumption of Ricardian agents decreases when they support the whole burden of taxation, while this does not happen when resticted households face the entire payment of the lump-sum tax. As could be expected the short run impact on RoT consumption is highly significant, as compared with agents that smooth consumption over their life time. However, the dynamics of aggregate consumption are not much affected by the distribution of the burden of lump-sum transfers[15].

6. Sensitivity analysis

In Table 4 we report a sensitivity analysis regarding the long-run effects of bringing tax wedges in Spain to levels prevailing in the United States. First, we show in this table how the long-run effects on key macroeconomic variables depend on the labour supply elasticity of households. As in Coenen, McAdam and Straub (2008), we change our baseline labour-supply elasticity of 0.5 to a value of 3, which is the same as that calibrated in Prescott (2004). Our results go, as was to be expected, in the same direction as those

[15] The dynamics of other macroeconomic variables are also affected by the assumption made about the distribution of transfers. However, as is the case with total consumption the effects are quite moderated. In any case, the steady state values are always the same, so that results in Table 3 are not affected.

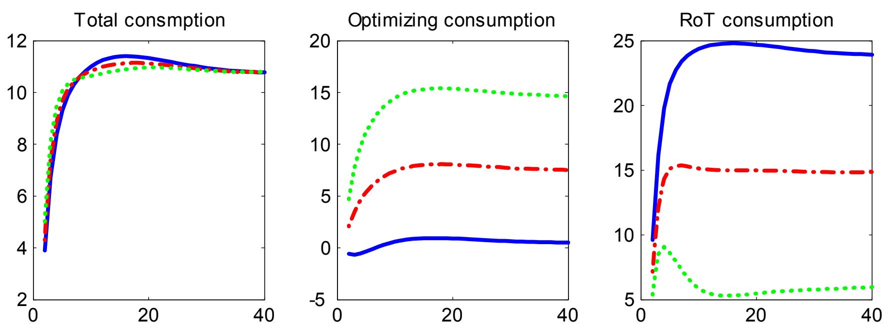

Figure 7: *Dynamics of consumption after a permanent reduction in overall tax wedge*

reported by Coenen, McAdam and Straub (2008). However, the magnitude of these effects on output and hours worked is less important than in their results. In our search and matching labour market context, total hours per adult increase in the new steady state 8.29% compared with a 6.85% increase for the baseline calibration of the reduction in the overall tax wedge (see last column in Tables 3 and 4). The smaller difference is due to the fact that in our model workers have more room to maneuver when faced with the shocks, as is readily apparent looking at the fact that extensive and intensive margins respond very differently when the labour-supply elasticity is increased. We observe that hours per employee increase a significant 8.53% in the new steady state, as compared with 3.35% in the baseline scenario. In contrast, the employment rate decreases slightly (-0.24%), while in our baseline calculations it increased 3.50%. Thus, in line with Fang and Rogerson (2008) there seems to be a trade-off between hours per employee and the employment rate, that makes total hours vary less. The smaller reduction in effective labour costs and greater willingness on behalf of workers to spend more time working, result in an important increase in hours worked by employees, so that firms hire less workers and post less vacancies. In line with these labour market effects, GDP also experiences a stronger effect than in the baseline simulation, rising by 9.77% compared to the 8.04% increase in the baseline scenario.

In addition to the previous findings regarding the labour supply elasticity, we have performed other exercises (not reported in the table) to check the robustness of our results to different parameter values. These exercises have to do mainly with relevant parameters in equations affecting the labour market. For instance, if we assume a more efficient matching technology (increasing χ_1 a 20%) our steady state impacts on relevant macroeconomic variables are not altered in a significant manner. Only the number of vacancies increases by one percentage point more in the new steady state as compared with our baseline calculations. Also, increasing the elasticity of matchings to vacancies (augmenting a 20% the value of χ_2) has only some mild, but noticeable effects, on the long run response of vacancies (reducing from 10.71% to 9.21% the steady state increase on this variable), and on the extensive and intensive margins. Hours per employed increase only a 3.06% in the new steady state, as compared with a 3.35% in the baseline scenario. In contrast, the employment rate increases a 4.0%, half a point more than in our baseline calculations where it increased 3.50%. In none of these exercises are noteworthy effects on other relevant macroeconomic aggregates. This is also the case, when we check our simulation results to changes in the worker's bargaining power (λ^w). To get an idea of the robustness of our results, a 25% reduction in λ^w implies that GDP (or investment) increases in the new steady state 8.20% (1.82%) compared with an 8.04% (1.91%) increase for the baseline calibration of the reduction in the overall tax wedge.

Table 4 − Sensitivity of Long Run Benefits of Lowering Tax Wedges in Spain

	Components of overall tax wedge			Overall wedge
	$\Delta\tau^c = -7.5$	$\Delta\tau^l = 3.0$	$\Delta\tau^{sc} = -15.0$	$\Delta\tau = -19.5$
Labour supply elasticity value of 3				
GDP	3.95	-1.90	7.63	9.77
Consumption	5.29	-2.57	10.20	13.04
Investment	0.86	-0.41	1.67	2.14
Exports	1.85	-0.90	3.55	4.52
Imports	0.42	-0.21	0.81	1.03
Tot. hours per adult	3.33	-1.59	6.46	8.29
Hours per employed	3.43	-1.64	6.65	8.53
Employment rate	-0.10	0.05	-0.19	-0.24
Real wage	-0.53	0.26	12.92	12.60
After tax real wage*	6.14	-2.95	11.91	15.28
Effective labour cost	-0.53	0.26	-1.02	-1.30
Terms of trade	-1.45	0.69	-2.82	-3.62
Vacancies	-0.60	0.30	-1.14	-1.45

(∗) Deflated with the price of consumption good

7. Conclusions

This paper employs a rational expectations model for simulation and policy evaluation of the Spanish Economy (the REMS model) to perform a simulation exercise consisting in reducing the overall tax wedge prevailing in Spain to US levels. This exercise is very similar in its objectives to other studies applied to European countries, such as Coenen, McAdam and Straub (2008), but using a model that characterizes a small open economy in a currency area. As our model also specifies a labour market in which there are search and matching between workers and firms, then it allows a richer and deeper analysis of the effects of taxes upon both the intensive and extensive margins of labour.

According to our results, a reduction in the overall tax wedge of 19.5 points, in order to reach US levels, has an unequivocally positive effect in the long run on the output and labour of the Spanish economy: total hours increase by about 7 per cent and GDP rises by about 8 percentage points. In terms of GDP per adult, these results account for one third of the gap with respect to the US, but imply a reduction of only one percentage point in the labour productivity gap. The rise in total hours per adult is explained by a similar increase in both hours per employee and the employment rate of about 3.5 percentage points. This effect accounts for around one third of the average difference in the employment rate between Spain and the US since 1985. The increase in hours per employee, however, would allow this variable to converge to US levels.

With respect to other macroeconomic aggregates, our simulation exercise predicts higher steady state levels of consumption, private investment, exports, imports, real wages and vacancies. On the other side, terms of trade and real effective labour costs would fall. In the short run, there are no important transition costs, except for the case of investment, which falls in the first few quarters. Vacancies, however, experience a boom over the first few years.

In summary, this paper has presented estimates of the costs of distortionary taxation in the Spanish economy. Nevertheless, as long as the intertemporal budget constraint of the government is satisfied, a lower level of taxation also implies a lower level of public expenditure. Taking into account this trade-off, the challenge is how to increase the efficiency of taxes without negatively affecting the provision of essential public services, which promote equal opportunities for all and a fair distribution of income, and the sustainability of the pension system.

Appendix 1: Transitional dynamics

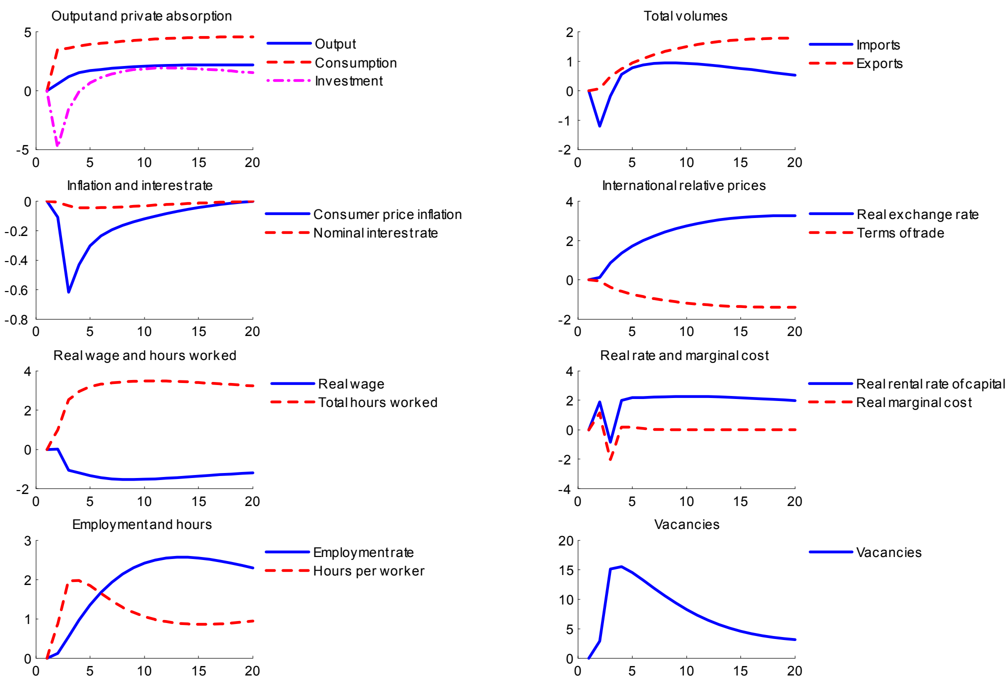

Figure 8: *Transitional dynamics after a permanent reduction in the consumption tax rate*

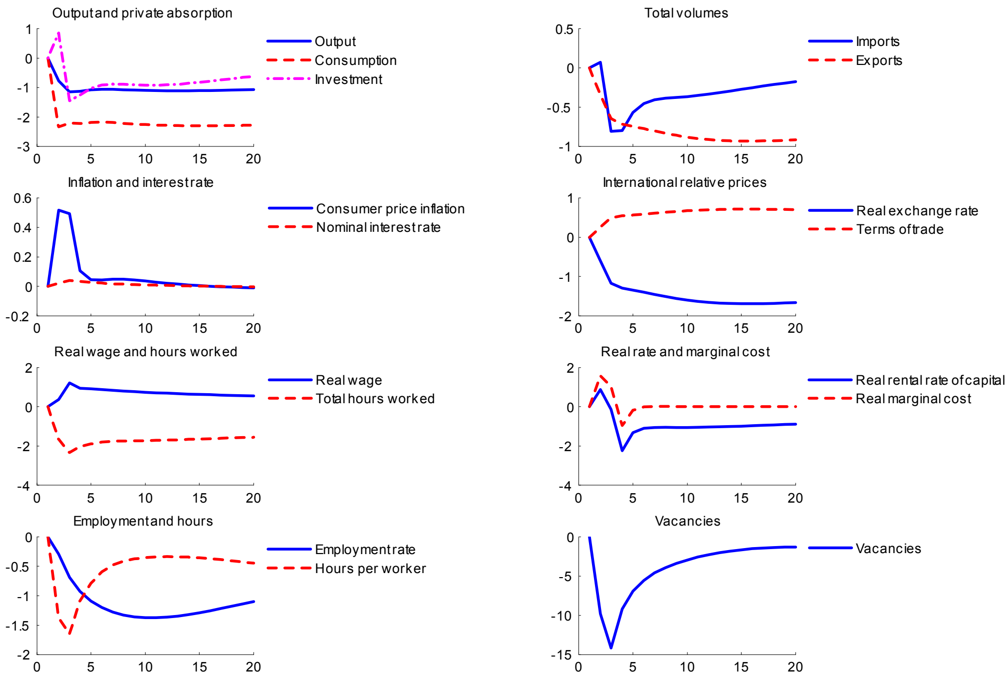

Figure 9: *Transitional dynamics after a permanent increase in labor tax rate*

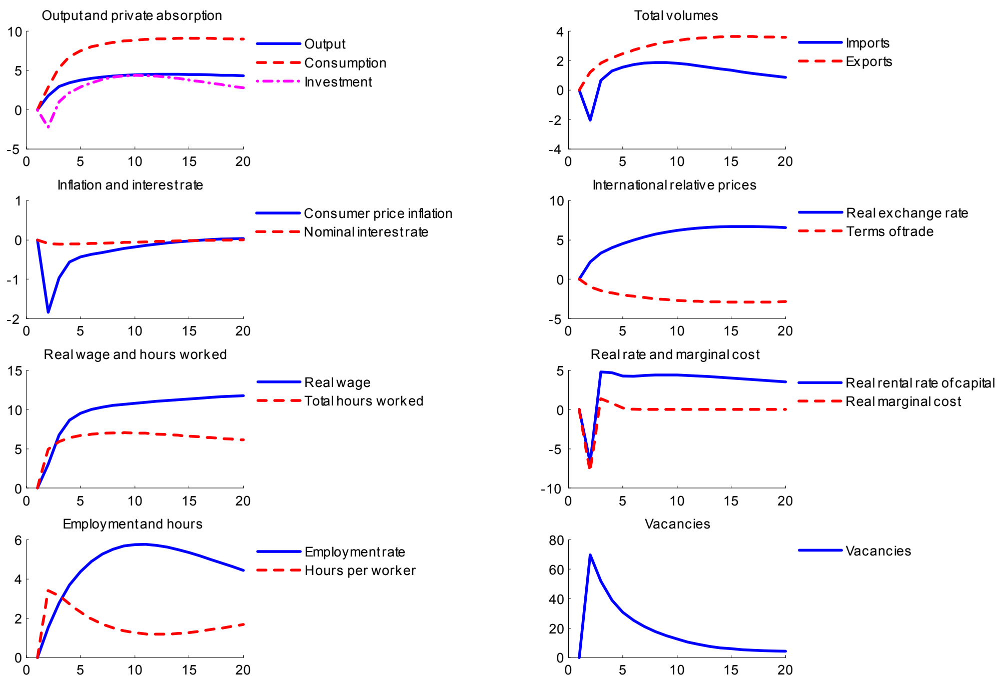

Figure 10: *Transitional dynamics after a permanent reduction in social security contributions*

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