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# Fiscal Devaluations in EMU

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## Fiscal Devaluations in EMU\*

J.E. Boscá<sup>a</sup>, R. Doménech<sup>a,b,t</sup> and J. Ferri<sup>a</sup>

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### Abstract

We use a small open economy general equilibrium model to analyse the effects of a fiscal devaluation in an EMU country. The model has been calibrated for the Spanish economy, which is a good example of the advantages of a change in the tax mix given that its tax system shows a positive bias in the ratio of social security contributions over consumption taxes. The preliminary empirical evidence for European countries shows that this bias was negatively correlated with the current account balance in the expansionary years leading up to the 2009 crisis, a period when many EMU members accumulated large external imbalances. Our simulation results point to significant positive effects of a fiscal devaluation on GDP and employment similar to the ones that could be obtained with an exchange rate devaluation. However, although the effects in terms of GDP and employment are similar, the composition effects of fiscal and nominal devaluations are not alike. In both cases, there is an improvement in net exports, but the effects on domestic and external demand are quite different.

Keywords: tax mix, fiscal devaluation, nominal devaluation.

JEL: E62, E47, F31.

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t: Corresponding author: BBVA. Castellana, 81. 28046, Madrid. Spain. Tel.: +34 915373672. E-mail address: rdomenech@bbva.com.

a: University of Valencia, Spain.

b: BBVA Research, Spain.

## 1. Introduction

The Spanish economy, as many other European countries, has been affected by an intense economic crisis since 2009. The Great Recession has especially hit the labour market with the unemployment rate rocketing to values in excess of 27 per cent. Amidst this very adverse situation the Spanish government has to accomplish with the task of consolidating its budget, with no margin for manoeuvre to stimulate economic activity with expansionary fiscal policies. Although significant structural reforms have recently been approved, i.e. labour market and financial system reforms, these may take some time to produce complete results. In addition, Spain cannot perform a nominal currency devaluation, as it used to do before its membership to the Eurozone.

In this situation, is it possible to generate a temporary economic stimulus? Fahrni, Gopinath and Itsikhoki (2011) have shown that, when the exchange rate cannot be devalued, a particular tax combination can replicate the real effects attained under a nominal exchange rate devaluation. This is the idea behind the so called fiscal devaluation, that is, an increase of consumption taxes with an appropriate reduction of employers' social contributions, such that the fiscal budget remains unchanged. Therefore, although this policy has no effects upon public deficit, it produces a decrease in terms of trade (price of exports over the price of imports) that is expected to generate positive output and employment effects<sup>1</sup>. In fact, fiscal devaluations are a particular case of changes in the tax structure, which previous contributions have shown to have considerable effects on economic activity<sup>2</sup>.

Fiscal devaluation analysis has gained stamina in recent years. Lipinska and von Thadden (2009), Franco (2011) and Farhi, Gopinath and Itsikhoki (2011) provide quantitative evaluations of the effects of a tax change from direct to indirect taxes in general equilibrium models, whereas Franco (2011) and de Mooij and Keen (2012) provide empirical estimations on the effects on net exports, the former using an SVAR for the Portuguese economy and, the latter by means of a dynamic panel of 30 OECD countries from 1965 to 2009. Also consistent with these results, using an experimental economy, Riedl and Winden (2012) find that a shift from wages to consumption taxes improves economic performance, given the producers' reluctance to incur production costs up-front when facing product price uncertainty.

In this paper we simulate the effects of a fiscal devaluation in a currency area, using

<sup>1</sup> See also the *IMF Fiscal Monitor* (2011) for a detailed description of the conditions under which a fiscal devaluation is more likely to generate an economic stimulus, and a theoretical and empirical review of some previous episodes of fiscal devaluations.

<sup>2</sup> Since a survey of this literature is beyond the aim of this paper, see among others Nickell (2006), Doménech and García (2008), Causa, 2008, Coenen, McAdam and Straub (2008), Boscá, Doménech and Ferri (2009) or OECD (2011).

REMS, a small open economy general equilibrium model that has been calibrated for the Spanish economy, given that it is a good example in the EMU of a tax system that shows a positive bias in the ratio of social security contributions over consumption taxes<sup>3</sup>. To compare the effects of a fiscal devaluation in a currency area with that of a standard nominal currency devaluation, we modify our general equilibrium model as if a counterfactual country had its own currency with the same calibrated parameters for the rest of the equations describing the equilibrium, with the exception of the monetary policy rule and the uncovered interest rate parity.

The paper is structured as follows. In section 2 we provide an empirical motivation for performing our simulation exercise, showing that the ratio of social security contributions to indirect taxes was negatively correlated with the current account balance from 1995 to 2009. Section 3 briefly presents the model. Section 4 shows our main results. We find that there is an equivalence between a fiscal devaluation, i.e., a change in the mix between consumption tax and social security contributions, and a standard monetary devaluation through the nominal exchange rate. Results point to significant positive effects of a fiscal devaluation on GDP and employment consistent with a real exchange devaluation, if a country like Spain had the capacity to manage its own monetary policy. Finally, section 5 concludes.

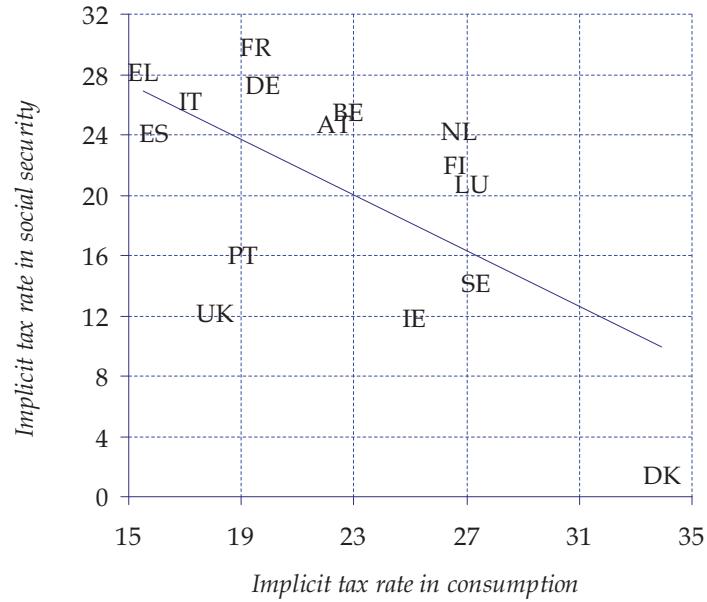
## 2. Empirical motivation

Despite the fact that EMU members share their currency, there are large differences between consumption ( $\tau^c$ ) and labour taxes, particularly in the case of social security contributions ( $\tau^{sc}$ ), where differences are even larger. This is also the case for other European countries, as shown in Figure 1, where we observe that the implicit tax rate in consumption ranged from 15 to almost 35 per cent in 2007<sup>4</sup>, whereas the implicit tax rate in social security ranged from 1.5 to 31 per cent<sup>5</sup>. In fact, there is a negative correlation between these implicit tax rates, implying that the tax rate mix, measured by the ratio of implicit tax rates on social security over consumption ( $\tau^{sc}/\tau^c$ ) changed significantly among this sample of countries, from a maximum value of 1.82 in Greece to 0.04 in Denmark.

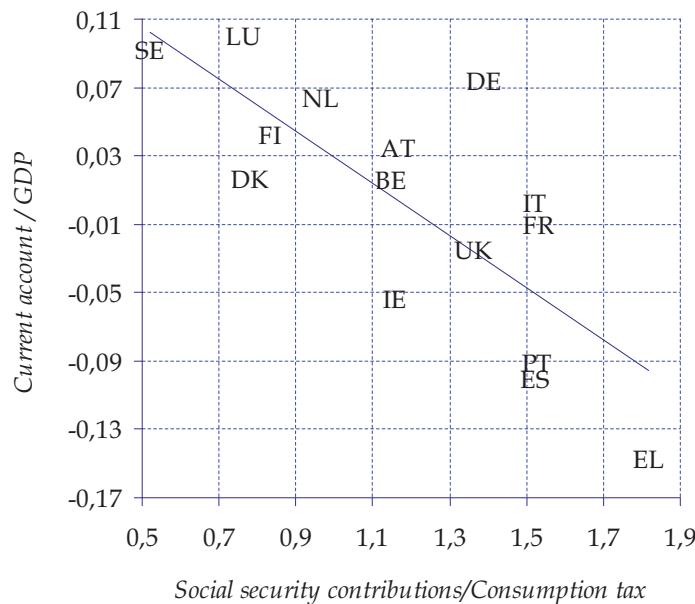
<sup>3</sup> For a complete description of the model, see Boscà et al. (2010) and Boscà et al. (2011).

<sup>4</sup> We focus on one year to offer a clear picture of the differences among countries. We choose the year 2007 because it represents the last year previous to the economic crisis and when differences in current account imbalances were also larger.

<sup>5</sup> Implicit tax rates have been taken from Eurostat (2013). The tax rate on consumption is defined as all consumption taxes divided by the final consumption expenditure of private households in the economic territory. The social security contributions rate is defined as the sum of employees' and employers' social contributions levied on employed labour income divided by the total compensation of employees working in the economic territory. Given that the convergence process may take time, in Figure 1 we focus only on the first 15 members of the European Union, after the enlargement in 1995.



**Figure 1:** Implicit tax rates in consumption and social security, EU15, 2007.



**Figure 2:** Ratio of implicit tax rates on social security over consumption and the current account over GDP, EU15, 2007.

The reduction of the tax mix  $\tau^{sc}/\tau^c$  is referred to as a fiscal devaluation since, at least in the short term, it can make home exports cheaper relative to foreign exports, inducing an improvement in net exports and boosting output and employment. In this section we offer some evidence that shows that the ratio of implicit tax rates on social security over consumption was negatively correlated with the surplus of the current account in terms of GDP, particularly in the years previous to the Great Recession, where large external imbalances were accumulated.

Table 1 presents some econometric results. Columns (1) to (4) show the pool estimations of regressing the current account (as a percentage of GDP) on  $\tau^{sc}/\tau^c$  and a set of different control variables. The sample considered covers the period from 1995 to 2009 for EU15. All the models also include a country dummy for Denmark, Ireland, Portugal and the UK<sup>6</sup>. As we can see in column (1), the coefficient of  $\tau^{sc}/\tau^c$  is negative and statistically significant. Columns (2) to (4) confirm that  $\tau^{sc}/\tau^c$  is statistically robust to the inclusion of other explanatory variables, such as the tax wedge  $(1 - \frac{(1-\tau^l)}{(1+\tau^c)(1+\tau^{sc})})$  or the log of GDP per capita. Finally, in column (5) we present the estimates corresponding to a cross-section sample of EU27 countries for 2007. Results in column (5) also confirm the negative coefficient for the variable  $\tau^{sc}/\tau^c$ <sup>7</sup>. Related to previous estimates, Figure 2 displays the evidence for 2007 pointing out that the lower the ratio of social security contributions over consumption taxes the larger the surplus of the current account over GDP<sup>8</sup>.

According to these results, and taking as reference the year 2007, if a country like Spain had reduced social security contributions by 1% of GDP and had increased consumption taxes revenues by the same amount (implying a change in its  $\tau^{sc}/\tau^c$  ratio from 1.52 to 1.29), it would have improved the current account by between 1.4 and 2.8 pp of GDP. These results are consistent with de Mooij and Keen (2011), who find that a shift of one percent of GDP from social security contributions to VAT taxes in the short term increase net exports between 1 and 4 percent of GDP. However, the number of contributions that have approached this question through simulated economies obtain smaller effects, as summarized by the IMF (2011).

<sup>6</sup> This is a dummy that takes the value 1 for these four countries and 0 for the rest. The coefficient of the ratio of social security contributions over consumption taxes is also negative when this dummy, which significantly improves the fit of the regression, is excluded in columns (1) to (4) of Table 1.

<sup>7</sup> Sample countries in column (5) also includes all enlargement countries from 2004 onwards, with the exception of Poland, although results are robust when considering only EMU countries.

<sup>8</sup> As in columns (1) to (4), Figure 2 also controls for the country dummy for Denmark, Ireland, Portugal and the UK. That is, in this figure we represent the orthogonal components of the current account over GDP and  $\tau^{sc}/\tau^c$  to the country dummy, after adding the corresponding sample averages. The Frisch-Waugh theorem states that the multiple regression coefficient of  $\tau^{sc}/\tau^c$  (which corresponds to the negative slope of the line in Figure 2) can be obtained by first netting out the effects of the dummy variable from both the dependent variable and  $\tau^{sc}/\tau^c$ .

TABLE 1 – TAX MIX AND CURRENT ACCOUNT

	(1)	(2)	(3)	(4)	(5)
Constant	0.15 (18.8)	0.20 (6.13)	-0.36 (-4.02)	-0.50 (-3.97)	-0.198 (1.63)
$\tau^{sc}/\tau^c$	-0.11 (-16.0)	-0.12 (-11.9)	-0.09 (-13.1)	-0.08 (-7.51)	-0.06 (-3.41)
$(1 + \tau^c)/(1 - \tau^l - \tau^{sc})$		-0.08 (1.99)		0.06 (1.21)	0.09 (2.16)
GDP per capita (log)			0.05 (5.72)	0.06 (5.73)	0.01 (3.03)
Country dummy	-0.12 (-18.5)	-0.13 (-14.6)	-0.10 (-17.0)	-0.09 (-10.1)	-0.09 (-4.90)
N. observations	219	211	219	211	27
$R^2$	0.63	0.64	0.67	0.69	0.78

Dependent variable: Current Account as percentage of GDP. t-statistics in parenthesis.

### 3. The dynamic model

We use a small open economy general equilibrium model to simulate the effects of a fiscal devaluation in Spain. To this aim we use the model developed by Boscá et al. (2010 and 2011). In this section we just outline its main characteristics, however, greater detail on the model's set-up can be found in the Appendix.

REMS is a small open economy dynamic general equilibrium model that features the main characteristics of the Spanish economy and it builds upon the existing literature on macroeconomic models<sup>9</sup>. The model is primarily intended to serve as a simulation tool for the Spanish economy, with a focus on the economic impact of alternative policy measures over the medium term. The small open economy assumption implies that a number of foreign variables are given from the perspective of the national economy and that the magnitude of spillover effects on other countries is small. This modelling choice seems to us to be a fair compromise between realism and tractability.

REMS is a New Neoclassical-Keynesian synthesis model. Equations in the model are explicitly derived from intertemporal optimization by representative households and firms under technological, budgetary and institutional constraints. Thus, economic decisions are solidly micro-founded and any ad-hoc dynamics have been avoided. Behaviour is predominantly forward-looking and short-term dynamics are embedded into a neoclassical growth model that determines economic developments over the long run. However,

<sup>9</sup> Many central banks and international institutions have elaborated D(S)GE models. These include, *inter alia*, QUEST III for the EU (Ratto et al., 2009), SIGMA for the US (Erceg et al., 2006), the BEQM for the UK (Harrison et al., 2005), the TOTEM for Canada (Murchison et al., 2004), AINO for Finland (Kilponen et al., 2004), or the models devised by Smets and Wouters (2003) for EMU, Lindé et al. (2004) for Sweden and Cadiou et al. (2001) for 14 OECD countries. Two models of the Spanish economy different to REMS are BEMOD and MEDEA, respectively developed by Andrés et al. (2006) and Burriel et al. (2010).

as markets do not generally work in a competitive fashion, the levels of employment and economic activity will be lower than those that would prevail in a competitive setting.

In the short term, REMS incorporates nominal, real and financial frictions. Real frictions include adjustment costs in consumption (via the incorporation into the model of consumption habits and rule-of-thumb households) and investment into physical capital. The model also allows for slow adjustment of wages, and price rigidities, which are specified through a Calvo-type Phillips curve. All these modelling choices are fairly in line with other existing models for the Spanish economy. The main contribution of REMS to this renewed vintage of D(S)GE models is the specification of the labour market according to the search paradigm. This approach has proved successful in providing micro-foundations for equilibrium unemployment in the long run and accounting for both the extensive and intensive margins of employment at business-cycle frequencies. It is therefore best suited to the assessment of welfare policies having an impact on the labour market (see also Stähler and Thomas, 2012)

Figure 3 sketches with more detail the main ingredients of the simulation model. In a decentralized economy optimizing (non-restricted) households, firms, policymakers and the external sector actively interact each period by trading one final good  $y$ ,  $j$  differentiated intermediate goods, government bonds ( $b$ ), three primary production factors (total labor  $nl$ , private capital,  $k$ , and public capital,  $k^p$ ) and one intermediate input (energy,  $e$ ).

In addition to optimizing or Ricardian households, there are restricted individuals (rule-of-thumb consumers) that do not have access to financial markets, so that they are liquidity constrained by their current income. Households are the owners of the available production factors and all the firms operating in the economy. Thus, they rent physical capital (Ricardian households) and labour services (both Ricardian and rule-of-thumb households) out to firms, for which they receive rental rates ( $r$ ) and wages ( $w$ ).

Each household is made up of working-age members who may be active or inactive. In turn, active workers participating in the labour market may either be employed or unemployed. Unemployed workers are actively searching for a job. Firm investment in vacant posts is endogenously determined and so are job inflows. Finally, job destruction is taken as exogenous. Job creation is costly in terms of time and real resources. Thus, pure economic rents arise from each job match over which the worker and the firm negotiate in an efficient-bargaining manner, determining hours per worker ( $l$ ) and wages ( $w$ ). Although optimizing and rule-of-thumb households have a different reservation wage, they delegate a trade union to bargain with firms over wages and hours and to distribute employment according to their shares in the working-age population (see Boscá, Doménech and Ferri, 2011).

All households in the economy pay taxes and receive transfers from the govern-

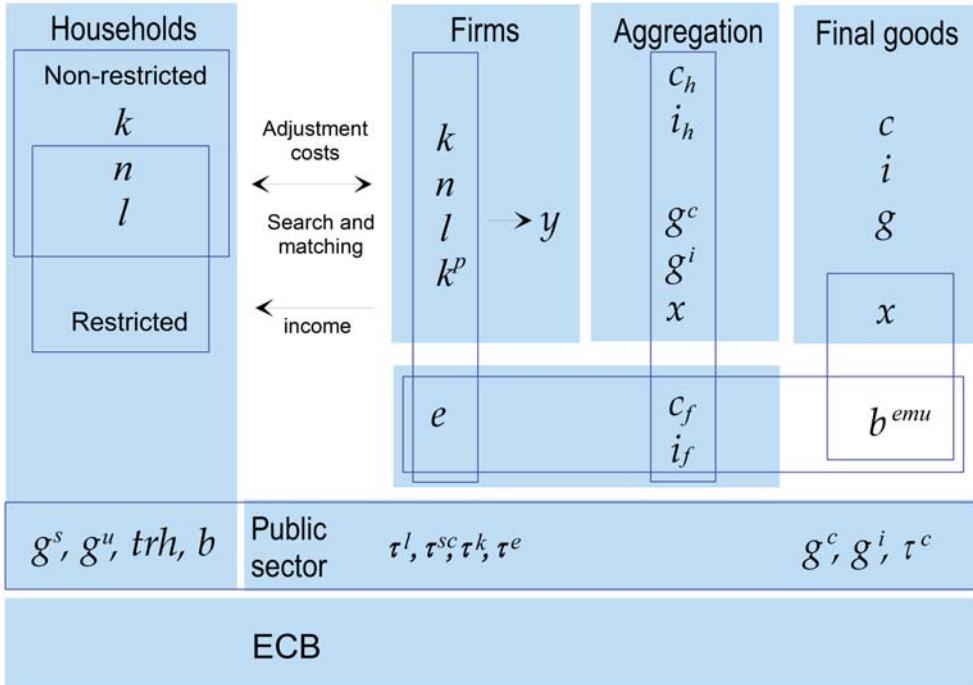


Figure 3: Agents, markets and variables in the REMS model.

ment. Each period the government faces a budget constraint where overall expenditure (public consumption,  $g^c$ , public investment,  $g^i$ , unemployment benefits,  $g^u$ , and other social transfers,  $g^s$ ) is financed by debt issuance ( $b$ ) and various distortionary taxes (labour income taxes,  $\tau^l$ , capital income taxes,  $\tau^k$ , social security contributions,  $\tau^{sc}$ , consumption taxes,  $\tau^c$ , and energy taxes,  $\tau^e$ ). Intertemporal sustainability of the fiscal balance is ensured by a conventional policy reaction function, whereby a lump-sum transfer,  $trh$ , accommodates the deviation of the debt-to-GDP ratio from its target level.

Monetary policy is managed by the European Central Bank (ECB) via a Taylor rule, which allows for some smoothing of the interest rate response to inflation and output gap (see below).

The intermediate sector is composed of monopolistically competitive firms which produce intermediate varieties employing capital, labour and energy. The final goods sector combines varieties of differentiated intermediate inputs to produce export goods ( $x$ ), as well as home produced consumption and investment goods ( $c_h$  and  $i_h$ ) which are imperfect substitutes for goods produced abroad ( $c_f$  and  $i_f$ ). Thus, total consumption ( $c$ ) and investment ( $i$ ) are defined as  $c = c_h + c_f$  and  $i = i_h + i_f$ . Net foreign assets ( $b^{emu}$ ) are

regarded as a stock variable resulting from the accumulation of current account flows.

The model is parameterised using Spanish data for the period 1985:3 to 2009:4. To this end, a database (REMSDB<sup>10</sup>) has been elaborated that satisfies the estimation and calibration requirements of the model and is suitable for generating a baseline scenario for REMS.

## 4. Results

The model described in the previous section is used here to simulate the advantages of a change in the tax mix in favour of increasing consumption taxes and reducing social security contributions. We illustrate it in two steps. First, we show the effects on GDP of a rise in every one of the different tax figures. Second, we find the equivalence between a fiscal devaluation, i.e., a change in the mix between consumption tax and social security contributions, and a more standard competitive devaluation taking place through the exchange rate.<sup>11</sup>

### 4.1 The effects of increasing taxes

As an indication of the different distortions originated by the set of taxes in the Spanish economy, we first perform an exercise consisting of permanently increasing the tax rates. The exercise is designed such as government revenues increase ex-ante by 1 percentage point of GDP. Figure 4 shows the accumulated effects on GDP after two years, in terms of its percentage deviation with respect to the steady state). This figure clearly shows that after two years the negative effect of rising taxes is greater for capital or social security taxes than for consumption taxes. This is the typical result in the theory of tax incidence in a dynamic framework. Capital taxation has important distortionary effects on economic activity (see, for example, Cooley, 1992 or Baylor, 2005). Higher capital taxes reduce the capital return net of taxes on impact, depressing investment and lowering the capital to labour ratio. In the long run, lower values for the capital stock and output negatively affect households consumption, given the steady-state reductions in wages and employment. Also in the REMS model increasing payroll or labour taxes is more harmful for economic activity than increasing indirect consumption taxes.

To compare the incidence of consumption taxes and social security contributions, let us define the tax wedge ( $\tau$ ) as the difference between the effective consumption wage

<sup>10</sup> See Boscá *et al.*, 2007, for further details.

<sup>11</sup> In this paper we focus on the effects of fiscal devaluation on employment and output. Using a similar small open economy model with equilibrium unemployment calibrated for the French economy, Langot, Patureauz and Soprasseth (2012) focus on the welfare effects of fiscal devaluations.

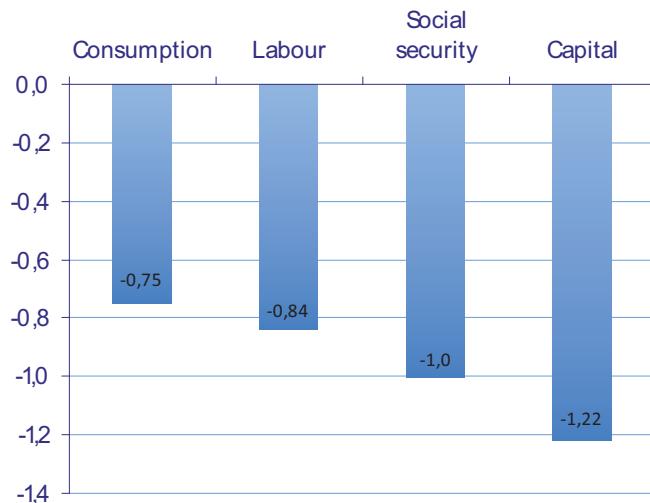
received by workers and the total effective cost paid by firms,

$$\tau = 1 - \frac{(1 - \tau^l)}{(1 + \tau^c)(1 + \tau^{sc})} \quad (1)$$

According to (1) given that the tax base of consumption is higher than the tax base of social security contributions, to maintain ex-ante revenue neutrality it is necessary to increase the tax rate on consumption less than the tax rate on social security contributions. This means that the tax wedge increases more using payroll taxes and, thus, generates larger distortionary effects (see a similar argument in Langot et al., 2012). In addition to this argument based on the tax base, the different effects of labour and consumption taxes can be explained by means of their influence on the behaviour of agents. Increasing payroll taxes has a direct negative effect on the value to firms of employing an additional worker and this disincentives the posting of vacancies, directly translating into lower wages and a reduction of hours worked. However, increasing consumption tax rates depresses consumption, consequently increasing the marginal utility of consumption, and making workers willing to negotiate lower wages, but contrary to payroll taxes stimulating negotiated hours. For this reason increasing consumption taxes is less harmful for output and employment than increasing social security contributions. Finally, comparing tax movements of direct labour taxes and social security contributions the effects on the economy may be ambiguous depending on the elasticity of labour demand and supply. An increase in labour taxes can be seen as an inward shift of the labour supply schedule, while increasing payroll taxes may be equivalent to a negative shift in labour demand. Although employment is harmed in both cases, the effect on wages is different and in general equilibrium the final effect on output and employment of both measures can be different depending on the structural characteristics of the economy. In the case of our model, as can be appreciated in Figure 4, the negative effect of rising social security contributions is greater than the effect of rising labour taxes.

#### 4.2 Modelling a fiscal devaluation

The empirical motivation presented in section 2 is very indicative of the existence of a positive gap in the ratio of social security contributions over consumption taxes in Spain, as compared to the average European country. In this subsection we study the effects of narrowing this gap, by simulating, with our model a, permanent reduction of 3.5 percentage points in the effective rate of employers' social security contributions  $\tau^{sc}$ . To maintain the condition of ex-ante revenue neutrality the effective tax rate on consumption ( $\tau^c$ ) has been increased by 2 percentage points. As explained in the introduction, this exercise has been called a fiscal devaluation in the literature. As can be seen in Table 2, the results imply that



**Figure 4:** Accumulated effects on GDP after 2 years (percentage deviation with respect to the steady state).

this replacement of social security contributions with VAT would have a cumulative effect on full-time equivalent employment of 1.3 per cent on the average for the first two years after the reform. This is equivalent to more than 200,000 jobs, while GDP would increase by 0.74%.<sup>12</sup> Additionally, the reduction of social security contributions increases exports by 0.9%, whereas the increase of activity leads to a significantly lower increase of imports of 0.4%, improving net exports, as suggested in section 2.

A detailed movement of the most relevant variables can be found in Figure (5) where we show the impulse-response functions for key variables along the forty quarters after the devaluation. According to the first plot, a different behaviour of investment and consumption is behind the effect on GDP. Whereas the combination of lower social security contributions and a higher tax on consumption boosts the investment from the very beginning due to the increase in the Tobin's q, it reduces consumption in the very short run before recovering afterwards, following an increase in the expected future income. Also from the second plot it is clear that the depreciation in the real exchange rate that follows after a fiscal devaluation has a positive effect on the volume of exports that reaches its maximum after two years. However, from the point of view of imports there are two opposite effects at play. On the one hand, the depreciation in the real exchange rate induces a substitution of imports by domestic production (substitution effect). On the other hand, the increase in the domestic demand contributes to pushing imports up (an income effect). Overall, the dynamics of the trade balance (not represented in the figure)

<sup>12</sup> Similar results were obtained by BBVA Research (2009), where a previous version of REMS was used.

TABLE 2: Equivalence between exchange rate and fiscal devaluations

Variable	Fiscal devaluation			Exchange rate devaluation		
	Year 1	Year 2	Average	Year 1	Year 1	Average
GDP	0.55	0.93	0.74	0.94	0.26	0.60
Employment	1.42	1.19	1.30	1.46	1.14	1.30
Exports	0.76	1.08	0.92	12.1	12.1	12.1
Imports	0.31	0.48	0.39	-12.2	-13.1	-12.6
Real Exchange Rate	0.59	0.83	0.70	9.18	9.16	9.17
$\Delta r^{emu}$ (pp) <sup>1</sup>	0	0	0	35	35	35
$\Delta VAT$ (pp) <sup>2</sup>	2.00	2.00	2.00	0	0	0
$\Delta$ Social contributions (pp) <sup>2</sup>	-3.50	-3.50	-3.50	0	0	0

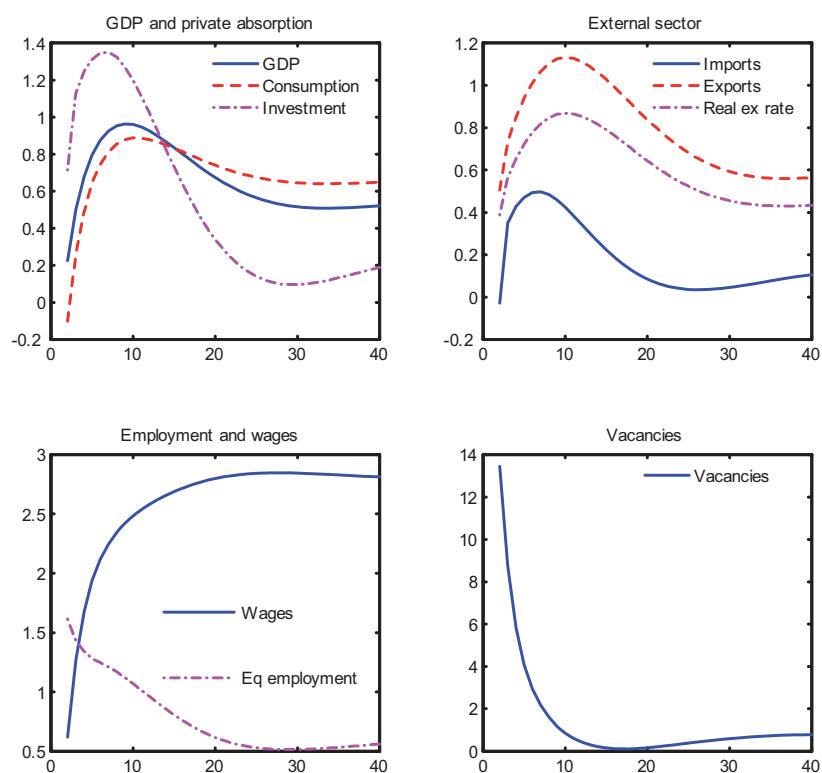
Notes: cumulated deviation in percentage points with respect to the baseline, except for VAT and social contributions. 1 Shock on the EMU interest rate to generate an increase in employment equivalent to that obtained with a fiscal devaluation. 2 Exogenous change in the tax rate.

displays the typical 'J-curve', with an initial positive effect on impact, followed by a deterioration induced by the increase in import prices that disappears in the medium term. Regarding the two last plots in the figure, as explained in the comments to Figure (4), the fall in social security contributions provokes an increase in both vacancies (and hence in employment) and hours per worker. The increase in consumption tax reinforces this last effect, making the impact on total hours highly positive. This, in addition to the increase in wages, augments labour income which is in part responsible for the positive effect in aggregate demand and GDP.

Now we establish a comparison between the consequences of the fiscal devaluation and the effects that an exchange rate devaluation may have on an economy similar to Spain. The only differences between Spain and this virtual economy would be in the existence of its own national central bank that manages monetary policy and can influence nominal exchange rates. Thus, we assume that the national central bank has complete sovereignty over the interest rate and that the exchange rate is flexible. For this reason we need to slightly modify some equations in our model. In the original model, monetary policy is managed by the European Central Bank (ECB) via the following Taylor rule, which allows for some smoothness of the interest rate response to the inflation and output gap:

$$\ln \frac{1 + r_t^{emu}}{1 + r_{t-1}^{emu}} = \rho^r \ln \frac{1 + r_{t-1}^{emu}}{1 + r_{t-2}^{emu}} + \rho^\pi (1 - \rho^r) \ln \frac{1 + \pi_t^{emu}}{1 + \pi_{t-1}^{emu}} + \rho^y (1 - \rho^r) \Delta \ln y_t^{emu} \quad (2)$$

where all the variables with the superscript "emu" refer to EMU aggregates. Thus,  $r_t^{emu}$  and  $\pi_t^{emu}$  are the euro-zone (nominal) short-term interest rate and inflation as measured in terms of the consumption price deflator and  $\Delta \ln y_t^{emu}$  measures the relative deviation of



**Figure 5:** Impulse-response after a fiscal devaluation

GDP growth from its trend. There is also some inertia in nominal interest rate setting. The Spanish economy contributes to EMU inflation according to its economic size in the euro zone,  $\omega_{Sp}$ :

$$\pi_t^{emu} = (1 - \omega_{Sp})\bar{\pi}_t^{remu} + \omega_{Sp}\pi_t^{sp} \quad (3)$$

where  $\bar{\pi}_t^{remu}$  is average inflation in the rest of the Eurozone. In addition, the disappearance of national currencies since the inception of the monetary union means that the intra-euro-area real exchange rate is 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 of the Spanish economy vis-à-vis the euro area:

$$\frac{rer_{t+1}}{rer_t} = \frac{1 + \pi_{t+1}^{emu}}{1 + \pi_{t+1}^{sp}} \quad (4)$$

To simulate the effects of a nominal devaluation we consider, first, as though the counterfactual economy had an independent central bank managing monetary policy. Thus, we set  $\omega_{Sp} = 1$ , and the Taylor's rule becomes

$$\ln \frac{1 + r_t^{sp}}{1 + r^{sp}} = \rho^r \ln \frac{1 + r_{t-1}^{sp}}{1 + r^{sp}} + \rho^\pi (1 - \rho^r) \ln \frac{1 + \pi_t^{sp}}{1 + \pi^{sp}} + \rho^y (1 - \rho^r) \Delta \ln y_t^{sp} \quad (5)$$

Second, given that we have to consider a nominal exchange rate, we substitute equation (4) with an uncovered interest rate parity:

$$1 + r_t^{sp} = (1 + \varepsilon_t \bar{r}^{remu}) \frac{rer_{t+1}}{rer_t} \frac{1 + \pi_{t+1}^{sp}}{1 + \pi_{t+1}^{emu}} \quad (6)$$

where  $\varepsilon_t$  captures the exogenous shock on the foreign interest rate that we need to generate the nominal exchange rate devaluation. To have a metric to compare the effects of the fiscal and nominal devaluations we have implemented a shock  $\varepsilon_t$  that generates with the nominal devaluation the same accumulated effect on employment after two years (1.3%).

According to the results in Table 2 an exchange rate depreciation of about 10% is required to generate similar employment effects to those obtained with the fiscal devaluation. As observed, the effects on GDP and employment are similar, although with less persistence, whereas the effects on exports and imports are much more pronounced. This suggests that, although the effects in terms of GDP and employment are similar, the composition effects of fiscal and nominal devaluations are different. In both cases, there is an improvement in net exports, but the effects on domestic and external demand are quite different.

Besides this composition effect, another difference between our nominal and fiscal

TABLE 3: Steady state results of the fiscal devaluation

Variable	Fiscal devaluation
	Steady state
GDP	0.55
Employment	0.58
Real Exchange Rate	0.46
Exports	0.59
Imports	0.13
$\Delta$ VAT (pp)	2.00
$\Delta$ Social contributions (pp)	-3.50

Cumulated deviation in percentage points with respect to the baseline, except for VAT and social contributions.

devaluations relates with the long term effects. Whereas the exchange rate devaluation is neutral from a steady state point of view, the fiscal devaluation has non-zero effects in the long run. This fact was already apparent in Figure (5). In Table 3 we show the exact long term effects. The reason we find non-zero steady-state effects is related to our design of the fiscal devaluation. Contrary to the ex-post revenue neutral exercise in Fahri et al (2011) we have implemented an ex-ante revenue neutral fiscal devaluation that can modify the steady state of the economy<sup>13</sup>. Thus, although total tax revenue would be constant if macroeconomic variables remained unaltered (ex-ante neutrality criterion), our change in the tax mix is going to effectively reduce economic distortions in the economy. This produces positive effects in macroeconomic variables, such as consumption, labour or wages, stimulating total tax revenues in the long run (ex-post revenue effect).

Finally, in order to check the robustness of our results, we have repeated the analysis of the effects of the fiscal devaluation considered in Table 2 under different specifications of our model. The results of these exercises are shown in Table 4. For each exercise we show average effects on employment and GDP after two years. To facilitate comparisons, the first row only shows the results of our baseline.

In the second row we show the results for  $\lambda^r = 0.8$ , that is, when we increase the share of rule-of-thumb consumers in the economy. The effects increase around 8 per cent with respect to the baseline. Conversely, as the share of Ricardian consumers is smaller, the effects of fiscal devaluation are also smaller, as row (3) shows.

In the fourth row we increase the bargaining power of workers ( $\lambda^w = 0.9$ ). A higher value of  $\lambda^w$  increases the sensitivity of wages to marginal labour productivity. In this case, the effects on employment and GDP are higher than in the baseline.

<sup>13</sup> This is also the approach in Langot et al (2012). This assumption is also more realistic from a policy-maker point of view.

TABLE 4: Sensitivity analysis. Average effects after two years

	Employment	GDP
(1) Baseline <sup>(1)</sup>	1.30	0.74
(2) $\lambda^r = 0.8$	1.40	0.81
(3) $\lambda^r = 0.0$	1.13	0.61
(4) $\lambda^w = 0.9$	1.60	0.97
(5) $\sigma_x, \sigma_c, \sigma_i \times 2$	1.31	0.76
(6) $s^x, \omega_c, \omega_i \times 0.5$	1.32	0.75
(7) $\rho^w = 0.9$	2.13	0.98
(8) $\eta = 1.5$	1.94	1.21

(1) Baseline values:  $\lambda^r = 0.5, \lambda^w = 0.43, \rho^w = 0.75, \eta = 2.0$

In the fifth row we multiply by 2 the elasticity of imports and exports to relative prices. In row (6), we reduce the degree of openness of the economy, dividing the scale factors in exports and imports equations ( $s^x, \omega_c$  and  $\omega_i$ ) by 2. In both cases the results show low sensitivity to these two sets of parameters.

In row (7) we show the case of a change in the coefficient of real wage inertia, from our baseline of  $\rho^w = 0.75$  to  $\rho^w = 0.9$ . We see our benchmark value of  $\rho^w = 0.75$  as a lower bound, given that it implies that wages adjust fully to negotiated wages after four quarters. With a value of  $\rho^w = 0.9$  full adjustment of wages would instead take ten quarters. As was shown in Figure (5) a fiscal devaluation induces a wage increase, because the reduction in social security contributions makes firms more willing to open new vacancies and to pay higher wages. Our results in row (7) confirm that making effective wages less dependent on negotiated wages increases the effects of the fiscal devaluation both on employment and GDP, since wages react upwards more slowly to the change in the tax structure. Hence, removing real rigidities from the wage setting process would reduce the impact that a fiscal devaluation has on GDP and employment, in the same way that the absence of nominal rigidities makes a nominal exchange rate devaluation ineffective.

In the last row we reduce the value of the parameter  $\eta$  from 2 to 1.5, implying that the Frisch elasticity of labour supply,  $1/\eta$ , increases from 0.5 to 0.67. As could be expected, a higher elasticity of labour supply makes negotiated hours more sensitive to a reduction in social security contributions, provoking a more intense effect of the fiscal devaluation on total employment and output.

#### 4.3 How feasible is it that a fiscal devaluation generates an economic stimulus?

The results presented in previous paragraphs point to significant positive effects on GDP

and employment of increasing VAT and simultaneously decreasing social contributions, similar to those that could be obtained with a nominal exchange rate devaluation. However, although these results are robust to different parameter configurations in our model, it is an open question if the proposed change in the tax mix may produce the desired results in the real economy. In this subsection we briefly discuss some important issues that may influence the way a fiscal devaluation may work in reality.

First, it must be noted that the final outcome of a fiscal devaluation depends crucially on the pass-through of VAT and payroll taxes to domestic prices. Increasing VAT and reducing social security contributions creates a positive gap between import prices and domestic prices. This change in relative prices is ultimately responsible for the gain in competitiveness and consequently for improvements in output and employment. Obviously, if the pass-through of VAT were complete, but the pass-through of payroll taxes were zero, the gains of the fiscal devaluation would disappear. Although it is difficult to accept such asymmetry, unfortunately, as far as we know, there is no empirical evidence on this issue for Spain. Fahri et al. (2011) provide some review of (the few) existing works for other countries. They conclude that, although pass-through from VAT to prices might have been important, the scarce existing evidence does not shed light on the magnitude of the pass-through from social security contributions.

Second, in political terms a fiscal devaluation has a very different conception than a nominal devaluation. Devaluating the exchange rate is a measure that can be adopted more than once in a short period of time (this has happened several times in many countries). However, a fiscal devaluation is only conceivable as a one-shot try to stimulate the economy in the short and mid term. Thus, it is crucial that economic agents perceive the measure as extraordinary, because if this is not the case labour supply decisions may change and make it less operative. Additionally, in countries like Spain the pension system is financed mainly through social security contributions and a measure like this would require a significant transfer from VAT revenues to the pension system (at least to ensure the same amount of revenues to the pension system as was the case previous to the fiscal consolidation).

Third, it must also be recognised that in the same vein that a nominal exchange rate devaluation can generate a process of competitive devaluations, a fiscal devaluation can also be adopted simultaneously by more than one country pertaining to the EMU. In fact, Germany approved such a measure in 2007 increasing VAT by 3 percentage points and cutting employer and employee payroll contributions by 2.3 percentage points. France at the end of 2012, Greece and Portugal have also recently discussed the convenience of this type of measure. A process of tax competition inside the EMU would reduce the effectiveness of any fiscal devaluation. The extent of this reduction to the benefits of a

fiscal devaluation depends crucially both on the share of trade with the rest of the partner countries and on the degree of competition in international product markets among these countries.

Fourth, the design of the fiscal devaluation matters. We have already shown that a higher value of the Frisch elasticity enhances the economic outcome of a fiscal devaluation (see Table 4). Thus, if workers in the lower part of the wage distribution display a higher elasticity of labour supply to wages, then cutting social security contributions for the worst paid workers could be more effective in terms of employment and output, due to the incentive of these workers to negotiate more hours for the same wage. Also, targeting the increase in VAT to tradable goods would reduce the relative price of non-tradables, creating a shift in demand from tradable towards non-tradable goods. If non-tradables were more labour intensive than tradables, this would reinforce the effect on employment of the cut in social security contributions. Finally, the timing in the implementation of the tax shift may also change the final effect of the measure. In our experiments we have assumed a non-anticipated fiscal devaluation. But if, for instance, agents anticipate a future increase in VAT, they would bring forward consumption, a decision that would reduce the positive impact of the fiscal devaluation on net exports.

Fifth, it can be argued that increasing VAT rates could contribute to higher tax evasion, but it is also true that lowering social security taxes could reduce tax fraud. Thus, the theoretical effect is ambiguous and country specific, depending on the administration's capacity to raise taxes and fight fiscal evasion. De Mooij and Keen (2012) conclude that, for Spain, the bad design of the VAT system, marked by frequent exemptions and different VAT rates, is more responsible than fraud for the low revenue from this tax. These authors suggest that increasing the VAT base would be a more effective way of compensating for the cut in social security contributions when designing the fiscal devaluation.

Sixth, there is a perception that VAT is a regressive tax, so increasing it could worsen income distribution<sup>14</sup>. Moreover, regarding particular VAT rates, some literature establishes the existence of a trade-off between efficiency and equity (see Ferri et al, 2009 or Crawford et al, 2010, for an argument on the VAT rate on food). However, any distributional effect of increasing VAT rates could be counteracted by means of targeted social benefits. In our baseline simulations ex-post total tax revenues increase by 0.25 percent of GDP after two years, providing some margin to redirect public funds for social support of the less favoured.

<sup>14</sup> In a recent study the European Commission (see Taxation Papers, WP 36, 2013) has analyzed the redistributive effects across income groups of fiscal devaluations in several European countries. In the case of the Spanish economy, microsimulation results show that the fiscal devaluation produces gains only for the richest 30 per cent. Nevertheless, these results do not take into account the dynamic effects of fiscal devaluation on income and employment, which could offset the negative effects on low income groups.

## 5. Conclusions

In this paper we have used a small open dynamic economy general equilibrium model to analyse the effects of a fiscal devaluation in EMU. The model has been calibrated for the Spanish economy, a country that is a good example of the advantages of a change in the tax mix, given that its tax system shows a positive bias in the ratio of social security contributions over consumption taxes. The results point to significant positive effects on GDP and employment of increasing VAT by 2 pp and simultaneously decreasing social contributions by 3.5 pp, similar to the ones that could be obtained with a exchange rate devaluation of about 10%. However, although the effects in terms of GDP and employment are similar, the composition effects of fiscal and nominal devaluations are not alike. In both cases, there is an improvement in net exports, but the effects on domestic and external demand are quite different. More generally, in the current circumstances in which many European countries should reduce their levels of public deficit and debt, similar to Cogan's et al (2012) proposal, our results show that fiscal consolidations should be accompanied by changes in the tax mix in order to reduce distortions on saving, employment, investment and capital accumulation, with beneficial effects on economic growth and welfare.

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## Appendix: The model

### 1. Optimizing households

Ricardian households face the following maximization programme:

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

subject to

$$\begin{aligned} & \left( r_t (1 - \tau_t^k) + \tau_t^k \delta \right) k_{t-1}^o + w_t \left( 1 - \tau_t^l \right) (n_{t-1}^o l_{1t} + \bar{r} s (1 - n_{t-1}^o) l_{2t}) + \left( \left( 1 - \tau_t^l \right) g_{st} - t r h_t \right) + \\ & \frac{m_{t-1}^o}{1 + \pi_t^c} + (1 + r_{t-1}^n) \frac{b_{t-1}^o}{1 + \pi_t^c} + (1 + r_{t-1}^{emu}) \frac{b_{t-1}^{o,emu}}{1 + \pi_t^c} \\ & - (1 + \tau_t^c) c_t^o \frac{P_t^c}{P_t} - \frac{P_t^i}{P_t} j_t^o \left( 1 + \frac{\phi}{2} \left( \frac{j_t^o}{k_{t-1}^o} \right) \right) - \gamma_A \gamma_N \left( m_t^o + b_t^o + \frac{b_t^{o,emu}}{\phi_{bt}} \right) = 0 \end{aligned} \quad (\text{A.2})$$

$$\gamma_A \gamma_N k_t^o = j_t^o + (1 - \delta) k_{t-1}^o \quad (\text{A.3})$$

$$\gamma_N n_t^o = (1 - \sigma) n_{t-1}^o + \rho_t^w s (1 - n_{t-1}^o) \quad (\text{A.4})$$

$c_t^o, n_{t-1}^o$  and  $s(1 - n_{t-1}^o)$  represent consumption, the employment rate and the unemployment rate of optimizing households;  $s$  is the (exogenous) share of the non-employed workers actively searching for jobs;  $T$ ,  $l_{1t}$  and  $l_{2t}$  are total endowment of time, hours worked per employee and hours devoted to job search by the unemployed.  $l_{1t}$  is determined jointly by the firm and the worker as part of the same Nash bargaining that is used to determine wages (see section 6 below).  $l_{2t}$  is assumed to be a function of the overall economic activity, so that individual households take it as given.

Future utility is discounted at a rate of  $\beta \in (0, 1)$ . The parameter  $\eta$  defines the Frisch elasticity of labour supply, which is equal to  $\frac{1}{\eta} \cdot h^o > 0$  indicates that consumption is subject to habits. The subjective value imputed to leisure by workers may vary across employment statuses, and thus  $\phi_1 \neq \phi_2$  in general.

The maximization of (A.1) is constrained as follows. The budget constraint (A.2) describes the various sources and uses of income. The term  $w_t (1 - \tau^l) n_{t-1}^o l_{1t}$  captures net labour income earned by the fraction of employed workers, where  $w_t$  stands for effective hourly real wages. The product  $\bar{r} w_t (1 - \tau^l) s (1 - n_{t-1}^o) l_{2t}$  measures unemployment benefits accruing to the unemployed, where  $\bar{r}$  denotes the replacement rate. We con-

sider staggered wages according to the expression  $w_t = w_{t-1}^{\rho^w} w_{t-1}^{*(1-\rho^w)}$  where  $w_t^*$  stands for the bargained wage (see below). Ricardian households hold four kinds of assets, namely private physical capital ( $k_t^o$ ), domestic and euro-zone bonds ( $b_t^o$  and  $b_t^{ow}$ ) and money balances ( $M_t^o$ ). Barring money, the remaining assets yield some remuneration. As reflected in  $r_t k_{t-1}^o (1 - \tau^k) + \tau^k \delta k_{t-1}^o$ , optimizing households pay capital income taxes less depreciation allowances after their earnings on physical capital. 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 differ because of a risk premium (see further below). The remaining two sources of revenues are lump-sum transfers,  $trh_t$ , and other government transfers,  $g_{st}$ .

The household's consumption is given by  $(1 + \tau^c) \frac{P_t^c}{P_t} c_t^o$ , where  $\tau^c$  is the consumption income tax. Investment into physical capital, which is affected by increasing marginal costs of installation, is captured by  $\frac{P_t^i}{P_t} j_t^o \left(1 + \frac{\phi}{2} \left(\frac{j_t}{k_{t-1}}\right)\right)$ . Note that 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  $\delta$  and is accumulated through investment,  $j_t^o$ . Thus, it evolves according to (A.3). Employment obeys the law of motion (A.4), where  $n_{t-1}^o$  and  $s(1 - n_{t-1}^o)$  respectively denote the share of employed and unemployed optimizing workers in the economy at the end of period  $t - 1$ . Each period employment is destroyed at the exogenous rate  $\sigma$  and new employment opportunities come at the rate  $\rho_t^w$ , which represents the probability that one unemployed worker will find a job. Although the job-finding rate  $\rho_t^w$  is taken as given by individual workers, it is endogenously determined at the aggregate level according to the following Cobb-Douglas matching function:

$$\rho_t^w s(1 - n_{t-1}) = \vartheta_t(v_t, n_{t-1}) = \chi_1 v_t^{\chi_2} [s(1 - n_{t-1}) l_{2t}]^{1-\chi_2} \quad (\text{A.5})$$

## 2. Rule-of-thumb households

*RoT* households do not have access to capital markets, so that they face the following maximization programme:

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

subject to the law of motion of employment (A.4) and the specific liquidity constraint

whereby each period's consumption expenditure must be equal to current labour income and government transfers, as reflected in:

$$w_t \left(1 - \tau_t^l\right) (n_{t-1}^r l_{1t} + \bar{r} \bar{s} (1 - n_{t-1}^r) l_{2t}) + g_{st} \left(1 - \tau_t^l\right) - trh_t - (1 + \tau_t^c) c_t^r \frac{P_t^c}{P_t} = 0 \quad (\text{A.6})$$

$$\gamma_N n_t^r = (1 - \sigma) n_{t-1}^r + \rho_t^w s (1 - n_{t-1}^r) \quad (\text{A.7})$$

### 3. Aggregation

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

$$c_t = (1 - \lambda^r) c_t^o + \lambda^r c_t^r \quad (\text{A.8})$$

$$n_t = (1 - \lambda^r) n_t^o + \lambda^r n_t^r \quad (\text{A.9})$$

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

$$k_t = (1 - \lambda^r) k_t^o \quad (\text{A.10})$$

$$j_t = (1 - \lambda^r) j_t^o \quad (\text{A.11})$$

$$b_t = (1 - \lambda^r) b_t^o \quad (\text{A.12})$$

$$b_t^{emu} = (1 - \lambda^r) b_t^{oemu} \quad (\text{A.13})$$

$$m_t = (1 - \lambda^r) m_t^o \quad (\text{A.14})$$

#### 4. 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.

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, namely, a CES composite input of private capital and energy, labour and public capital. Technology possibilities are given by:

$$y_{it} = z_{it} \left\{ \left[ ak_{it-1}^{-\rho} + (1-a)e_{it}^{-\rho} \right]^{-\frac{1}{\rho}} \right\}^{1-\alpha} (n_{it-1}l_{it})^\alpha \left( k_{it-1}^p \right)^\zeta \quad (\text{A.15})$$

where  $z_t$  represents a transitory technology shock. Each variety producer rents physical capital,  $k_{t-1}$ , and labour services,  $n_{t-1}l_{it}$ , 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. For the sake of clarity, let us denote capital services by  $k_{iet}$  as:

$$k_{iet} = \left[ ak_{it-1}^{-\rho} + (1-a)e_{it}^{-\rho} \right]^{-\frac{1}{\rho}} \quad (\text{A.16})$$

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)

$$\min_{k_t, n_t, v_t, e_t} E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{1t+1}^o}{\lambda_{1t}^o} \left( r_t k_{t-1} + w_t (1 + \tau^{sc}) n_{t-1} l_{it} + \kappa_v v_t + \frac{P_t^e}{P_t} e_t (1 + \tau^e) \right) \quad (\text{A.17})$$

subject to

$$y_t = z_{it} \left( \left[ ak_{t-1}^{-\rho} + (1-a)e_t^{-\rho} \right]^{-\frac{1}{\rho}} \right)^{1-\alpha} (n_{t-1}l_{it})^\alpha \left( k_{t-1}^p \right)^\zeta \quad (\text{A.18})$$

$$\gamma_N n_t = (1 - \sigma) n_{t-1} + \rho_t^f v_t \quad (\text{A.19})$$

$\kappa_v$  captures recruiting costs per vacancy,  $\tau^{sc}$  is the social security tax rate levied on gross wages, and  $\rho_t^f$  is the probability that a vacancy will be filled in any given period  $t$ .  $\rho_t^f$  is exogenously taken by the firm. However, from the perspective of the overall economy, this

probability is endogenously determined according to the following matching function:

$$\rho_t^w s(1 - n_{t-1}) = \rho_t^f v_t = \chi_1 v_t^{\chi_2} [s(1 - n_{t-1}) l_{2t}]^{1-\chi_2} \quad (\text{A.20})$$

## 5. Pricing behavior of intermediate firms: the New Phillips curve

Each firm faces a downward-sloping demand curve of the form:

$$y_{it} = y_t \left( \frac{P_{it}}{P_t} \right)^{-\varepsilon} \quad (\text{A.21})$$

where  $\left( \frac{P_{it}}{P_t} \right)$  is the relative price of variety  $y_i$ ,  $\varepsilon = (1 + \zeta) / \zeta$ , where  $\zeta \geq 0$  is the elasticity of substitution between intermediate goods, and  $y_t$  represents the production of the final good which combines varieties of differentiated intermediate inputs as follows

$$y_t = \left( \int_0^1 y_{it}^{1/(1+\zeta)} di \right)^{1+\zeta} \text{ and } P_t = \left( \int_0^1 P_{it}^{-\frac{1}{\zeta}} di \right)^{-\zeta} \quad (\text{A.22})$$

Variety producers act as monopolists and set prices when allowed. As in Calvo hypothesis (Calvo, 1983) we assume overlapping price adjustment. Each period, a proportion  $\theta$  of non-optimizing firms index prices to lagged inflation, according to the rule  $P_{it} = (1 + \pi_{t-1})^\varkappa P_{it-1}$  (with  $\varkappa$  representing the degree of indexation); a measure  $1 - \theta$  of firms set their prices  $\tilde{P}_t$  optimally. The corresponding aggregate price index is equal to

$$P_t = \left[ \theta (\pi_{t-1}^\varkappa P_{t-1})^{1-\varepsilon} + (1 - \theta) \tilde{P}_t^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \quad (\text{A.23})$$

Equation (A.23) can be used to obtain an expression for aggregate inflation of the form:

$$\pi_t = \frac{\beta}{1 + \varkappa\beta} E_t \pi_{t+1} + \frac{(1 - \beta\theta)(1 - \theta)}{\theta(1 + \varkappa\beta)} \widehat{mc}_t + \frac{\varkappa}{1 + \varkappa\beta} \pi_{t-1} \quad (\text{A.24})$$

where  $\widehat{mc}_t$  in  $mc_t = \frac{\varepsilon-1}{\varepsilon}(1 + \widehat{mc}_t)$  measures the deviation of the firm's marginal cost from the steady state. Equation (A.24) is known in the literature as the New Phillips curve.

## 6. Labour market negotiation

The outcome of the bargaining process maximizes the weighted individual surpluses from the match

$$\max_{w_{t+1}, l_{1t+1}} \left[ \lambda^r \frac{\lambda_{3t}^r}{\lambda_{1t}^r} + (1 - \lambda^r) \frac{\lambda_{3t}^o}{\lambda_{1t}^o} \right]^{\lambda^w} \left( \lambda_t^{nd} \right)^{(1-\lambda^w)} \quad (\text{A.25})$$

where  $\lambda^w \in (0, 1)$  reflects the worker's bargaining power. The two terms in brackets reflect the worker's and firm's surpluses from the bargain.  $\lambda_{3t}^o / \lambda_{1t}^o$  and  $\lambda_{3t}^r / \lambda_{1t}^r$  respectively denote the earning premium of employment over unemployment for a Ricardian and a *RoT* worker. Similarly,  $\lambda_t^{nd}$  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*.

Efficient real wage and hours worked (A.25) satisfy the following conditions :

$$\begin{aligned} w_t^* (1 - \tau^l) l_{1t} &= \lambda^w \left[ \frac{(1 - \tau^l)}{(1 + \tau^{sc})} \alpha m c_t \frac{y_t}{n_{t-1}} + \frac{(1 - \tau^l)}{(1 + \tau^{sc})} \frac{\kappa_v v_t}{(1 - n_{t-1})} \right] \\ &+ (1 - \lambda^w) \left[ \left( \frac{(1 - \lambda^r)}{\lambda_{1t}^o} + \frac{\lambda^r}{\lambda_{1t}^r} \right) \left( \phi_2 \frac{(1 - l_2)^{1-\eta}}{1 - \eta} - \phi_1 \frac{(1 - l_{1t})^{1-\eta}}{1 - \eta} \right) + (1 - \tau^l) g_{ut} \right] \\ &+ (1 - \lambda^w)(1 - \sigma - \rho_t^w) \lambda^r \beta E_t \frac{\lambda_{3t+1}^r}{\lambda_{1t+1}^r} \left( \frac{\lambda_{1t+1}^o}{\lambda_{1t}^o} - \frac{\lambda_{1t+1}^r}{\lambda_{1t}^r} \right) \end{aligned} \quad (\text{A.26})$$

$$\frac{(1 - \tau^l)}{(1 + \tau^{sc})} \alpha m c_t \frac{y_t}{n_{t-1} l_{1t}} = \phi_1 (T - l_{1t})^{-\eta} \left[ \frac{1 - \lambda^r}{\lambda_{1t}^o} + \frac{\lambda^r}{\lambda_{1t}^r} \right] \quad (\text{A.27})$$

where we see that the equilibrium wage in a search framework is a weighted average between the highest feasible wage (i.e., the marginal productivity of labour augmented by the expected hiring cost per unemployed worker) and the lowest acceptable wage (i.e., the reservation wage, as given by the second and third terms in the right hand side of (A.26)). Weights are given by the parties' bargaining power in the negotiation,  $\lambda^w$  and  $(1 - \lambda^w)$ . 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.

## 7. Government

It is assumed that government purchases of goods and services ( $g_t^c$ ) and public investment ( $g_t^i$ ) follow an exogenously given pattern, while interest payments on government bonds  $(1 + r_t)b_{t-1}$  are model-determined, as well as unemployment benefits  $g_{ut}(1 - n_{t-1})$  and government social transfers  $g_{st}$  which are given by

$$g_{ut} = \bar{r} \cdot w_t \quad (\text{A.28})$$

$$g_{st} = \bar{r} \cdot gdp_t \quad (\text{A.29})$$

whereby  $g_{ut}$  and  $g_{st}$  are indexed to the level of real wages,  $w_t$ , and activity,  $gdp_t$ , through  $\overline{rr}$  and  $\overline{tr}$ .

Government revenues are made up of direct taxation on labour income (personal labour income tax,  $\tau_t^l$ , and social security contributions,  $\tau_t^{sc}$ ) and capital income ( $\tau_t^k$ ), as well as indirect taxation, including a consumption tax at the rate  $\tau_t^c$ , and an energy tax at the rate  $\tau_t^e$ . Government revenues are therefore given by

$$\begin{aligned} t_t = & (\tau_t^l + \tau_t^{sc}) w_t (n_{t-1} l_{1t}) + \tau_t^k (r_t - \delta) k_{t-1} \\ & + \tau_t^c \frac{P_t^c}{P_t} c_t + \tau_t^e \frac{P_t^e}{P_t} e_t + trh_t + \tau_t^l \overline{rr} w_t s (1 - n_{t-1}) l_{2t} + \tau_t^l g_{st} \end{aligned} \quad (\text{A.30})$$

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

Goverment revenues and expenditures each period are made consistent by means of the intertemporal budget constraint

$$\gamma_A \gamma_N b_t = g_t^c + g_t^i + g_{ut}s(1 - n_{t-1}) l_{2t} + g_{st} - t_t + \frac{(1 + r_t^n)}{1 + \pi_t} b_{t-1} \quad (\text{A.31})$$

In order to enforce the government's intertemporal budget constraint, the following fiscal policy reaction function is imposed

$$trh_t = trh_{t-1} + \psi_1 \left[ \frac{b_t}{gdp_t} - \overline{\left( \frac{b}{gdp} \right)} \right] + \psi_2 \left[ \frac{b_t}{gdp_t} - \frac{b_{t-1}}{gdp_{t-1}} \right] \quad (\text{A.32})$$

where  $\psi_1 > 0$  captures the speed of adjustment from the current ratio towards the desired target  $\overline{\left( \frac{b}{gdp} \right)}$ . The value of  $\psi_2 > 0$  is chosen to ensure a smooth adjustment of current debt towards its steady-state level.

Government investment (exogenous in the model) augments public capital, which, given the depreciation  $\delta^p$ , follows the law of motion:

$$\gamma_A \gamma_N k_t^p = g_t^i + (1 - \delta^p) k_{t-1}^p \quad (\text{A.33})$$

## 8. Monetary policy

Monetary policy is managed by the European Central Bank (ECB) via the following Taylor rule, which allows for some smoothness of the interest rate response to the inflation and output gap

$$\ln \frac{1 + r_t^{emu}}{1 + \overline{r^{emu}}} = \rho^r \ln \frac{1 + r_{t-1}^{emu}}{1 + \overline{r^{emu}}} + \rho^\pi (1 - \rho^r) \ln \frac{1 + \pi_t^{emu}}{1 + \overline{\pi^{emu}}} + \rho^y (1 - \rho^r) \Delta \ln y_t^{emu} \quad (\text{A.34})$$

where all the variables with the superscript "emu" refer to EMU aggregates. Thus,  $r_t^{emu}$  and  $\pi_t^{emu}$  are the euro-zone (nominal) short-term interest rate and inflation as measured in terms of the consumption price deflator and  $\Delta \ln y_t^{emu}$  measures the relative deviation of GDP growth from its trend. There is also some inertia in nominal interest rate setting.

The Spanish economy contributes to EMU inflation according to its economic size in the euro zone,  $\omega_{Sp}$ :

$$\pi_t^{emu} = (1 - \omega_{Sp}) \overline{\pi}_t^{remu} + \omega_{Sp} \pi_t \quad (\text{A.35})$$

where  $\overline{\pi}_t^{remu}$  is average inflation in the rest of the Eurozone.

Intra-euro-area real exchange rate is 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 of the Spanish economy vis-à-vis the euro area:

$$\frac{rer_{t+1}}{rer_t} = \frac{1 + \pi_{t+1}^{emu}}{1 + \pi_{t+1}} \quad (\text{A.36})$$

## 9. The External Sector

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

Consumption and investment distributors determine the share of aggregate consumption (investment) to be satisfied with home produced goods  $c_h$  and  $i_h$ , and foreign imported goods  $c_f$  and  $i_f$ . The aggregation technology is expressed by the following CES functions:

$$c_t = \left( (1 - \omega_{ct})^{\frac{1}{\sigma_c}} c_{ht}^{\frac{\sigma_c-1}{\sigma_c}} + \omega_{ct}^{\frac{1}{\sigma_c}} (c_{ft})^{\frac{\sigma_c-1}{\sigma_c}} \right)^{\frac{\sigma_c}{\sigma_c-1}} \quad (\text{A.37})$$

$$i_t = \left( (1 - \omega_{it})^{\frac{1}{\sigma_i}} i_{ht}^{\frac{\sigma_i-1}{\sigma_i}} + \omega_{it}^{\frac{1}{\sigma_i}} (i_{ft})^{\frac{\sigma_i-1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i-1}} \quad (\text{A.38})$$

where  $\sigma_c$  and  $\sigma_i$  are the consumption and investment elasticities 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 (A.37).

The optimal allocation of aggregate consumption between domestic and foreign goods,  $c_{ht}$  and  $c_{ft}$ , satisfies the following conditions:

$$c_{ht} = (1 - \omega_c) \left( \frac{P_t}{P_t^c} \right)^{-\sigma_c} c_t \quad (\text{A.39})$$

$$c_{ft} = \omega_c \left( \frac{P_t^m}{P_t^c} \right)^{-\sigma_c} c_t \quad (\text{A.40})$$

where  $P_t$  and  $P_t^m$  are respectively the prices of home and foreign produced goods, and  $P_t^c$  represents the price of the consumption good.

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  $i_{ft}$

$$i_{ht} = (1 - \omega_i) \left( \frac{P_t}{P_t^i} \right)^{-\sigma_i} i_t \quad (\text{A.41})$$

$$i_{ft} = \omega_i \left( \frac{P_t^m}{P_t^i} \right)^{-\sigma_i} i_t \quad (\text{A.42})$$

## 9.2 Price formation

The price of domestically produced consumption and investment goods is the GDP deflator,  $P_t$ . In order to obtain the consumption price deflator, the demands for home and foreign consumption goods (A.39) and (A.40) need to be incorporated 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 unitary production cost is equal to the price of production, one can express the consumption and investment price deflators as a function of the GDP and import deflators

$$P_t^c = \left( (1 - \omega_{ct}) P_t^{1-\sigma_c} + \omega_{ct} P_t^{m1-\sigma_c} \right)^{\frac{1}{1-\sigma_c}} \quad (\text{A.43})$$

$$P_t^i = \left( (1 - \omega_{it}) P_t^{1-\sigma_i} + \omega_{it} P_t^{m1-\sigma_i} \right)^{\frac{1}{1-\sigma_i}} \quad (\text{A.44})$$

The exogenous world price is a weighted average of the final and intermediate goods 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:

$$P_t^m = (\tilde{\alpha}_e P_t^e + (1 - \tilde{\alpha}_e) \overline{PFM}_t) \quad (\text{A.45})$$

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

We assume some degree of pricing-to-market considering a fraction of  $(1 - ptm)$  firms whose prices at home and abroad differ. The remaining  $ptm$  goods can be freely traded by consumers so firms set a unified price across countries (i.e., the law of one price holds). The Spanish export price deflator is then defined as

$$P_t^x = P_t^{(1-ptm)} (\overline{PFM}_t)^{ptm} \quad (\text{A.46})$$

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

### 9.3 Exports and Imports

The national economy imports two final goods, consumption and investment, and one intermediate commodity, energy:

$$im_t = c_{ft} + i_{ft} + \alpha_e e_t \quad (\text{A.47})$$

where  $\alpha_e$  represents the ratio of energy imports over total energy consumption.

Exports are a function of aggregate consumption and investment abroad,  $\bar{y}_t^w$ , and the ratio of the export price deflator to the competitors price index (expressed in euros),  $P_t^x / \overline{PFM}_t$ :

$$ex_t = s_t^x \left( \frac{P_t^x}{\overline{PFM}_t} \right)^{-\sigma_x} \bar{y}_t^w \quad (\text{A.48})$$

where  $\sigma_x$  is the long-run price elasticity of exports.

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

The current account balance is defined as the trade balance plus net factor income from abroad:

$$ca_t = \frac{P_t^x}{P_t} ex_t - \frac{P_t^m}{P_t} im_t + (r_t^{emu} - \pi_t) b_{t-1}^{oemu} \quad (\text{A.49})$$

Net foreign assets are regarded as a stock variable resulting from the accumulation of current account flows:

$$\frac{\gamma_A \gamma_N b_t^{oemu}}{\phi_{bt}} = \frac{(1 + r_t^{emu})}{1 + \pi_t^c} b_{t-1}^{oemu} + \frac{P_t^x}{P_t} ex_t - \frac{P_t^m}{P_t} im_t \quad (\text{A.50})$$

## 10. Accounting identities in the economy

Gross output can be defined as the sum of demand components and the consumption of energy:

$$y_t = c_{ht} + i_{ht} + g_t^i + g_t^c + \frac{P_t^x}{P_t} ex_t + \kappa_v v_t + \frac{P_t^e}{P_t} (1 - \alpha_e) e_t + \kappa_f \quad (\text{A.51})$$

where  $\kappa_f$  is an entry cost which ensures that extraordinary profits vanish in imperfectly-competitive equilibrium in the long-run. Value added generated in the economy is given by:

$$gd p_t = y_t - \frac{P_t^e}{P_t} e_t - \kappa_f - \kappa_v v_t \quad (\text{A.52})$$

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## Contact details

**BBVA Research**  
Paseo Castellana, 81 - 7th floor  
28046 Madrid (Spain)  
Tel: +34 91 374 60 00 and +34 91 537 70 00  
Fax: +34 91 374 30 25  
[bbvareresearch@bbva.com](mailto:bbvareresearch@bbva.com)  
[www.bbvareresearch.com](http://www.bbvareresearch.com)