ropean Central Bank (ECB) via the following Taylor rule, which allows for some smoothness of the interest rate response to the inflation and output gap:

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

where all the variables with the superscript *"emu"* refer to EMU aggregates Thus, r_t^{emu} and π_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, ω_{sp}:

$$\pi_t^{emu}=(1-\omega_{sp})\overline{\pi_t^{remu}}+\omega_{sp}\pi_t^{sp}$$

where $\overline{\pi_t^{remu}}$ 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:

$$\frac{rer_{t+1}}{rer_t}=\frac{1+\pi_{t+1}^{emu}}{1+\pi_{t+1}^{sp}}$$

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 ω_{sp}=1, and the Taylor's rule becomes

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

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

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

where ε_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 ε_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 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 [13]. 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, estimulating total tax revenues in the long run (ex-post revenue effect).

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
ΔVAT (pp)	2.00
ΔSocial contributions (pp)	–3.50

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

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 λ^r=0.8, that is, when we increase the share of rule-of-thumb consumers in the economy. The effects increase around 8% 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 (λ^w=0.9). A higher value of λ^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.

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, w_c and w_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 ρ^w=0.75 to ρ^w=0.9. We see our benchmark value of ρ^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 ρ^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 η 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.

Table 4
SENSITIVITY ANALYSIS. AVERAGE EFFECTS AFTER TWO YEARS

	Employment	GDP
(1) Baseline[1]	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) σ_x, σ_c, σ_i, x 2	1.31	0.76
(6) s^x, ω_c, ω_i, x 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: $\lambda^r = 0.5$, $\lambda^w = 0.43$, $\rho^w = 0.75$, $\eta = 2.0$.

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 devaluation).

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 [14]. 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.

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.

Appendix: The model

1. Optimizing households

Ricardian households face the following maximization programme:

$$\max_{\substack{c_t^0, n_t^0, j_t^0, k_t^0, \\ b_t^0, b_t^{0,emu}, m_t^0}} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t^o - h^o c_{t-1}^o) + n_{t-1}^o \varphi_1 \frac{(T - l_{1t})^{1-\eta}}{1-\eta} + (1 - n_{t-1}^o)\varphi_2 \frac{(T - l_{2t})^{1-\eta}}{1-\eta} + \chi_m \ln(m_t^o) \right] \quad \text{(A.1)}$$

subject to

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

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

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

c^o_t, n^o_{t-1} and $s(1–n^o_{t-1})$ 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 is l_{1t} determined jointly by the firm and the worker as part of the same Nash bargaing 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 η defines the Frisch elasticity of labour supply, which is equal to $1/\eta$. $h^o>0$ indicates that consumption is subject to habits. The subjective value imputed to leisure by workers may vary across employment statuses, and thus $\varphi_1 \neq \varphi_2$ in general.

The maximization problem is constrained as follows. The budget constraint (A.2) describes the various sources and uses of income. The term $w_t(1–\tau^l)n^o_{t-1}l_{1t}$ captures net labour income earned by the fraction of employed workers, where w_t stands for effective hourly real wages. The product $\overline{rr}w_t(1-\tau^l)s(1-n^o_{t-1})l_{2t}$ measures unemployment benefits accruing to the unemployed, where $\overline{rr}$ denotes the replacement rate. We consider 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^o_t), domestic and euro-zone bonds (b^o_t and k^{ow}_t) and money balances (M^o_t). Barring money, the remaining assets yield some remuneration. As reflected in $r_t k^o_{t-1}(1-\tau^k) + \tau^k\delta k^o_{t-1}$, 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 $r^n_{t-1}\frac{b^o_{t-1}}{1+\pi^c_t}$ and $r^{emu}_{t-1}\frac{b^{ow}_{t-1}}{1+\pi^c_t}$, 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 $(1+\tau^c)\frac{P^c_t}{P_t}c^o_t$, τ^c where is the consumption income tax. Investment into physical capital, which is affected by increasing marginal costs of installation, is captured by $\frac{P^i_t}{P_t}j^o_t(1+\frac{\varphi}{2}(\frac{j_t}{k_{t-1}}))$. Note that the presence in the model of the relative prices P^c_t/P_t and P^i_t/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^o_t depreciates at the exogenous rate δ and is accumulated through investment, j^o_t. Thus, it evolves according to (A.3). Employment obeys the law of motion (A.4), where n^o_{t-1} and $s(1-n^o_{t-1})$ 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 σ and new employment opportunities come at the rate ρ^w_t, which represents the probability that one unemployed worker will find a job. Although the job-finding rate ρ^w_t is taken as given by individual workers, it is endogenously determined at the aggregate level according to the following Cobb-Douglas matching function:

$$\rho^w_t s(1-n_{t-1}) = \vartheta_t(v_t, n_{t-1}) = \chi_1 v_t^{\chi_2}\left[s(1-n_{t-1})l_{2t}\right]^{1-\chi_2} \tag{A.5}$$

2. Rule-of-thumb households

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

$$\max_{c^r_t, n^r_t} E_t\sum_{t=0}^{\infty}\beta^t\left[\ln(c^r_t - h^r c^r_{t-1}) + n^r_{t-1}\varphi_1\frac{(T-l_{1t})^{1-\eta}}{1-\eta} + (1-n^r_{t-1})\varphi_2\frac{(T-l_{2t})^{1-\eta}}{1-\eta}\right]$$

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:

$$w_t(1-\tau_t^l)(n_{t-1}^r l_{1t} + \overline{rr}s(1-n_{t-1}^r)l_{2t}) + g_{st}(1-\tau_t^l) - trh_t - (1+\tau_t^c)c_t^r \frac{P_t^c}{P_t} = 0 \tag{A.6}$$

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

3. Aggregation

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

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

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

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

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

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

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

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

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

4. Factor demands

Production in the economy takes place at two different levels. At the lower level, an infinite number of mopolistically 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∊(0,1)* uses three inputs, namely, a CES composite input of private capital and e-nergy, labour and public capital. Technology possibilities are given by:

$$y_{it} = z_{it} \left\{ \left[\alpha k_{it-1}^{-\rho} + (1-\alpha) e_{it}^{-\rho} \right]^{-\frac{1}{\rho}} \right\}^{1-\alpha} (n_{it-1} l_{i1t})^{\alpha} (k_{it-1}^{p})^{\zeta} \tag{A.15}$$

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

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

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)

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

subject to

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

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

κ_v captures recruiting costs per vacancy, τ^{sc} is the social security tax rate levied on gross wages, and ρ_t^f is the probability that a vacancy will be filled in any given period *t*. ρ_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:

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

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

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

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

where — is the relative price of variety y_i, $\varepsilon=(1+\varsigma)/s$, where $\varsigma \geq 0$ 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

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

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 θ of non-optimizing firms index prices to lagged inflation, according to the rule (with χ representing the degree of indexation); a measure $1-\theta$ of firms set their prices $\widehat{P}_t$ optimally. The corresponding aggregate price index is equal to

$$P_t = \left[\theta(\pi_{t-1}^{\chi} P_{t-1})^{1-\varepsilon} + (1-\theta)\widehat{P}_t^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{A.23}$$

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

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

where $\widehat{mc}_t$ in $mc_t = \varepsilon\text{-}1(1+\widehat{mc}_t)$ measures the deviation of the firm's marginal cost from the steady state. Equation (phillips curve) 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

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

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

$$\begin{aligned} w_t^*(1-\tau^l)l_{1t} = {} & \lambda^w \left[\frac{(1-\tau^l)}{1+\tau^{sc}} \alpha mc_t \frac{y_t}{n_{t-1}} + \frac{(1-\tau^l)}{(1+\tau^{sc})} \frac{(\kappa_v v_t)}{(1-n_{t-1})}\right] + \\ & +(1-\lambda^w)\left[\left(\frac{(1-\lambda^r)}{\lambda_{1t}^o} + \frac{\lambda^r}{\lambda_{1t}^r}\right)\left(\varphi_2 \frac{(1-l_2)^{1-\eta}}{1-\eta} - \varphi_1 \frac{(1-l_{1t})^{1-\eta}}{1-\eta}\right) + (1-\tau^l) g_{ut}\right] + \\ & +(1-\lambda^w)(1-\sigma-\rho_t^w)\lambda^r \beta E_t \frac{\lambda_{3t+1}^r}{\lambda_{1t+1}^r}\left(\frac{\lambda_{1t+1}^o}{\lambda_{1t}^o} - \frac{\lambda_{1t+1}^r}{\lambda_{1t}^r}\right) \end{aligned} \tag{A.26}$$

$$\frac{(1-\tau^{l})}{(1+\tau^{sc})}\alpha mc_t \frac{y_t}{n_{t-1}l_{1t}} = \varphi_1 (T - l_{1t})^{-\eta}\left[\frac{1-\lambda^r}{\lambda_{1t}^0} + \frac{\lambda^r}{\lambda_{1t}^r}\right] \qquad \text{(A.27)}$$

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, λ^w and $(1-\lambda^w)$. Notice that when λ^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

$$g_{ut} = \overline{rr} \cdot w_t \qquad \text{(A.28)}$$

$$g_{st} = \overline{tr} \cdot gdp_t \qquad \text{(A.29)}$$

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, τ_t^l, and social security contributions, τ_t^{sc}) and capital income (τ_t^k), as well as indirect taxation, including a consumption tax at the rate τ_t^c, and an energy tax at the rate τ_t^e. Government revenues are therefore given by

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

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

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

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 δ^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

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

where all the variables with the superscript *"emu"* refer to EMU aggregates Thus, r_t^{emu} and π_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, ω_{sp}:

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

where $\overline{\pi_t^{emu}}$ 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:

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

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

where σ_c and σ_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:

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

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

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_{th} and i_{fh}

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

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

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 ($P_t c_{ht} + P^m_t c_{ft}$). 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

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

$$P_t^i = \left((1-\omega_{it})P_t^{1-\sigma_i} + \omega_{it}P_t^{m1-\sigma_i}\right)^{\frac{1}{1-\sigma_1}} \quad \text{(A.44)}$$

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:

$$P^m_t = (\widehat{\alpha}_e P^e{}_t + (1-\widehat{\alpha}_e)\,\overline{PFM}_t) \quad \text{(A.45)}$$

where $\widehat{\alpha}_e$ 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

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

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

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

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

where σ_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:

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

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

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

10. Accounting identities in the economy

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

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

where κ_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:

$$gdp_t = y_t - \frac{P_t^e}{P_t} e_t - \kappa_f - \kappa_v v_t \tag{A.52}$$

Notes

1. 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.
2. 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).
3. For a complete description of the model, see Boscá *et al.* (2010) and Boscá *et al.* (2011).

4. 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.

5. 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.

6. 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.

7. The sample 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.

8. 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 τ^{sc}/τ^{c} to the country dummy, after adding the corresponding sample averages. The Frisch-Waugh theorem states that the multiple regression coefficient of τ^{sc}/τ^{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 τ^{sc}/τ^{c}.

9. 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).

10. See Boscá *et al.,* 2007, for further details.

11. 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 Sopraseuth (2012) focus on the welfare effects of fiscal devaluations.

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

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

14. 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.

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Resumen

En este artículo utilizamos un modelo de equilibrio general para una pequeña economía abierta para analizar los efectos de una devaluación fiscal en los países de la eurozona. El modelo ha sido calibrado para la economía española, que es un buen ejemplo de las ventajas potenciales de una devaluación fiscal, dado que su sistema impositivo se caracteriza por una ratio de las contribuciones a la seguridad social sobre la imposición indirecta mayor que otros países de la eurozona. La evidencia empírica para los países europeos indica que esta ratio mantuvo una correlación negativa con el saldo de la balanza por cuenta corriente en los años de expansión previos a la crisis de 2009, un periodo en el que muchos miembros de la eurozona acumularon grandes desequilibrios externos. Los resultados simulados con nuestro modelo apuntan importantes efectos positivos de una devaluación fiscal sobre el PIB y el empleo, similares a los que se podrían obtener con una devaluación del tipo de cambio, aunque con efectos distintos en la composición de la demanda agregada. En ambos casos, hay una mejora de las exportaciones netas, pero los efectos sobre la demanda interna y externa son bastante diferentes.

Palabras clave: estructura impositiva, devaluación fiscal, devaluación nominal.

Clasificación JEL: E62, E47, F31.