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IN A MONETARY UNION

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# DECIPHERING THE MACROECONOMIC EFFECTS OF INTERNAL DEVALUATIONS IN A MONETARY UNION (\*)

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## Abstract

We study the macroeconomic effects of internal devaluations undertaken by a periphery of countries belonging to a monetary union. We find that internal devaluations have large and positive output effects in the long run. Through an expectations channel, most of these effects carry over to the short run. Internal devaluations focused on goods markets reforms are generally more powerful in stimulating growth than reforms aimed at moderating wages, but the latter are less deflationary. For a monetary union with a periphery the size of the euro area's, the countries at the periphery benefit from internal devaluations even at the zero lower bound (ZLB) of the nominal interest rate. Nevertheless, when the ZLB binds, there is a case for a sequencing of reforms that prioritizes labor policies over goods markets reforms.

**Keywords:** monetary union, internal devaluation, structural reforms, zero lower bound, policy sequencing.

**JEL classification:** E44, E63, D42.

## Resumen

Estudiamos los efectos macroeconómicos de devaluaciones internas llevadas a cabo en los países de la periferia de una unión monetaria. Encontramos que las devaluaciones internas tienen efectos grandes y positivos sobre el *output* en el largo plazo. A través del canal de expectativas, la mayor parte de estos efectos se traslada también al corto plazo. Las devaluaciones internas centradas en mercados de bienes son generalmente más potentes para estimular el crecimiento en el corto plazo que las centradas en la moderación salarial, pero estas últimas resultan menos deflacionarias. En una unión monetaria como el área del euro, los países de la periferia se benefician de estas devaluaciones internas incluso estando en la cota cero (CC) de los tipos de interés nominales. Sin embargo, en la CC existen argumentos a favor de una secuencia de reformas que comience por las del mercado de trabajo y aplique con cierto retraso las de mercados de bienes.

**Palabras clave:** devaluación interna, unión monetaria, secuencia de políticas, reformas estructurales, cota cero de los tipos de interés.

**Códigos JEL:** E44, E63, D42.

# 1 Introduction

Many policymakers and economists have read the European debt crisis of 2009-2014 as a call to increase the competitiveness of the periphery of the euro area, mainly Italy, Spain, Portugal, and Greece. For example, Draghi (2017) and the OECD (2015) have argued that such an increase is vital to enhancing the growth prospects of these countries and reducing their dependency on foreign savings. The economic fallout from the ongoing health crisis, which has hit Italy and Spain particularly hard, is bound to revive this discussion over the next several years as these countries struggle to rebuild their economies.

Since nominal devaluations are impossible within a monetary union, Italy and Spain have few short-run alternatives to restore competitiveness except through an internal devaluation.<sup>1</sup> In those internal devaluations, a variety of policies push domestic prices and wages down in a persistent manner.

A straightforward policy to achieve this is to reduce production costs, for example, with lower VAT or payroll taxes (Farhi et al., 2014). Unfortunately, the delicate budgetary conditions and the high public debt to GDP ratios of the countries in the euro periphery impose tight limits on this fiscal strategy.

A more promising alternative is to implement structural reforms that reduce the mark-ups in goods and labor markets. First, these structural reforms entail low budgetary costs. Second, since at least Blanchard and Giavazzi (2003), economists have pointed out the many rigidities existing in goods and labor markets in the periphery of the eurozone and, thus, the existence of a “target-rich environment” for such reforms.

However, internal devaluations that reduce the mark-ups in goods and labor markets bring risks of their own. An internal devaluation begets, by its very nature, deflationary pressures. If monetary policy does not accommodate these pressures, the economy undertaking a structural reform experiences an increase in the domestic real interest rate. This increase may reverse the gains from the internal devaluation.

When might we lack monetary policy accommodation? First, when the devaluating country is too small to affect the aggregate variables of the monetary union much. Take the case of Malta, which accounts for around 0.1% of the euro area’s GDP. No Maltese internal devaluation will have any measurable effect on the euro area aggregates and, thus, on the nominal interest rate of the eurozone. Second, when the monetary union is at the zero lower bound (ZLB) of the nominal interest rate and further monetary easing is impossible. This last case has been singled out by Eggertsson et al. (2014) as particularly dangerous for internal devaluations.

Deflationary pressures also bring a “Fisher effect”: nominal debts increase their real value. Debt deflation can be a daunting drag on the deleveraging process of households and firms in

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<sup>1</sup>While gains in productivity are a less costly path than internal devaluations to restore growth, it may be hard to gain much from them in the short run because of time-to-build lags in human capital and R&D. See, nevertheless, Fernández-Villaverde et al. (2012) for the importance of future improvements in productivity in short-term outcomes. Lastly, notice that the European Union law prohibits the use of optimal capital controls as those suggested by Farhi and Werning (2012) and tariffs.

countries with high private and public indebtedness (such as Italy and Spain in the 2010s). Lastly, the improvement of domestic competitiveness may occur at the cost of harming trade partners, generating negative spillovers for the rest of the monetary union.

To analyze the macroeconomic effects of internal devaluations, we build a dynamic stochastic general equilibrium model that incorporates the mechanisms we presented in our previous discussion. First, we have a monetary union, with a common central bank that sets the nominal policy interest rate using a Taylor rule, subject to a ZLB constraint. Second, the monetary union is divided between a periphery region undertaking an internal devaluation and a core region that receives spillovers from the internal devaluation. By making the size of the periphery arbitrarily close to one, our model encompasses a closed economy. Conversely, by making the size of the periphery arbitrarily close to zero, we encompass a small open periphery economy. We will exploit this encompassing property in Section 4 to understand how our model operates. Third, within each region, we have households and entrepreneurs, subject to borrowing constraints on the long-term debt on which they rely to finance their investments in capital and real estate (residential and commercial). Fourth, wages and prices are subject to monopoly power and nominal rigidities.

We employ our model to quantitatively measure the effects of internal devaluations implemented through reductions in price and wage mark-ups. To make the internal devaluations empirically relevant, we explore “marginal” reforms, where the mark-ups are permanently reduced by 1% (we also consider, as a robustness analysis, a reform that makes wages marginally more flexible). Thus, we are not considering dramatic reforms, but policies that have a reasonable chance of being feasible within the political-economic game of the periphery countries. In addition, we gauge the effects of the internal devaluations under normal monetary conditions and at the ZLB. To reflect the situation of the eurozone circa 2010, we engineer a spell at the ZLB by hitting the economy with a large deleveraging shock (i.e., a tightening of the borrowing constraint) and a negative demand shock (i.e., a substantial discount factor shock).

Our first result is that internal devaluations stimulate output in the long run, with present values of accumulated GDP gains in the periphery as high as 35%. While this number might seem large, we are calibrating the model to replicate an environment with low real interest rates. As emphasized by Blanchard (2019), in such an environment, any positive improvement in an economy’s efficiency has a large discounted value.

In contrast to nominal devaluations, internal devaluations permanently reduce the incidence of some real frictions and generate large long-run benefits. These long-run benefits help the core because of the enhanced efficiency of the monetary union as a whole, an outcome that does not occur with nominal devaluations, where the core usually loses. In our analysis, the supply-side effect is usually stronger than the demand channels that operate through the real exchange and real interest rates.

Our second result is that, in most cases of interest, the long-run positive effects of internal devaluations carry over to the short run –both in the periphery and the core– whether or not the ZLB binds. The mechanism is the expectations channel: higher long-run efficiency induces an



increase in investment today. A basic property of models with monopolistic competition is that, when there is less market power, entrepreneurs want to produce more and at a lower price. For that, they need more capital, even if the real rate increases at the ZLB. This result highlights the importance of using models to assess internal devaluations that incorporate investment and capital. Even in the presence of borrowing frictions, internal devaluations work mainly through changes in the investment decisions of agents. This point was conjectured in Fernández-Villaverde (2014).

Our third result is that labor market reforms bring smaller output effects and more muted deflationary pressures than goods markets reforms. The reason, standard in new Keynesian models, is that the cut in desired wage mark-ups has to overcome two layers of nominal rigidities (wages and prices) to exert its effect on final goods prices. Hence, if the monetary union is at the ZLB, labor market reforms are particularly attractive. In comparison, goods markets reforms reduce output in the periphery only if we are at the ZLB *and* the size of the periphery is above 55% of the GDP of the monetary union (at the ZLB, a goods markets reform in the periphery always slightly lowers the output of the core through a standard terms of trade channel). Fortunately, this 55% threshold is well above the size of the euro area's periphery.

Our fourth result is a clear-cut implication concerning the optimal sequencing of reforms. In the wake of a crisis hitting a monetary union that exhausts the monetary policy margins, labor market reforms should be implemented as soon as possible, whereas it is advantageous to postpone goods market reforms until nominal interest rates have lifted from the ZLB.

We conclude that, once the general equilibrium effects of internal devaluations within a monetary union are accounted for, the concerns about the undesired short-run effects of structural reforms largely evaporate. While there are circumstances under which some goods markets reforms are counterproductive in the short run for the countries undertaking them, those cases are not relevant given the actual size of the euro area's periphery. Nevertheless, when the ZLB binds, there is a case for a sequencing of reforms that prioritizes labor policies over goods markets reforms.

Our paper contributes to the literature on the macroeconomic effects of structural reforms in goods and labor markets prompted by the seminal work of Blanchard and Giavazzi (2003). Following Andrés et al. (2017), Campagne and Poissonnier (2016), Eggertsson et al. (2014), Fernández-Villaverde et al. (2012), Galí and Monacelli (2016), and Gerali et al. (2015), among others, we characterize the reforms as permanent reductions in price and wage mark-ups.

Our main methodological contribution is that our model allows for a detailed analysis of the different components of aggregate demand (consumption, investment, net exports) and supply (employment, capital, real estate) in a monetary union environment where reforms trigger effects on both the periphery and the core. Indeed, to show the importance of the spillover effects, we will present a robustness analysis when we change the degree of economic integration between the periphery and the core.

In addition, and in contrast to the existing work, by placing the previous union-wide general equilibrium channels at the heart of our analysis, we shed light on some of the most relevant

questions around the recent debate about the euro area, including i) the differential effects within the union of internal devaluations; ii) how the size of the reforming region shapes the aggregate effects of internal devaluations; iii) the optimal sequencing of implementing reforms; and iv) the role of union-wide monetary conditions.

Let us then start our analysis by presenting our model.

## 2 A core-periphery model of a monetary union

We model a monetary union with two countries: periphery and core. Since we will rely on the model to think about the policy choices that countries at the periphery face, we will employ  $H$  (for home) to refer to the former and  $F$  (for foreign) to the latter.

A fraction  $s$  of the total population in the monetary union (normalized to 1) lives in the periphery. There are three types of representative consumers in each country: an unconstrained household, a constrained household, and an entrepreneur. Households supply labor and obtain utility from consumption and housing. The entrepreneur produces intermediate good varieties, real estate for housing and commercial purposes, and equipment using labor, commercial real estate, and equipment. In addition, the economy is populated by retailers, which transform intermediate goods into final good varieties, and unions, which set wages. The prices of final good varieties and wages are subject to nominal rigidities.

The unconstrained household is a saver, while the constrained household and entrepreneur are borrowers. Debt contracts between the saver and the borrowers are long term and subject to real-estate collateral requirements because real estate is the only pledgeable asset in the economy. If the value of their collateral is too low, borrowers may not take on new loans, and they repay their outstanding debts at a fixed contractual rate. Otherwise, the constrained household and entrepreneur borrow up to the limit posed by their collateral holdings.

In terms of policy, each country has its fiscal authority, but both countries share a central bank that sets the nominal policy interest rate using a Taylor rule, subject to a ZLB constraint. Variables are defined in real per capita terms unless otherwise specified. The final consumption goods basket of each country acts as the local numeraire.

In terms of shocks and to analyze the effects of internal devaluations, we only need two sources of uncertainty: first, a discount factor shock, which works as a demand shock; second, a “loan-to-value” shock, which works as a deleveraging shock. In some of our quantitative exercises, these two shocks will push the monetary union to the ZLB. Other standard shocks in business cycle models –productivity, monetary and fiscal policy, etc.– are not powerful enough in a plausible calibration to achieve such a goal (Fernández-Villaverde et al., 2015) and, hence, are not required here.

We now describe the model structure in the periphery country (the core country is analogous). Further details of the model, which builds on Arce et al. (2016) and Andrés et al. (2017), are laid out in the Appendix.

## 2.1 Households and the entrepreneur

In country  $H$ , there is a representative unconstrained household, a representative constrained household, and a representative entrepreneur, denoted respectively by superscripts  $u$ ,  $c$ , and  $e$ .

### 2.1.1 Cost minimization

The households and the entrepreneur,  $x = u, c, e$ , consume a basket of home and foreign goods:

$$c_t^x = \left( \omega_H^{1/\varepsilon_H} (c_{H,t}^x)^{(\varepsilon_H-1)/\varepsilon_H} + (1 - \omega_H)^{1/\varepsilon_H} (c_{F,t}^x)^{(\varepsilon_H-1)/\varepsilon_H} \right)^{\varepsilon_H/(\varepsilon_H-1)}, \quad (1)$$

where  $c_{H,t}^x = \left( \int_0^1 c_{H,t}^x(z)^{(\varepsilon_p-1)/\varepsilon_p} dz \right)^{\varepsilon_p/(\varepsilon_p-1)}$  and  $c_{F,t}^x = \left( \int_0^1 c_{F,t}^x(z')^{(\varepsilon_p^*-1)/\varepsilon_p^*} dz' \right)^{\varepsilon_p^*/(\varepsilon_p^*-1)}$  aggregate a continuum of home,  $c_{H,t}^x(z)$ , and foreign final good varieties,  $c_{F,t}^x(z')$ , with elasticities of substitution  $\varepsilon_p, \varepsilon_p^* > 1$ .

We use  $P_{H,t}(z)$  and  $P_{F,t}(z')$  to denote the prices of the home good variety  $z$  and the foreign good variety  $z'$ , respectively. Minimization of nominal consumption expenditure yields:

$$\begin{aligned} c_{H,t}^x &= \omega_H \left( \frac{P_{H,t}}{P_t} \right)^{-\varepsilon_H} c_t^x \\ c_{F,t}^x &= (1 - \omega_H) \left( \frac{P_{F,t}}{P_t} \right)^{-\varepsilon_H} c_t^x \\ c_{H,t}^x(z) &= \left( \frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\varepsilon_p} c_{H,t}^x \\ c_{F,t}^x(z') &= \left( \frac{P_{F,t}(z')}{P_{F,t}} \right)^{-\varepsilon_p^*} c_{F,t}^x \end{aligned}$$

where  $P_t = (\omega_H P_{H,t}^{1-\varepsilon_H} + (1 - \omega_H) P_{F,t}^{1-\varepsilon_H})^{1/(1-\varepsilon_H)}$  is the periphery's consumer price index (CPI),

$P_{H,t} = \left( \int_0^1 P_{H,t}(z)^{1-\varepsilon_p} dz \right)^{1/(1-\varepsilon_p)}$  is the periphery's producer price index (PPI), and:

$$P_{F,t} = \left( \int_0^1 P_{F,t}(z')^{1-\varepsilon_p^*} dz' \right)^{1/(1-\varepsilon_p^*)}$$

is a price index of foreign goods.

Nominal spending on home and foreign goods equals  $P_{H,t} c_{H,t}^x = \int_0^1 P_{H,t}(z) c_{H,t}^x(z) dz$  and  $P_{F,t} c_{F,t}^x = \int_0^1 P_{F,t}(z') c_{F,t}^x(z') dz'$ , respectively, whereas  $P_t c_t^x = P_{H,t} c_{H,t}^x + P_{F,t} c_{F,t}^x$  is total nominal consumption spending.

The home and foreign final good varieties are also used as inputs in the production of real estate and equipment to be described below according to equation (1) and the aggregators for  $c_{H,t}^x$  and  $c_{F,t}^x$ . This symmetry assumption gives rise to demand functions by the entrepreneur operating these technologies with the same form as the demand functions above.

### 2.1.2 The unconstrained household

The unconstrained household maximizes:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^u)^t \zeta_t \left\{ \log(c_t^u) + \vartheta \log(h_t^u) - \chi \int_0^1 \frac{n_t^u(i)^{1+\varphi}}{1+\varphi} di \right\},$$

where  $\zeta_t$  is a shock to the discount factor (common to all home agents in the model),  $h_t^u$  are units of housing owned by the household, and  $n_t^u(i)$  are labor services of type  $i \in [0, 1]$ . The discount factor shock will operate as a demand shock in our model.

The budget constraint of this household is:

$$c_t^u + d_t + p_t^h [h_t^u - (1 - \delta_h) h_{t-1}^u] = \frac{R_{t-1}}{\pi_t} d_{t-1} + (1 - \tau_w) \int_0^1 \frac{W_t(i)}{P_t} n_t^u(i) di - T_t,$$

where  $d_t$  is the real value of net holdings of riskless loanable funds,  $p_t^h$  is the real price of housing,  $\delta_h$  is the depreciation rate of housing,  $R_t$  is the gross nominal interest rate at which home agents lend and borrow,  $\pi_t \equiv P_t/P_{t-1}$  is gross CPI inflation,  $\tau_w$  is a tax rate on labor income,  $W_t(i)$  is the nominal wage for labor services of type  $i$ , and  $T_t$  are lump-sum taxes.

### 2.1.3 The constrained household

The constrained household maximizes:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \zeta_t \left\{ \log(c_t^c) + \vartheta \log(h_t) - \chi \int_0^1 \frac{n_t^c(i)^{1+\varphi}}{1+\varphi} di \right\}.$$

These preferences are the same as those of the unconstrained household, except that  $\beta < \beta^u$ , that is, the constrained household is more impatient. The higher impatience makes operative the borrowing constraint (2) that we will describe momentarily.

The constrained household faces the budget constraint:

$$c_t^c + p_t^h [h_t - (1 - \delta_h) h_{t-1}] = b_t - \frac{R_{t-1}}{\pi_t} b_{t-1} + (1 - \tau_w) \int_0^1 \frac{W_t(i)}{P_t} n_t^c(i) di - T_t,$$

where  $b_t$  is the real value of household debt outstanding at the end of period  $t$ .

Unlike in most of the literature, which typically assumes short-term (one-period) debt, we assume that debt contracts are long term, which generates a more realistic shape of the borrowing constraint below. At the beginning of time  $t$  the household repays a fraction  $1 - \gamma$  of all nominal debt outstanding at the end of  $t - 1$ , regardless of when that debt was issued (Woodford, 2001). In real terms, the outstanding principal of household debt evolves as:

$$b_t = \frac{b_{t-1}}{\pi_t} + b_t^{new} - (1 - \gamma) \frac{b_{t-1}}{\pi_t} = b_t^{new} + \gamma \frac{b_{t-1}}{\pi_t},$$

where  $b_t^{new}$  is gross new credit net of voluntary amortizations.

Following Kiyotaki and Moore (1997) and Iacoviello (2005),  $b_t$  cannot exceed a fraction  $m_t$  of the expected discounted value of the household's housing stock:  $b_t \leq m_t R_t^{-1} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t$ . The debt limit, however, is only effective as long as it exceeds  $\gamma b_{t-1} / \pi_t$ , which we will henceforth refer to as the contractual amortization path. The “loan-to-value ratio”  $m_t$  is a time-varying exogenous stochastic process that induces cycles of leveraging and deleveraging. Thus,  $m_t$  is the second source of uncertainty in our model.

Since lenders cannot force borrowers to pay back faster than the contractual amortization rate (i.e., they cannot enforce  $b_t^{new} < 0$ ), the following asymmetric borrowing constraint holds:

$$\begin{aligned} b_t &\leq R_t^{-1} m_t \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t, & \text{if } \frac{m_t}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t \geq \gamma \frac{b_{t-1}}{\pi_t} \\ b_t &\leq \gamma \frac{b_{t-1}}{\pi_t}, & \text{if } \frac{m_t}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t < \gamma \frac{b_{t-1}}{\pi_t}. \end{aligned} \quad (2)$$

This asymmetric borrowing constraint creates a double debt regime. In “normal times,” in which collateral values exceed the contractual amortization path, debt is restricted by the former. In this regime, households can receive new credit against their housing collateral with the constraint that such new credit does not exceed the gap between collateral values and the amortization path. Indeed, after some algebra, you get  $b_t^{new} \leq m_t R_t^{-1} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t - \gamma b_{t-1} / \pi_t$ .

If collateral values become sufficiently low, the economy switches to an alternative regime, in which there is no new credit and debt is restricted by the contractual amortization path. Importantly, changes from one regime to the other occur endogenously, and may thus be affected by the discount factor and “loan-to-value” shocks and policy.

To understand the role of the borrowing constraint further, we can look at the condition determining the optimal choice of housing:

$$\lambda_t^c p_t^h = \frac{\zeta_t \vartheta}{h_t} + \beta \mathbb{E}_t \lambda_{t+1}^c (1 - \delta_h) p_{t+1}^h + \xi_t \frac{m_t}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h, \quad (3)$$

where  $\lambda_t^x = \zeta_t / c_t^x$  and  $\xi_t$  are the Lagrange multipliers associated with the budget constraint of household type  $x = u, c$  and to the collateral constraint (2), respectively. Equation (3) illustrates that, when the collateral constraint is binding ( $\xi_t > 0$ ), the marginal value of housing is higher than its utility service flows due to the possibility of borrowing against it.

#### 2.1.4 The entrepreneur

The entrepreneur operates three technologies under perfect competition. First, the entrepreneur produces an intermediate good with technology  $y_t^e = k_{t-1}^{\alpha_k} (h_{t-1}^e)^{\alpha_h} (n_t^e)^{1-\alpha_k-\alpha_h}$ , where  $y_t^e$  is output of the intermediate good,  $k_{t-1}$  is equipment,  $h_{t-1}^e$  is commercial real estate, and  $n_t^e$  is a basket of labor services (to be defined below).

The intermediate good is sold to retailers at a real (CPI-deflated) price  $m c_t$  (also the marginal cost). We assume that the entrepreneur owns the equipment, with unit price  $q_t$  and depreciation rate  $\delta_k$ , and the commercial real estate, which has the same price,  $p_t^h$ , and depreciation rate,  $\delta_h$ , as

housing. The basket of labor services is rented at wage  $W_t$ . Thus, the real cash flow from producing the intermediate good is  $\Pi_t^r = mc_t y_t^e - \frac{W_t}{P_t} n_t^e - p_t^h [h_t^e - (1 - \delta_h) h_{t-1}^e] - q_t [k_t - (1 - \delta_k) k_{t-1}]$ .

Second, the entrepreneur operates a construction firm that produces new real estate units,  $I_t^h$ , given the technology:

$$I_t^h = (n_t^h)^\omega \left\{ i_t^h \left[ 1 - \frac{\Phi_h}{2} \left( \frac{i_t^h}{i_{t-1}^h} - 1 \right)^2 \right] \right\}^{1-\omega},$$

where  $n_t^h$  is labor services and  $i_t^h$  is units of the basket of aggregated final good varieties according to equation (1).<sup>2</sup> The new real estate units can be used for residential ( $h_t, h_t^u$ ) or commercial ( $h_t^e$ ) purposes. The real cash flow from this activity is  $\Pi_t^h = p_t^h I_t^h - \frac{W_t}{P_t} n_t^h - i_t^h$ .

Third, the entrepreneur operates an equipment company that builds new equipment,  $I_t$ , given the technology:

$$I_t = i_t \left[ 1 - \frac{\Phi_k}{2} \left( \frac{i_t}{i_{t-1}} - 1 \right)^2 \right],$$

where  $i_t$  is units of the basket of aggregated final good varieties according to equation (1). The real cash flow from this activity is  $\Pi_t^k = q_t I_t - i_t$ .

Define  $b_t^e$  as the real value of entrepreneurial debt outstanding at the end of period  $t$  and  $\Pi_t^r$  as the profits of the retailer activity (to be described in the next subsection). Thus, the entrepreneur maximizes:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \zeta_t \log c_t^e,$$

subject to

$$c_t^e = b_t^e - \frac{R_{t-1}}{\pi_t} b_{t-1}^e + \Pi_t^e + \Pi_t^h + \Pi_t^k + \Pi_t^r,$$

and an asymmetric borrowing constraint analogous to the one on constrained households:

$$\begin{aligned} b_t^e &\leq R_t^{-1} m_t^e \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t^e, & \text{if } \frac{m_t^e}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t^e &\geq \gamma^e \frac{b_{t-1}^e}{\pi_t} \\ b_t^e &\leq \gamma^e \frac{b_{t-1}^e}{\pi_t}, & \text{if } \frac{m_t^e}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t^e &< \gamma^e \frac{b_{t-1}^e}{\pi_t}, \end{aligned} \quad (4)$$

where we allow for a different loan-to-value ratio ( $m_t^e$ ) and contractual amortization rate ( $1 - \gamma^e$ ) for entrepreneurs. The entrepreneur has the same discount factor as the constrained household and, therefore, she is also impatient.

In the spirit of being a representative entrepreneur, the entrepreneur optimizes the activity level of each of the three technologies individually, taking all prices parametrically.

<sup>2</sup>We include labor services in the production function of construction firms to allow for long-run changes in real estate prices. If  $\omega = 0$ , the real estate price in the steady state,  $p_{ss}$ , is one. In the more general case  $\omega \neq 0$ ,  $p_{ss}^h = (w_{ss})^\omega \omega^{-\omega} (1 - \omega)^{-(1-\omega)}$ .

Again, it is instructive to analyze the optimality condition for commercial real estate:

$$\lambda_t^e p_t^h = \beta \mathbb{E}_t \lambda_{t+1}^e \left\{ mc_{t+1} \alpha_h \frac{y_{t+1}^e}{h_t^e} + (1 - \delta_h) p_{t+1}^h \right\} + \xi_t^e \frac{m_t^e}{R_t} \mathbb{E}_t \pi_{t+1} p_{t+1}^h, \quad (5)$$

where  $\xi_t^e$  is the Lagrange multiplier associated with the constraint (4). As in equation (3), when the collateral constraint binds ( $\xi_t^e > 0$ ), the marginal value of commercial real estate is higher than its production services, thanks to the possibility of borrowing against it.

## 2.2 Retailers

Monopolistically competitive retailers ( $z \in [0, 1]$ ) purchase the intermediate inputs from entrepreneurs at the real price  $mc_t$ , and transform them one for one into final good varieties. Each retailer  $z$  faces a demand curve implied by the aggregator (1):

$$y_t(z) = \left( \frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\varepsilon_p} y_t \equiv y_t^d(P_{H,t}(z)),$$

where  $y_t$  is aggregate demand for the basket of home goods.

Monopolistically competitive retailers are subject to nominal rigidities à la Calvo (1983). More concretely, a retailer that has the chance of setting its nominal price at time  $t$  solves:

$$\max_{P_{H,t}(z)} \mathbb{E}_t \sum_{s=0}^{\infty} (\beta \theta_p)^s \frac{\lambda_{t+s}^e}{\lambda_t^e} \left[ (1 - \tau_p) \frac{P_{H,t}(z)}{P_{t+s}} - mc_{t+s} \right] y_{t+s}^d(P_{H,t}(z)),$$

where  $\theta_p$  is the probability of not adjusting the price and  $\tau_p$  is a tax rate on retailers' revenue. The retailer uses the stochastic discount factor of the entrepreneur to value its profits since we assume that these profits are transferred to the entrepreneur. Indeed, we could collapse the entrepreneur and the retailer into a single agent at the cost of heavier algebra.

If retailers were able to reset prices in every period ( $\theta_p = 0$ ), they would set

$$\tilde{P}_{H,t} = \frac{1}{1 - \tau_p} \frac{\varepsilon_p}{\varepsilon_p - 1} P_t mc_t,$$

where the desired price mark-up over nominal marginal cost,  $\frac{1}{1 - \tau_p} \frac{\varepsilon_p}{\varepsilon_p - 1}$ , measures the degree of monopolistic distortions in the goods markets.

## 2.3 Wage setting

The entrepreneur, when operating the intermediate good and construction technologies, uses a basket of labor services provided by households,  $n_t^s = (n_t^{s,c})^{\mu_s} (n_t^{s,u})^{1 - \mu_s}$ , where  $n_t^{s,x}$  are labor services provided by a type- $x$  household,  $x = u, c$ , to each technology  $s = e, h$ . We assume that both labor services earn the same wage.

The demand for the basket of labor service varieties from each household type is, for each technology:

$$n_t^{s,x} = \left( \int_0^1 n_t^{s,x}(i)^{(\varepsilon_w-1)/\varepsilon_w} di \right)^{\varepsilon_w/(\varepsilon_w-1)},$$

Cost minimization implies  $n_t^{s,x}(i) = (W_t(i)/W_t)^{-\varepsilon_w} n_t^{s,x}$ , where  $W_t \equiv (\int_0^1 W_t(i)^{1-\varepsilon_w} di)^{1/(1-\varepsilon_w)}$  is the nominal wage index. Total demand for each variety of labor services is thus:

$$n_t^x(i) \equiv n_t^{e,x}(i) + n_t^{h,x}(i) = \left( \frac{W_t(i)}{W_t} \right)^{-\varepsilon_w} \left( n_t^{e,x} + n_t^{h,x} \right) \equiv n_t^{d,x}(W_t(i)).$$

As in Erceg et al. (2000), nominal wages are set à la Calvo by a union representing all type- $i$  workers. When the union can reset the nominal wage at time  $t$ , it chooses  $W_t(i)$  to maximize:

$$\sum_{x=u,c} \mathbb{E}_t \sum_{s=0}^{\infty} (\beta^x \theta_w)^s \left[ \lambda_{t+s}^x (1 - \tau_w) \frac{W_t(i)}{P_{t+s}} n_{t+s}^{d,x}(W_t(i)) - \zeta_{t+s} \chi \frac{\left( n_{t+s}^{d,x}(W_t(i)) \right)^{1+\varphi}}{1 + \varphi} \right],$$

where  $\theta_w$  is the probability of not adjusting the wage and  $\beta^c = \beta$ . If workers were able to reset wages in every period ( $\theta_w = 0$ ), then they would charge a mark-up:

$$\frac{1}{1 - \tau_w} \frac{\varepsilon_w}{\varepsilon_w - 1} \quad (6)$$

over a weighted average of constrained and unconstrained households' marginal rates of substitution between consumption and labor. Thus, the desired wage mark-up (6) measures the degree of monopolistic distortions in the labor market. The implied level of unemployment is derived in the Appendix.

## 2.4 The fiscal authority

The fiscal authority purchases an exogenously determined basket of home final good varieties

$$g_t = \left( \int_0^1 g_t(z)^{(\varepsilon_p-1)/\varepsilon_p} dz \right)^{\varepsilon_p/(\varepsilon_p-1)},$$

which generates a demand for each home variety  $z$  equal to  $g_t(z) = (P_{H,t}(z)/P_{H,t})^{-\varepsilon_p} g_t$ . We assume full home bias in  $g_t$  because we think about government consumption as mainly involving home goods and services (i.e., a local police force or public schools).

The fiscal authority balances its budget period-by-period by adjusting lump-sum taxes  $T_t$ :

$$\tau_w \frac{W_t}{P_t} (n_t^c + n_t^u) + \tau_p \frac{P_{H,t}}{P_t} y_t + 2T_t = \frac{P_{H,t}}{P_t} g_t.$$

We have a 2 in front of  $T_t$  because each type of household pays the same lump-sum taxes.



## 2.5 The common central bank

The common monetary authority sets the gross nominal policy interest rate  $R_t^{MU}$  according to a simple inflation-based Taylor rule and subject to a ZLB constraint:

$$R_t^{MU} = \max \{1, \bar{R}^{MU} (\pi_t^{MU})^{\rho_\pi}\},$$

where  $\rho_\pi > 1$ ,  $\bar{R}^{MU}$  is the long-run target for the policy rate, and  $\pi_t^{MU} = s\pi_t + (1-s)\pi_t^*$  is a measure of the union-wide gross CPI inflation rate, where  $\pi_t^* \equiv P_t^*/P_{t-1}^*$  is the foreign CPI inflation. Since we are dealing with a model with endogenous investment, once the central bank picks a long-run target for the policy rate, it is also implicitly picking a long-run inflation target.

## 2.6 International linkages

The foreign agents demand baskets of the home good varieties  $c_{H,t}^{c*}$ ,  $c_{H,t}^{u*}$ , etc., in the same way as home agents. We assume that the law of one price holds for each home good variety, such that  $P_{H,t}^*(z) = P_{H,t}(z)$  for all  $z \in [0, 1]$ , implying  $P_{H,t}^* = P_{H,t}$ . Thus, export demand for each home good variety  $z$  is  $x_t(z) = (P_{H,t}(z)/P_{H,t})^{-\varepsilon_F} x_t$ , where real per capita exports equal:

$$x_t = \frac{1-s}{s} (1 - \omega_F^*) \left( \frac{P_{H,t}}{P_t^*} \right)^{-\varepsilon_F} (c_t^{u*} + c_t^{c*} + c_t^{e*} + i_t^* + i_t^{h*}).$$

with  $\omega_F^*$  and  $\varepsilon_F$  being the relative weight on foreign goods and the elasticity of substitution between home and foreign goods, respectively, in foreign agents' consumption and investment baskets.  $P_t^*$  is the core's CPI, and  $z_t^*$ ,  $z = c^u, c^c, c^e, i, i^h$ , are per capita demand for home good varieties by the different foreign agents.

Home agents can lend to and borrow from foreigners and other domestic agents at a riskless nominal rate  $R_t$ . The periphery's real (CPI-deflated) per capita net foreign asset position is  $nfa_t \equiv d_t - b_t - b_t^e$ . To ensure stationarity of this net foreign asset position, we assume that  $R_t$  is given by:

$$R_t = R_t^{MU} \exp \left( -\psi \frac{P_t nfa_t}{P_{H,t} gdp_t} \right),$$

where  $\psi > 0$  and  $gdp_t$  is the real (PPI-deflated) per capita GDP (to be defined momentarily).

## 2.7 Aggregation and market clearing

Market clearing in the intermediate good market requires  $y_t \Delta_t = k_{t-1}^{\alpha_k} (h_{t-1}^e)^{\alpha_h} (n_t^e)^{1-\alpha_h-\alpha_k}$ , where  $\Delta_t \equiv \int_0^1 (P_{H,t}(z)/P_{H,t})^{-\varepsilon_F} dz$  denotes relative price dispersion. Aggregate demand for the basket of home good varieties is  $y_t = c_{H,t}^u + c_{H,t}^c + c_{H,t}^e + i_{H,t} + i_{H,t}^h + g_t + x_t$ . Total demand for real estate must equal total supply:  $h_t^u + h_t + h_t^e = I_t^h + (1 - \delta_h) (h_{t-1}^u + h_{t-1} + h_{t-1}^e)$ . The demand for equipment must equal supply:  $k_t = I_t + (1 - \delta_k) k_{t-1}$ . Labor market clearing requires  $n_t^u + n_t^c = n_t^e + n_t^h$ .

We define real (PPI-deflated) per capita GDP as

$$\begin{aligned} gdp_t &\equiv y_t + \frac{P_t}{P_{H,t}} (q_t I_t - i_t) + \frac{P_t}{P_{H,t}} (p_t^h I_t^h - i_t^h) \\ &= \frac{P_t}{P_{H,t}} c_t^{tot} + \frac{P_t}{P_{H,t}} (q_t I_t + p_t^h I_t^h) + \left[ x_t - \frac{P_{F,t}}{P_{H,t}} (c_{F,t}^{tot} + i_{F,t} + i_{F,t}^h) \right], \end{aligned}$$

where in the second equality we used that  $z_{H,t} = \frac{P_t}{P_{H,t}} z_t - \frac{P_{F,t}}{P_{H,t}} z_{F,t}$  for  $z = c^u, c^c, c^e, i, i^h$ , and where  $c_t^{tot} \equiv c_t^u + c_t^c + c_t^e$  is total consumption (total consumption imports  $c_{F,t}^{tot}$  are defined analogously).

Zero net supply of nominal international bonds requires  $s P_t nfa_t + (1-s) P_t^* nfa_t^* = 0$ , where the core's real per capita net foreign asset position,  $nfa_t^*$ , is defined in the same way as  $nfa_t$ . Then, we can combine all domestic market-clearing conditions and budget constraints to obtain the periphery's current account identity:

$$nfa_t = \frac{R_{t-1}}{\pi_t} nfa_{t-1} + \frac{P_{H,t}}{P_t} x_t - \frac{P_{F,t}}{P_t} (c_{F,t}^{tot} + i_{F,t} + i_{F,t}^h).$$

### 3 Calibration

Table 1 summarizes the calibration of our model to the eurozone using a quarter as a period. First, we select union-wide parameter values. We define the periphery as Italy, Spain, Portugal, and Greece (we do not consider Ireland part of the periphery because of its high GDP per capita and already-flexible markets). Since these four countries constitute around 25% of the eurozone GDP, we make  $s = 0.25$ . To allow for different choices of which countries to include in the periphery, we will present robustness scenarios for this parameter value.

The long-run inflation target  $\bar{\pi}^{MU}$  is set to 1, to be consistent with the tough stand of the European Central Bank with respect to inflation during the 2000s. We follow Iacoviello (2005) and set  $\beta$ , the discount factor of the impatient agents, to 0.98. Then, we pick  $\beta^u = 0.994$ , the discount factor of the patient household, to generate a  $\bar{R}^{MU} = 1.02^{1/4}$ , the observed nominal rate at the start of 2007, right before the onset of the financial crisis in the eurozone, and roughly the average of the previous decade. We assume a standard value of 1.5 for the Taylor rule coefficient  $\phi$ . The inverse labor supply elasticity is  $\varphi = 4$ , consistent with a large body of micro evidence suggesting low labor supply elasticities in the euro area. Finally, we set  $\delta_h = 0.01$  (Iacoviello and Neri, 2010) and  $\delta_k = 0.025$ .

For transparency, we opt for selecting home-specific parameters using Spanish observations for 2007, rather than building consolidated aggregates for the peripheral eurozone economies, which involves complex issues of nonlinear weighting and comparability that would distract from the focus of our analysis with little additional insight.

In particular, we select  $\psi$  to replicate Spain's net foreign assets over GDP in 2007,  $nfa_{ss}^y = -79.3\%$ . The parameter  $\omega_H$  is set to match gross exports over GDP in 2007 (26.9%). Based on evidence for Spain in García et al. (2009), the price elasticity of exports and imports is set to  $\varepsilon_F = \varepsilon_H = 1$ . The elasticities  $\alpha_k = 0.11$  and  $\alpha_h = 0.21$  are chosen to replicate the labor share

of GDP in 2007 (61.6%) and the share of equipment in the total stock of productive capital (21.4%). The elasticity  $\omega$  matches the construction share of total employment in 2007 (13.4%). The weight of utility from housing services,  $\vartheta$ , helps to replicate gross household debt over annual GDP (80.2%), and we set  $\mu_h = \mu_e \equiv \mu = 1/2$ . The adjustment costs,  $\Phi_h$  and  $\Phi_k$ , are chosen such that the fall in construction and equipment investment in our baseline deleveraging scenario resembles their behavior during the financial crisis that started in 2008. The Calvo

Table 1: Calibration

Parameter	Value	Description
$s$	0.25	size of periphery
Preferences		
$\beta^u, \beta^{u*}$	0.994	unconstrained household discount factor
$\beta, \beta^*$	0.98	constrained household discount factor
$\varphi, \varphi^*$	4	(inverse) labor supply elasticity
$\vartheta, \vartheta^*$	0.38	weight on housing utility
$\varepsilon_p, \varepsilon_p^*$	7	elasticity of substitution across consumption varieties
$\varepsilon_w, \varepsilon_w^*$	3.31	elasticity of substitution across labor varieties
$\omega_H, \omega_F^*$	0.72, 0.86	weight on domestic goods in consumption basket
$\varepsilon_H, \varepsilon_F$	1	elast. of subst. between domestic and imported goods
Technology		
$\alpha_h, \alpha_h^*$	0.21	elasticity output w.r.t. real estate
$\alpha_k, \alpha_k^*$	0.11	elasticity output w.r.t equipment
$\omega, \omega^*$	0.43	elasticity construction w.r.t labor
$\delta_h, \delta_h^*$	0.01	depreciation real estate
$\delta_k, \delta_k^*$	0.025	depreciation equipment
$\mu, \mu^*$	0.5	share of constrained households in labor baskets
$\Phi_h, \Phi_h^*$	6.1	investment adjustment costs construction
$\Phi_k, \Phi_k^*$	2.4	investment adjustment costs equipment
Price/wage setting		
$\theta_p, \theta_p^*$	0.67	fraction of non-adjusting prices
$\theta_w, \theta_w^*$	0.75	fraction of non-adjusting wages
Debt constraints		
$\bar{m}, \bar{m}^*$	0.70	household LTV ratio
$\bar{m}^e, \bar{m}^{e*}$	0.64	entrepreneur LTV ratio
$\gamma, \gamma^*$	0.98	amortization rate household debt
$\gamma^e, \gamma^{e*}$	0.97	amortization rate entrepreneurial debt
Monetary policy		
$\phi, \bar{R}^{MU}$	1.5, $1.02^{1/4}$	Taylor rule coefficient, long-run policy rate

parameters are set to  $\theta_p = 2/3$  and  $\theta_w = 3/4$ , consistent with survey evidence for the Spanish economy (Druant et al., 2009).

According to data from the Spanish Land Registry office, loan-to-value ratios for new mortgages prior to the crisis were slightly below 70%. We thus set  $\bar{m} = 0.70$  for the household's initial loan-to-value ratio. The entrepreneurial initial loan-to-value ratio is chosen to match the ratio of gross non-financial corporate debt to annual GDP (125.4% in 2007), which yields  $\bar{m}^e = 0.64$ . We calibrate the contractual amortization rates at  $1 - \gamma = 0.02$  and  $1 - \gamma^e = 0.03$ , to replicate the average age of the stock of outstanding mortgage debt prior to the crisis.

Finally, we can move to the parameter determining the degree of monopolistic distortions. We set  $\tau_p = \tau_w = 0$  because it allows us to isolate the effects of internal devaluations modeled as changes to  $\varepsilon_p$  and  $\varepsilon_w$  from additional fiscal effects operating through changes in the lump-sum taxes paid by the constrained households,  $T_t$  (see Andrés et al., 2017, for a discussion of the effects of reforms implemented via reductions in  $\tau_p$  and  $\tau_w$ ). We set  $\varepsilon_p = 7$  to get an initial price mark-up of  $(1 - \tau_p)^{-1} \varepsilon_p / (\varepsilon_p - 1) = 1.17$ , which is broadly consistent with estimates by Montero and Urtasun (2014) based on Spanish firm-level data. For wage mark-ups, we follow Galí (2011) and target an unemployment rate of 8.6% in 2007, which yields an initial wage mark-up of  $(1 - \tau_w)^{-1} \varepsilon_w / (\varepsilon_w - 1) = 1.43$ , which we achieve by setting  $\varepsilon_w = 3.31$ .

Notice that since we will trace the deterministic effects of an internal devaluation under certainty equivalence, we do not need to specify the details of the stochastic processes governing the discount factor and the “loan-to-value” shocks beyond their initial values. In most cases, we will look at the values of these shocks in the steady state.

For the core, we assume a fully symmetric calibration, with two exceptions. First,  $\omega_F^*$  is set to normalize the terms-of-trade in the initial steady state to 1. Unlike  $\omega_H$ , which was calibrated to match an exports target for the home country (equivalently, an imports target, given the target for the NFA-to-GDP ratio),  $\omega_F^*$  cannot be targeted to the foreign country’s exports because they must equal the home country’s imports in the model. Second, we allow for an additional parameter in the interest rate premium of the core to deliver interest rates that are the same in both countries in the initial steady state. This extra parameter allows us to match what we saw in 2007, when country-specific risk premia within the eurozone were close to zero. In particular, we assume  $R_t^* = R_t^{MU} \exp[-\psi^* (P_t^* nfa_t^* / P_{F,t} gdp_t^*) + \psi_0^*]$ , with  $\psi^* = \psi$ , and set  $\psi_0^*$  such that  $R_{ss} = R_{ss}^*$ .

## 4 Internal devaluations in closed and small open economies

We are now ready to evaluate how internal devaluations work. To do so, we first simulate two extreme cases that shed light on the main mechanisms at work: a closed economy and a small open economy within a monetary union. Our model in Section 2 encompasses both cases by setting the relative size of the periphery close to 1 (a closed economy that includes all of the monetary union) and to 0 (a small open economy that does not affect the monetary union policy; recall our example of Malta in the introduction). The rest of the parameter values are those in Table 1.

An internal devaluation in this environment can be achieved by reducing either the steady-state price or the wage mark-ups. We can call the former a goods markets reform and the latter a labor market reform. For concreteness, we gauge the consequences of a reduction in these mark-ups by 1% in both cases. Fixing the same size for both exercises, plus the fact that the two reforms have similar long-run impacts on GDP, makes the policies comparable.

What internal devaluations have in common with traditional nominal exchange devaluations is that both seek to improve external competitiveness. But in contrast to nominal devaluations,

internal devaluations have a permanent impact on output that depends on the interplay among demand- and supply-side channels.

On the demand side, the effects on the terms of trade and the real interest rate of an internal devaluation crucially depend on whether the central bank is constrained by the ZLB and the inflationary impact of the reform. On the supply side, these reforms mitigate the inefficiency caused by the presence of market power in the economy and they realign the relative price of labor and capital (which, unless otherwise stated, we will consider from now on includes both equipment,  $k$ , and commercial real estate,  $h^e$ ).

A reduction in the wage mark-up increases the demand for labor and leads to higher aggregate labor income and consumption for empirically plausible values of the labor demand elasticity. Likewise, the moderation of price mark-ups mitigates the distortions in the price of consumption goods relative to leisure caused by market power and nominal rigidities, thus increasing the supply of labor.<sup>3</sup> Importantly, supply and demand channels operate differently depending on the nature of the reform implemented and, to a lesser extent, on the macroeconomic environment in which they take place.

Admittedly, governments have at their disposal more sophisticated policy measures to achieve internal devaluations. Those include incentives to investment in R&D or fostering firm creation (Bilbiie et al., 2012) and growth (Andrés and Burriel, 2014, 2018), and reforms in the labor market that encourage firms to post more vacancies, that induce workers to intensify their search effort, or that make the matching more efficient (Cacciatore and Fiori, 2016; Cacciatore et al., 2016). Those policies have positive effects on the economy, some of which are missing in our exercises, especially in the medium and long run. The choice of a more basic policy framework helps to compare the effects of internal devaluations with those of nominal exchange rate devaluations that operate through demand realignments caused by transitory movements in the terms of trade. More targeted transformations in goods and labor markets would have additional side effects that, in the interest of clarity, we prefer to skip.

## 4.1 The closed economy case

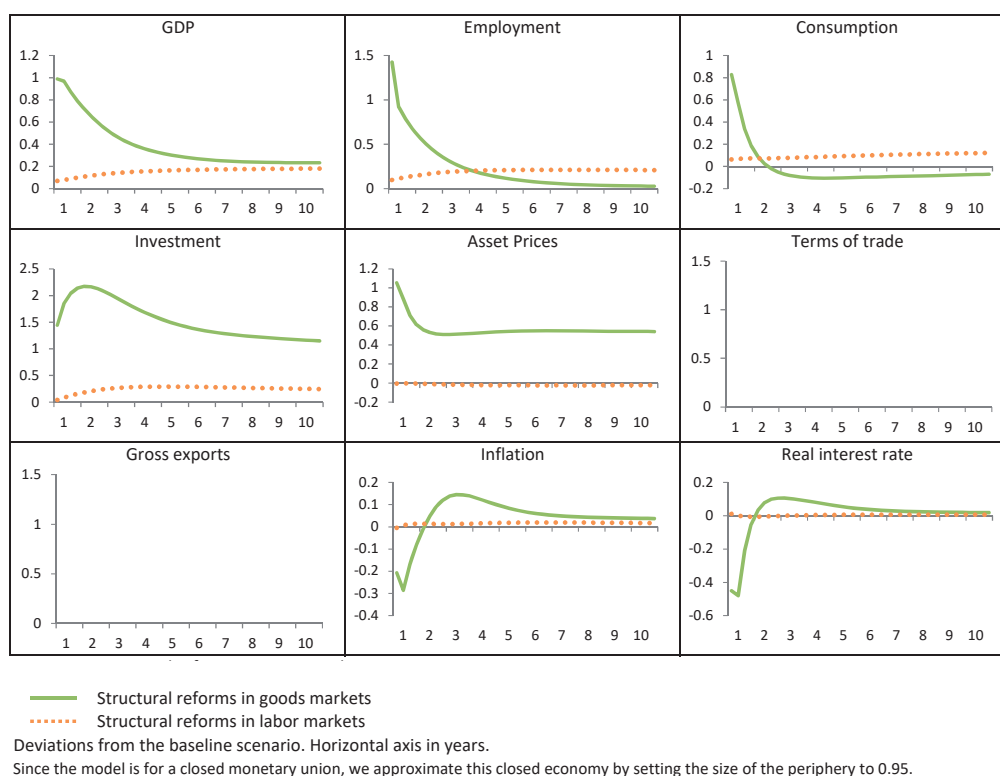
Figure 1 plots the impact of goods and labor markets reforms on aggregate variables in a closed economy. Thus, we can think about this case more as a policy-induced deflation than as an internal devaluation. We initialize the economy at its steady state and implement a marginal (i.e., 1%) permanent reduction in either prices (continuous lines) or wage mark-ups (discontinuous lines). To compute the transitional dynamics between the original steady state with the original mark-ups and the new steady state with lower mark-ups, we use a Newton method to clear markets period by period given zero realized aggregate shocks. We will apply the same approach to the other exercises in the rest of the paper unless noted.

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<sup>3</sup>In this case, there is an offsetting effect on employment caused by the income effect that pushes the labor supply upward. When the mark-up reduction is temporary, this supply-side effect is much weaker or even absent, so the beggar-thy-neighbor effects dominate in favor of the periphery and against the core.

Figure 1: Internal devaluations in a closed economy.

Marginal effects of structural reforms, in a closed economy with no other shocks



Both reforms have a similar effect on GDP and inflation over the long run, but their impact on capital and labor is very different. The labor market reform increases long-run employment as the labor supply shifts downward along a given labor demand schedule. Higher employment leads to a rise in labor income and, with it, higher consumption and GDP.

The boost to activity following the moderation of price mark-ups comes mostly through an increase in investment and the capital-labor ratio. When the economy is away from the ZLB, the deflationary impact of this reform leads to a negative overreaction of the nominal interest rate (recall the Taylor rule coefficient  $\phi = 1.5$ ) that reduces the real rate, increases Tobin's  $q$ , and stimulates investment. Also, lower price mark-ups soften the distortion in the relative price of leisure vs. consumption goods caused by market power and nominal rigidities. Lower price mark-ups increase the demand for labor and capital. Since the labor supply is inelastic in our calibration ( $\varphi = 4$ ), the effect on employment is small (Campagne and Poissonnier, 2016, explore the role of the elasticity of labor supply in the impact of mark-up reforms). Wages and the capital-labor ratio rise significantly. Interestingly, consumption does not increase in the long run, which reflects the need to finance the persistently higher level of investment.

The short-run responses of these two reforms are even more different. Following the goods markets reform, the impact on GDP, consumption, investment, asset prices, and employment overshoots the long-run level of all these variables, whereas, after the labor reform, most variables undershoot their long-run level. The powerful short-run effect of cuts in price mark-ups stems

from the substantial decline in the real interest rate and the significant increase in asset prices. These changes set in motion the expectations channel that raises current private spending. Furthermore, these responses result in an improvement in the borrowing capacity of credit-constrained agents: consumption and investment rise on impact and investment remains well above its pre-reform levels in the medium run. On the other hand, the wage mark-up reform has little effect on inflation in the short term, so the real interest rate hardly reacts, and asset prices remain flat. Absent this financial channel, both consumption, and investment increase gradually over time as employment gathers momentum.

These differences can be better understood by looking at the entrepreneurs' demand for labor to produce the intermediate goods:

$$n_t^e = \left[ \frac{mc_t (1 - \alpha_h - \alpha_k) k_{t-1}^{\alpha_k} (h_{t-1}^e)^{\alpha_h}}{w_t} \right]^{1/(\alpha_h + \alpha_k)}.$$

As  $\varepsilon_W$  increases, the labor market becomes more competitive, and the real wage falls. A similar effect appears in the demand for labor by the construction firm. The direct impact of this reform on output, marginal cost, investment, and housing demand is weak, so employment increases along with lower real wages. The dynamics of employment and output are mostly driven by the sluggish adjustment in nominal and real wages, with little action in other aggregate variables.

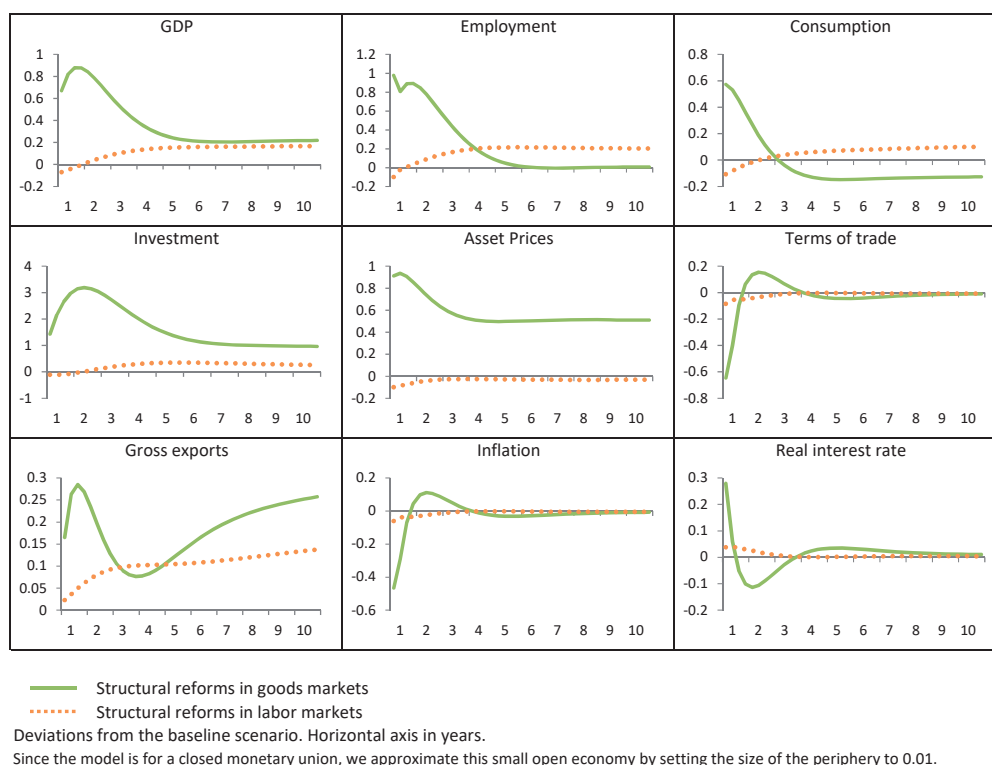
Following an increase in  $\varepsilon_p$ , firms face a more competitive market. This reduces their mark-up and increases demand and production along an upward-sloping marginal cost curve. The rise in the marginal cost for a given real wage increases the demand for labor on impact. The rise in the marginal product of labor is further sustained by the increase in  $k$  and  $h^e$ , which react promptly through the overshooting of asset prices. As time goes by, the increase in the demand for labor along a highly inelastic supply of labor gives rise to a significant increase in real wages that wipes out most of the short-run employment gains.

## 4.2 The open economy case

Figure 2 reveals that the patterns described in the closed economy case still appear in the small open economy case, even if now the monetary policy response is absent. Following a price mark-up reform (continuous lines), the ensuing disinflation does not trigger a reaction of the area-wide policy rate and raises the real rate on impact. Nevertheless, this absence is compensated by the real depreciation triggered by price moderation. When we lower the wage mark-up (discontinuous lines), the trade channel operates more slowly, and the short-run reaction of GDP, employment, consumption, and investment is negative. However, the recession is marginal and very short-lived: after three quarters, GDP and other variables enter into positive territory and converge smoothly toward their positive long-run responses.

Figure 2: Internal devaluation in a small open economy.

Marginal effects of structural reforms, in a small open economy with no other shocks



### 4.3 Taking stock

Although goods and labor markets reforms have similar effects on long-term GDP, they display essential differences regarding their dynamics, the channels through which they operate, their impact on employment, and the composition of aggregate demand. In the long run, wage moderations are more employment-friendly, but they hardly affect total investment. In contrast, the rise in output after a reduction in price mark-ups is mostly driven by an increase in investment and the capital/labor ratio. The most remarkable difference between both reforms occurs in the short term, when the price mark-up reform shows an overshooting of GDP and employment with respect to their long-run levels, whereas the labor reform has only a very limited impact during the first 2 to 3 quarters after the reform. The next section will show how these asymmetric long-run responses of the aggregate variables operate in a monetary union.

## 5 Internal devaluations in a monetary union

We revisit now the goods and labor markets reforms, but in a monetary union where, since the periphery has our calibrated weight of 25%, there are sizable bidirectional repercussions of reforms between regions. In this context, dimensions other than the nature of the reform itself matter when we evaluate the impact of such reforms. In particular, we vary, in the short and



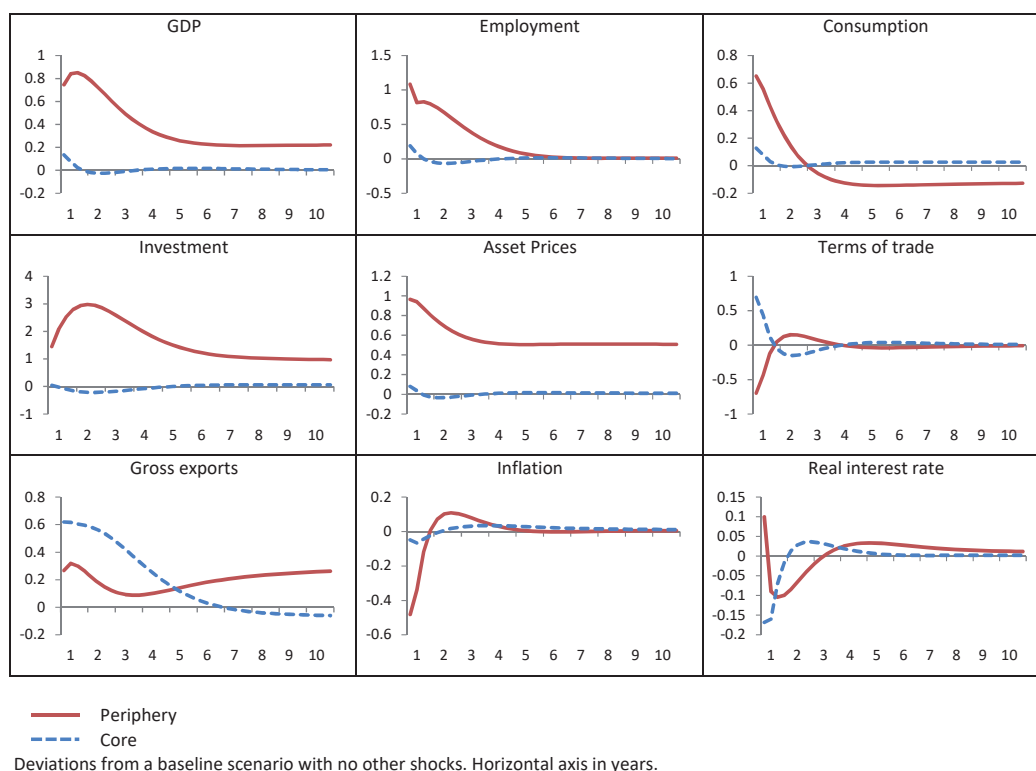
long run: i) the country we focus on (periphery vs. the core); ii) the macroeconomic scenario (normal monetary conditions vs. ZLB is operative); iii) the size of the periphery undergoing the reforms; iv) the degree of trade integration; v) the sequencing of the reforms; and vi) the flexibility of wages.

## 5.1 Reforms in the periphery and their impact on the core

Figure 3 displays the effect of a marginal (i.e., 1%) permanent reduction in price mark-ups in the periphery (continuous lines) and its impact on the core (discontinuous lines).

Figure 3: Goods markets reform in the periphery of a monetary union.

Marginal effects of structural reforms in goods markets



In the periphery, the effect of this reform is positive both in the short and medium run, with the exception of employment, which goes back to its pre-reform value after a few quarters, and consumption, which actually falls below its pre-reform value quickly. Lower price mark-ups push the inflation rate down and trigger a real exchange rate depreciation and opposite movements (on impact) of the real interest rate in the periphery and the core.

This pattern of responses replicates those in Section 4. As in the small open economy case, the real interest rate increases in the periphery, but the contractionary effects of this channel are limited and overwhelmed by the expansionary forces of net exports and investment. Regarding the latter, the permanent rise in capital causes, already in the short run, a sharp increase in real estate prices and investment.

The effects in the core are small but positive. Despite the beggar-thy-neighbor nature of internal devaluations, the core enjoys the positive effects of the reduction in the relative prices of goods imported from the periphery, as well as an increase in foreign demand, due to the boom in the periphery. These two effects compensate for the appreciation of the real rate. This result is a key difference between internal and nominal devaluations: in the former case, the core suffers a real appreciation of its currency, but still benefits from the enhanced efficiency of markets in the monetary union as a whole.

Figure 4: Labor market reform in the periphery of a monetary union.

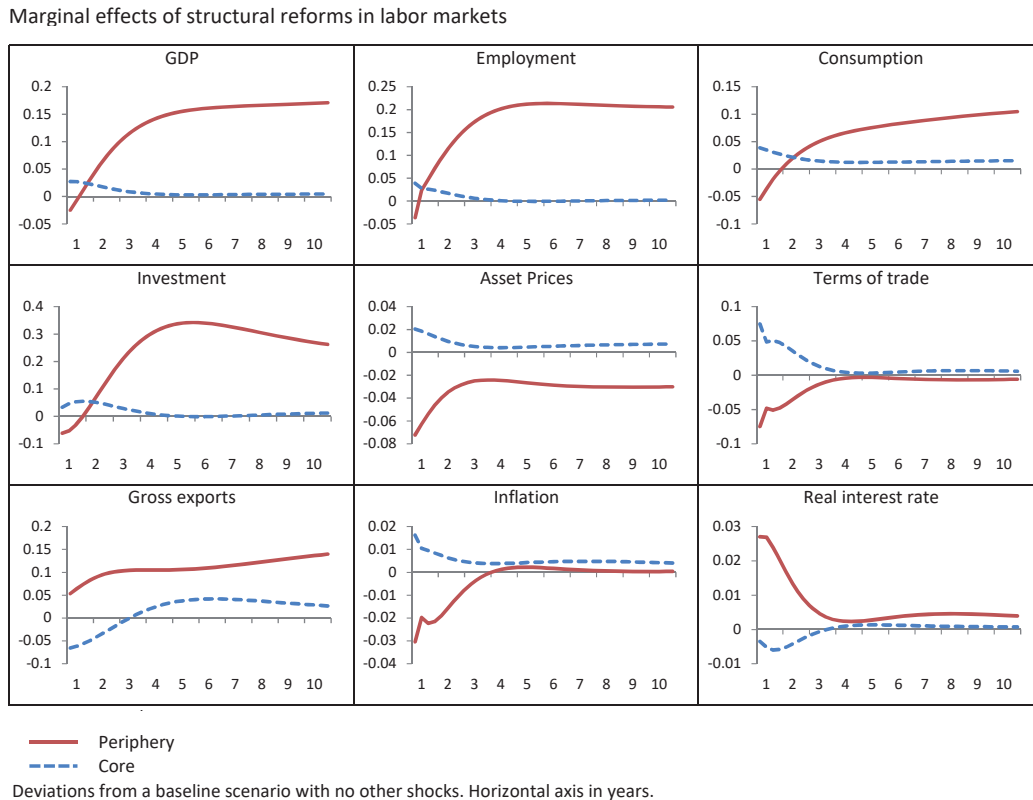


Figure 4 shows the effects of a marginal (i.e., 1%) permanent reduction in wage mark-ups in the periphery (continuous lines) and its impact on the core (discontinuous lines). The effects are similar to the ones from a price mark-up reduction. The effects on inflation and the terms of trade are around ten times smaller since the cut in desired wage mark-ups has to overcome two layers of nominal rigidities (wages and prices) to exert its effect on final goods prices. Thus, the gain in competitiveness is weak. Nevertheless, inflation in the core increases, along with the area-wide nominal interest rate. This makes the real rate rise in the periphery, inducing a small recession in the very short run. As time goes by, wages adjust sluggishly, and both the supply and the competitiveness effects gain traction, turning the effects in the periphery into higher GDP, employment, consumption, and investment.

The effects in the core are again small but positive. The loss of competitiveness of the core is of minor importance compared with the positive supply-side effect induced by a more

competitive labor market in a significant proportion of the monetary union.<sup>4</sup> Unlike in the periphery, consumption in the core also increases in the short run. At longer horizons, the positive output and employment effects become weaker, as the loss of competitiveness against the periphery becomes stronger, and a negative trade effect gradually shows up.

## 5.2 Internal devaluations at the ZLB

What happens when we undertake an internal devaluation at the ZLB, and the nominal interest rates do not react to further deflationary shocks? To generate a ZLB scenario that resembles the state of the eurozone during the early 2010s, the worst years of the euro crisis, we combine two shocks. First, we permanently lower the “loan-to-value” ratios by 7.5 percentage points ( $\bar{m}$  goes from 0.70 to 0.625 and  $\bar{m}^e$  from 0.64 to 0.565) to trigger a credit crunch and push the periphery into a lengthy deleveraging. Second, the whole monetary union is hit by a large negative demand shock (i.e., a transitory discount factor shock). Given a persistence of 0.9, we calibrate the innovation of the demand shock such that, in combination with the permanent “loan-to-value” shock, the monetary union is sent to the ZLB for four quarters.<sup>5</sup>

Taking the scenario with these two shocks as our baseline benchmark, we consider permanent goods and labor markets reforms similar to the ones described above. We modify our solution algorithm to consider the endogenous exit from the ZLB in the economy as the transitory demand shock dissipates.

In the case of the goods markets reform (Figure 6), the response in the periphery is more muted than outside the ZLB. Since the reform is strongly deflationary, we trigger an increase in the real interest rate. The lack of new credit in the deleveraging regime hinders growth in variables such as consumption, which is the only main variable that changes sign because of the presence of a deleveraging shock. The kinks in the response are caused by the nonlinear effects stemming from the fact that the reform brings forward the time at which the deleveraging process in the periphery comes to an end. Gross exports also grow less in the ZLB case, since, with no reaction by monetary policy, the spillover effect in the core is now negative. Because of the deflationary effects coming from the periphery, GDP, employment, consumption, investment, and asset prices all fall on impact in the core. In the periphery, a goods markets reform increases output and employment at impact even at the ZLB.

Due to their relatively small effect on prices, labor market reforms (Figure 6) have an impact under the ZLB very similar impact to that outside the bound, both in the periphery and in the core, with significant increases in output, employment, and consumption.

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<sup>4</sup>For the positive effect on the core’s GDP to be significant, the reform must be permanent: a temporary reduction in wage mark-ups (not shown here in the interest of space) has a much smaller effect.

<sup>5</sup>Fernández-Villaverde et al. (2015) show it is hard to generate endogenous spells at the ZLB that last for more than four quarters without introducing a wedge in the investment optimality condition. This wedge, however, makes it difficult to evaluate internal devaluations, since it affects all the optimality conditions of the agents.

Figure 5: The ZLB. Goods markets reform.

Marginal effects of structural reforms in goods markets, when the baseline has ZLB

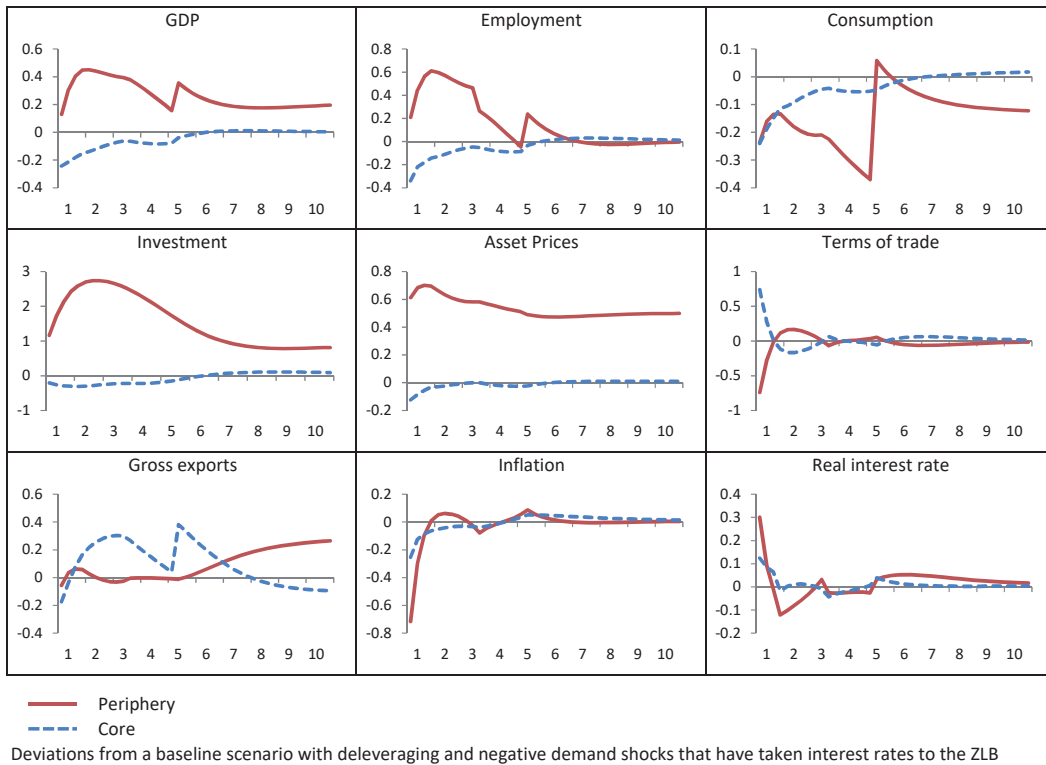
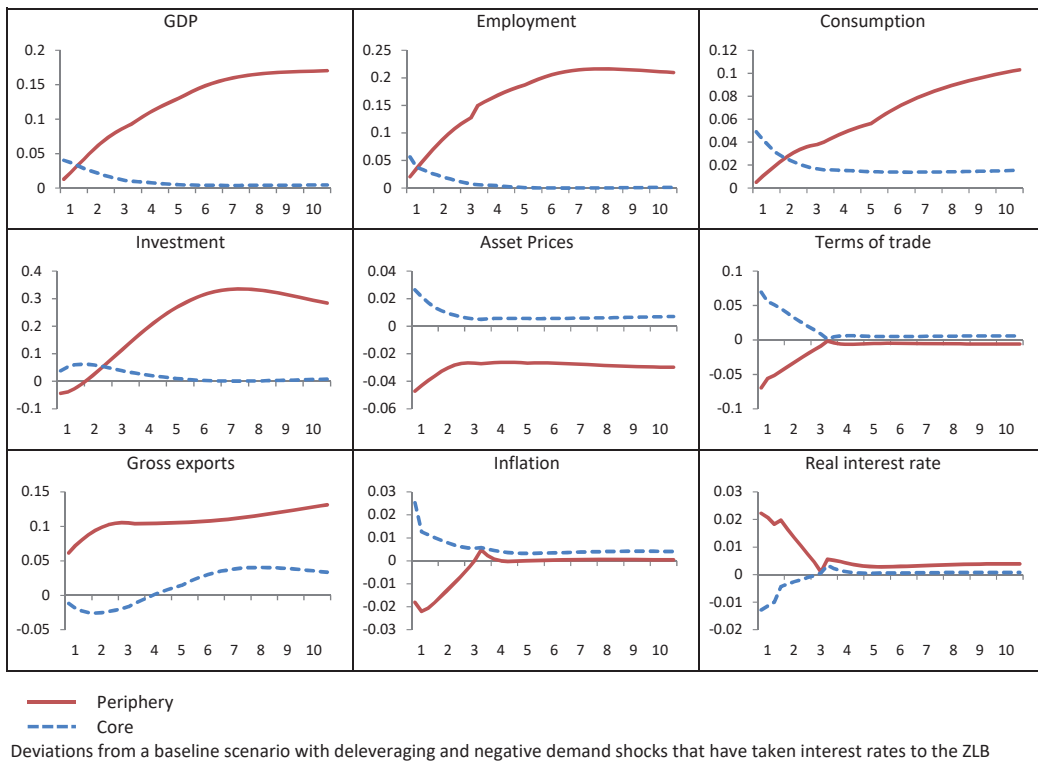


Figure 6: The ZLB. Labor market reform.

Marginal effects of structural reforms in labor markets, when the baseline has zero lower bound



### 5.3 Internal devaluations and the size of the periphery

How important is the size of the periphery on the effects of internal devaluations? We can think about this question as addressing both the issue of what occurs when the size of the periphery changes (e.g., a new country joins the eurozone) and gauging differences in how many peripheral countries undertake an internal devaluation (e.g., just Spain doing so or Spain and Italy simultaneously?).

Figures 7 to 10 answer this question both under normal monetary conditions and at the ZLB. We plot the short-term responses (i.e., the average of the first year of the simulation) of different variables for the periphery (lines with squares) and the core (lines with crosses) as the relative size of the former increases from 5% to 60% of the monetary union.

Figure 7 shows the effect of a marginal (i.e., 1%) permanent reduction in price mark-ups when the economy is away from the ZLB. The size of the periphery has little impact on the response of aggregate variables at the periphery, except inflation, the terms of trade, and the real interest rate, whose reaction becomes slightly more pronounced as the region undergoing the reform gets larger.

Why? Because as the size of the periphery increases, we have several forces operating in different directions. On the one hand, the competitiveness channel loses strength: the size of commercial partners against which competitiveness gains can be exploited narrows. On the other hand, the supply effects gain strength, as a larger fraction of the monetary union is becoming more efficient, and the real interest rate effect gets stronger as the deflationary impact becomes more prominent and the central bank engineers a larger interest rate cut.

Indeed, the larger the periphery, the more the core benefits. This result might seem counterintuitive if we only consider the “beggar-thy-neighbor” nature of internal devaluations, but it can be explained by the aggregate gains in efficiency and the accommodative reaction of nominal interest rates. Both of these mechanisms depend positively on the size of the periphery.

Figure 8 revisits the same exercise but at the ZLB. Now, as the periphery gets bigger, deflationary pressures become larger, and so does the real interest rate. If the size of the periphery is large enough, the negative real interest rate channel dominates and output, employment, consumption, and investment fall both in the core and in the periphery.

As in Andrés et al. (2017) and Gerali et al. (2015), our model predicts that an internal devaluation achieved through goods markets reforms spurs economic growth, even if the economy lacks an autonomous monetary policy or is at the ZLB. This result differs from that of Eggertsson et al. (2014), who find that such reforms reduce output in the domestic economy and in the monetary union as a whole at the ZLB. The response of asset prices and investment explains this difference. As seen in Figure 6, the goods markets reform at the ZLB generates a sharp appreciation of asset prices that is followed by a boost in domestic investment. Thus, the expectations channel is a key element of the transmission mechanism that we want to include in models that evaluate internal devaluations.

Figure 7: The size of the periphery. Goods markets reform

Marginal effects of goods markets reforms in periphery, depending on the size of periphery

Horizontal axis: size of periphery

Short-term effects (average of first year)

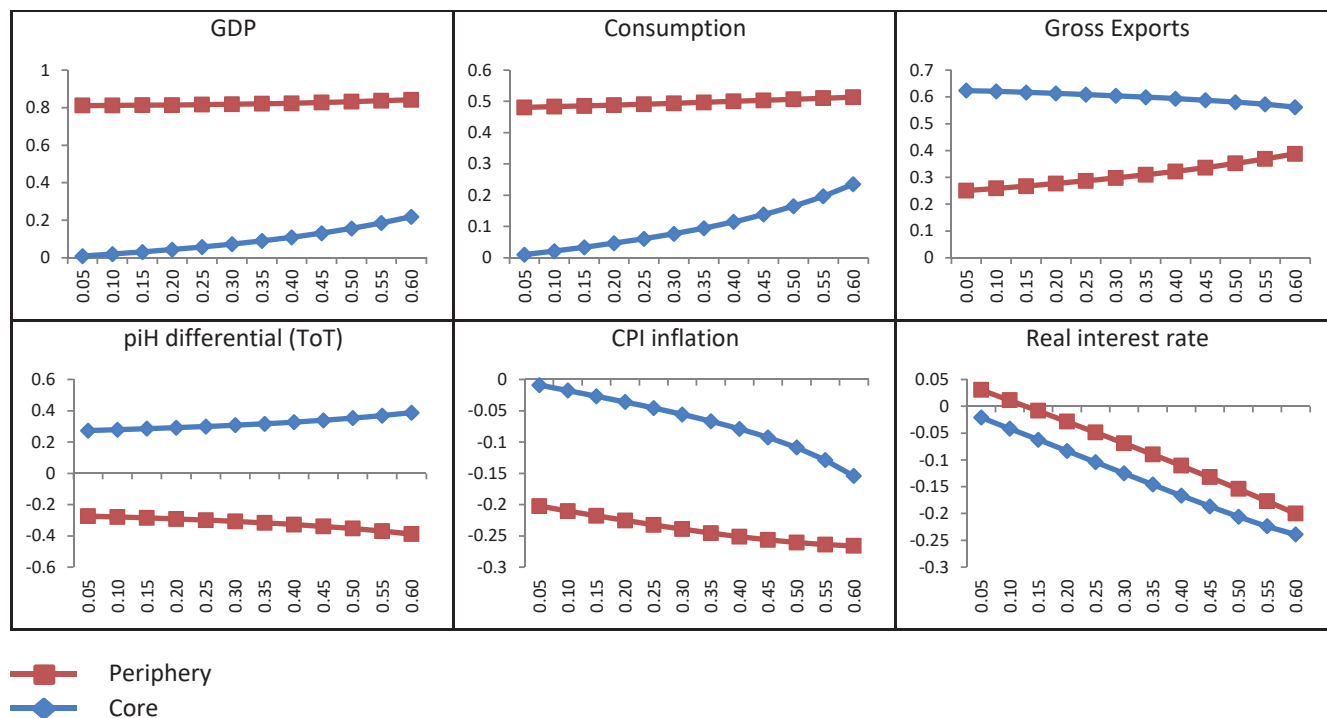
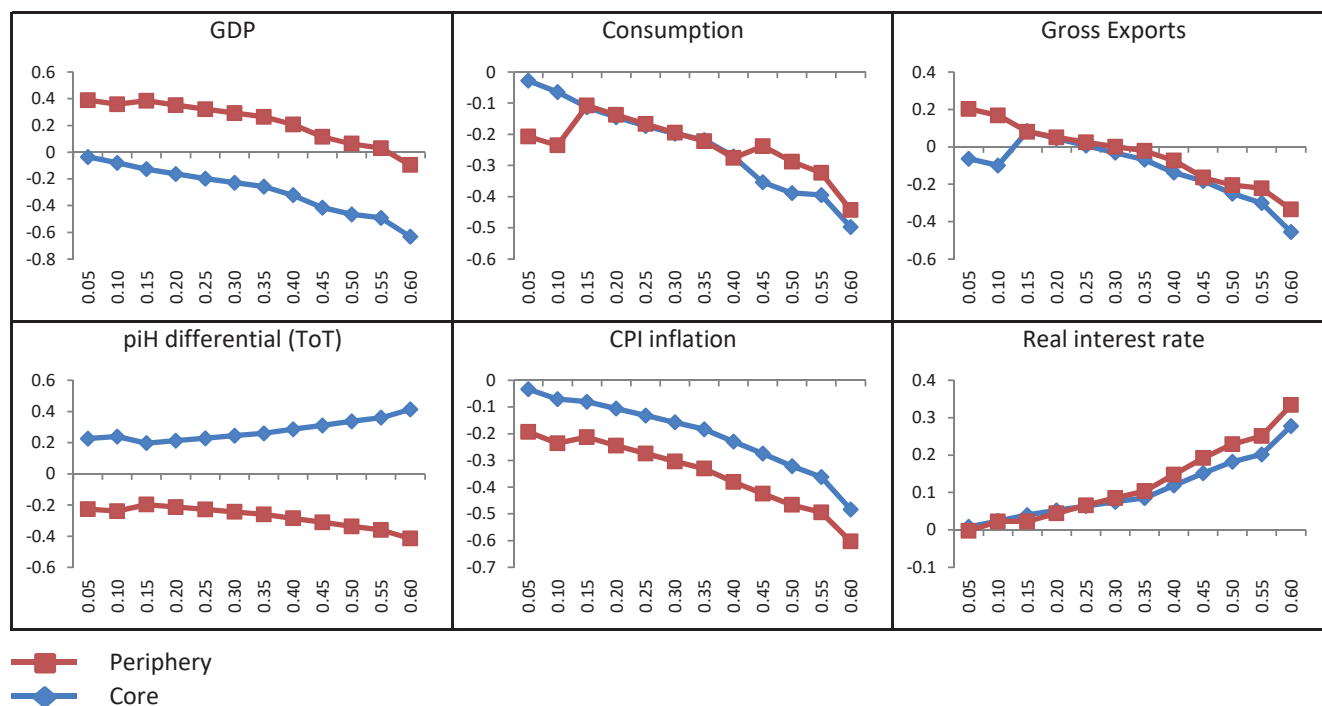


Figure 8: The size of the periphery. Goods markets reform at the ZLB

Marginal effects of goods markets reforms in periphery, depending on the size of periphery

Horizontal axis: size of periphery

Short-term effects (average of first year)



This pattern of response also explains why our model predicts that, at the ZLB, the positive output effects are circumscribed to the periphery and do not reach the rest of the monetary union, which departs from the predictions in Gerali et al. (2015). The key difference is that, in our analysis, the internal devaluation is only implemented in one region, and thus their effects are asymmetric across the monetary union. Importantly, the supply channel associated with the efficiency gain of the internal devaluation is limited to the reforming country, so the rest of the union only perceives the increase in the real interest rate and a real appreciation. Both forces exert a negative effect on demand in the core with an intensity that depends positively on the size of the periphery.

Figure 9 shows that the positive effects of the wage mark-up reform under normal monetary conditions are enhanced for both the core and the periphery when the size of the area implementing the reform increases because the long-term benefits of the reform become larger. For sizes of the periphery below 20%, the effect of the wage moderation in the periphery is negative in the short run (in terms of GDP, employment, consumption, and investment), but it becomes positive and larger as the size of the area undertaking the reforms increases beyond 25% of the monetary union and the accommodative reaction of monetary policy becomes bigger. Consumption is the main driver of this result: the response of exports also increases with the size of the periphery, but net exports barely change due to a parallel rise in imports. The reform is mildly deflationary in the periphery. In the core, the short-term effects are always positive, and this spillover effect is increasing with the size of the periphery.

Since the labor reform is just barely deflationary in the short term, the results described above remain mostly unchanged even at the ZLB (Figure 10). Even without accommodative monetary policy, the union-wide efficiency gain grows with the size of the periphery.

Summing up: internal devaluations in a region of the monetary union through goods markets reforms have union-wide expansionary effects when the real interest rate can fall with the positive development on the supply side of the periphery. This positive impact may turn negative in the short run for the whole monetary union only if the central bank is constrained by the ZLB and the size of the periphery is large, in fact quite larger than the size of the periphery in the euro area. A small periphery can always profit from the disinflationary effects of its reform by exploiting its competitiveness gains against a big core.

On the other hand, the short-run effects of labor market reforms are largely independent of the monetary policy regime. Since the pass-through from lower mark-ups imposed by wage-setters into final goods prices is low for this reform due to the double nominal-rigidity layer, disinflationary effects are much smaller than under goods markets reforms. This ensures that labor market reforms do not backfire in the short run even when there is no margin for monetary policy accommodation and the periphery is big.

Figure 9: The size of the periphery. Labor market reform

Marginal effects of labor market reforms in periphery, depending on the size of periphery

Horizontal axis: size of periphery

Short-term effects (average of first year)

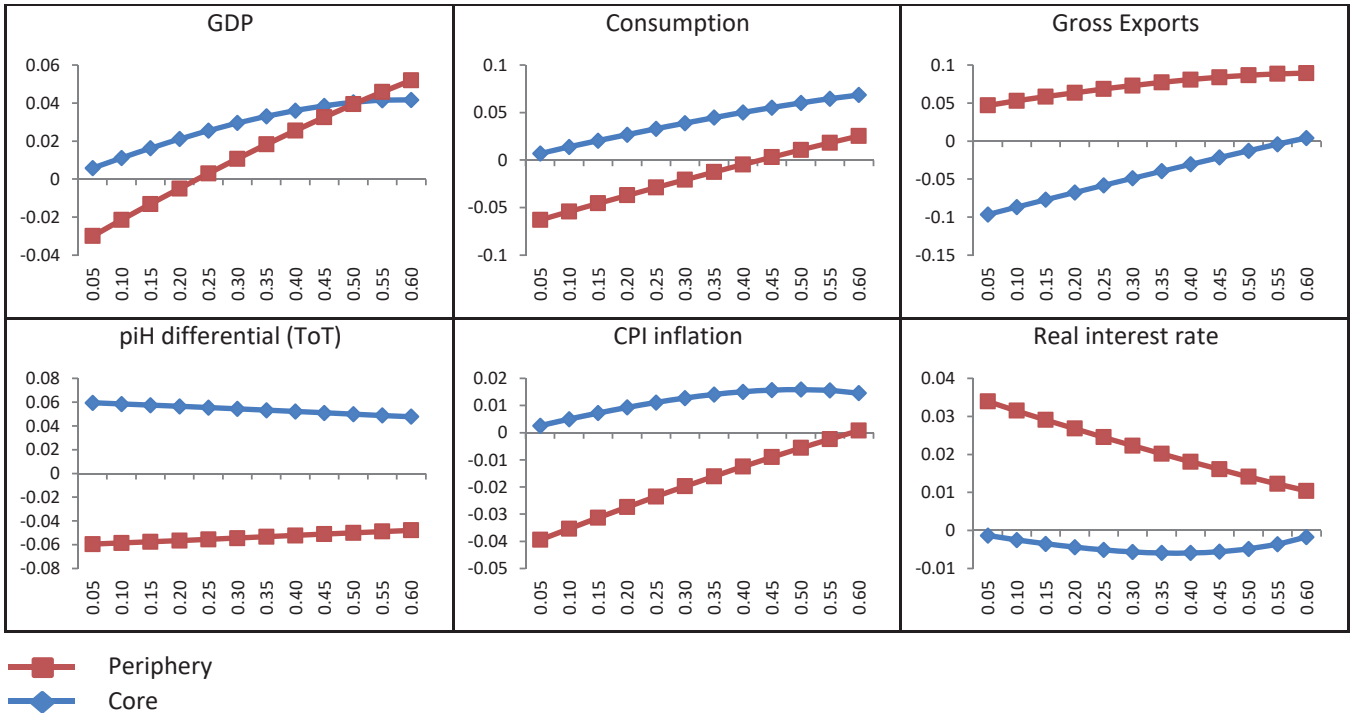
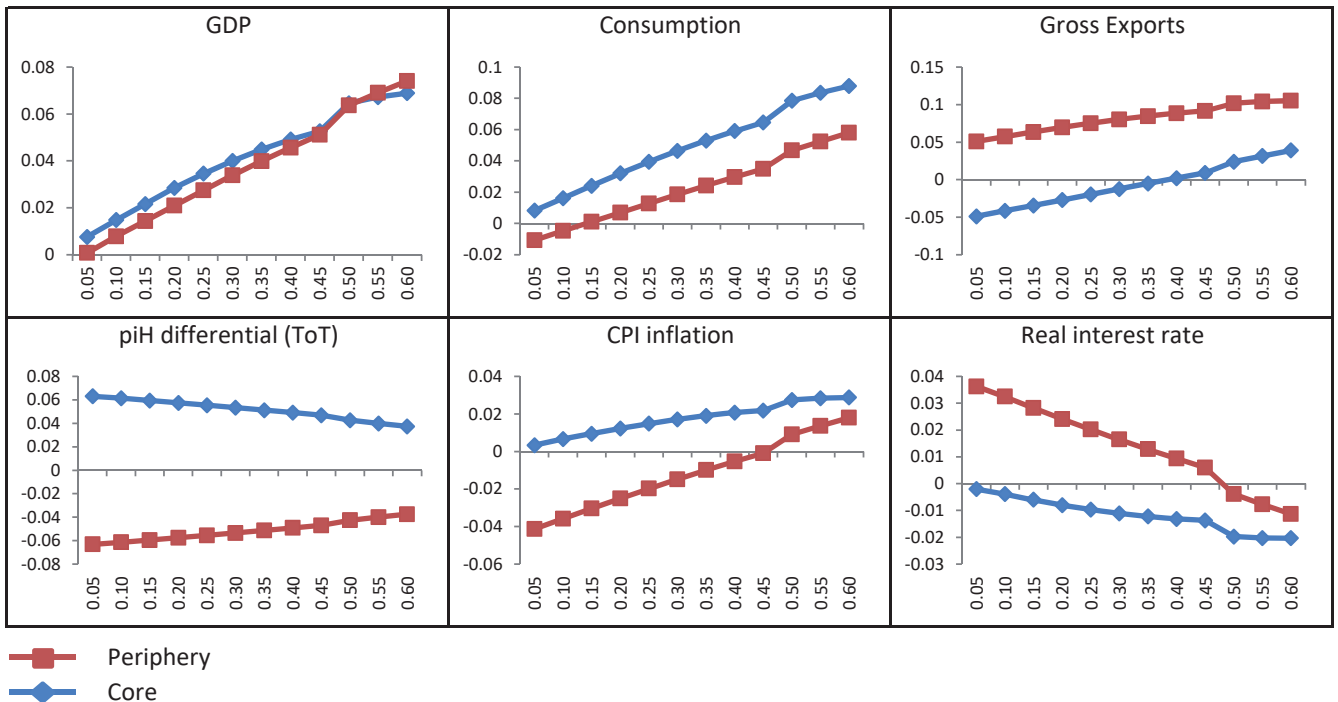


Figure 10: The size of the periphery. Labor market reform at the ZLB

Marginal effects of labor market reforms in periphery, depending on the size of periphery

Horizontal axis: size of periphery

Short-term effects (average of first year)

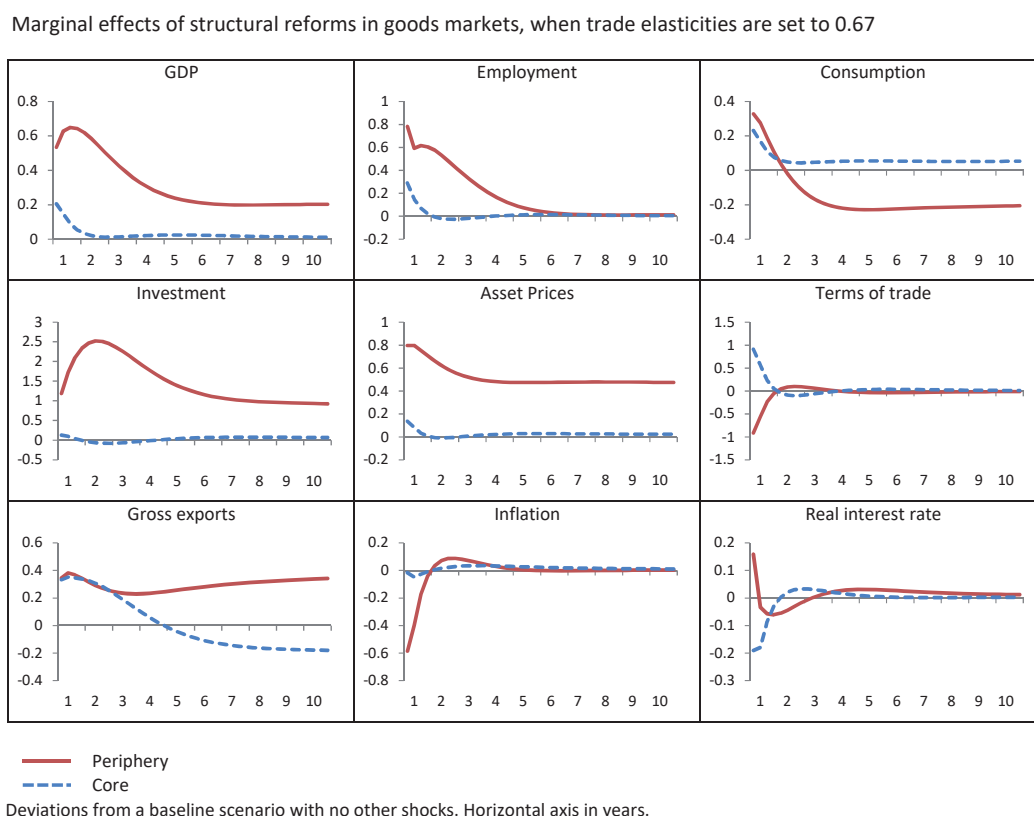




## 5.4 Internal devaluations and the degree of trade integration

How does the degree of trade integration between the core and the periphery change the answers from the previous pages? We can answer this question by lowering  $\varepsilon_H$  in equation (1), the elasticity of substitution between home and foreign varieties, from our calibrated value of 1 to 0.67, which represents a lower degree of trade integration.

Figure 11: Lower trade integration. Goods markets reform.

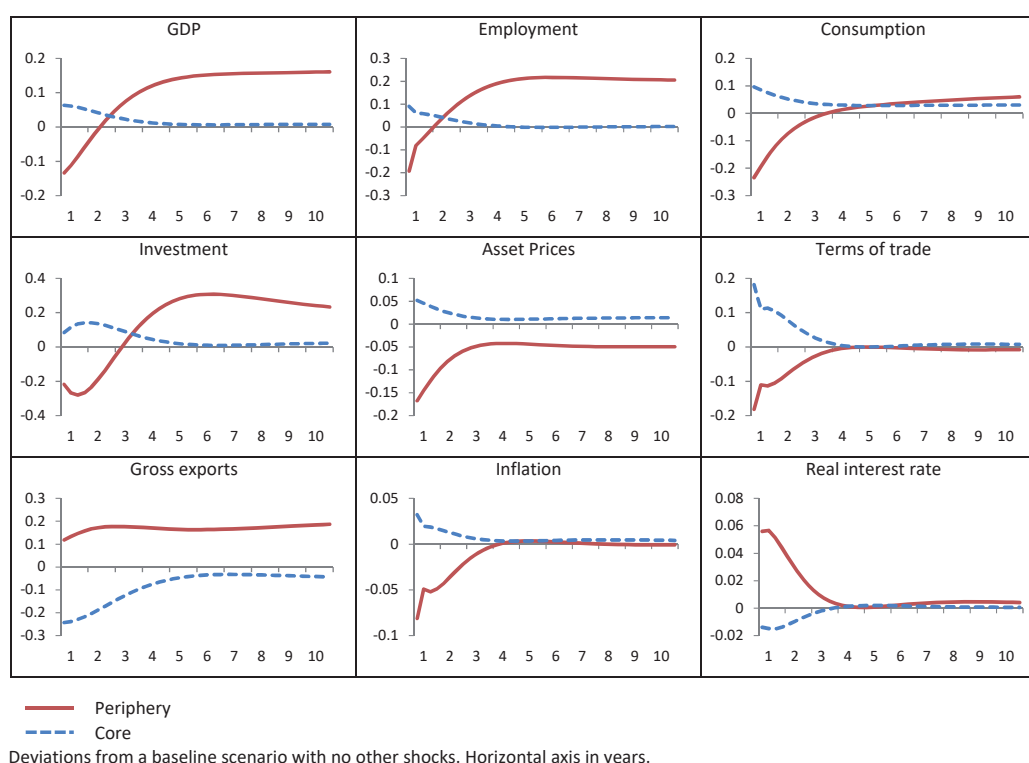


Figures 11 and 12 document that the positive effects of goods and labor markets reforms (under normal monetary conditions) become smaller (symmetrically, a higher  $\varepsilon_H$  makes the responses stronger) and have more prolonged adverse transitory effects. In the core, the opposite happens: a lower elasticity induces better output and employment outcomes.

When  $\varepsilon_H = 0.67$ , the periphery reacts more negatively and the core more positively in terms of GDP, employment, output, and consumption. However, we have the opposite result for gross and net exports in each region: exports evolve better in the periphery and worse in the core. This result is explained by the real interest rate channel, which creates a demand effect that ends up being stronger than the relative price effect. When  $\varepsilon_H = 0.67$ , both reforms are more deflationary in the periphery and more inflationary in the core, but the monetary union-wide inflation rate is roughly unchanged. Thus, the rise in the nominal rate is also the same across different elasticities of substitution. This makes for a larger increase in the real rate in the periphery and a lower one in the core in the case of low trade elasticities, which in turn explains why domestic demand rises less in the periphery and more in the core.

Figure 12: Lower trade integration. Labor market reform.

Marginal effects of structural reforms in labor markets, when trade elasticities are set to 0.67



## 5.5 Reform sequencing

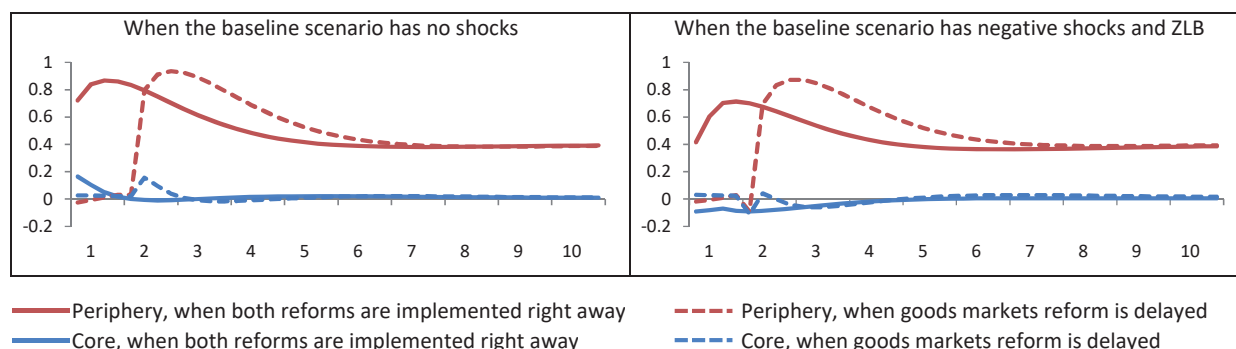
A concern for policymakers is whether there is a desirable sequencing for implementing reforms. Which reform should go first, goods or labor markets? The discussion relies not so much on the likely interaction among these reforms, as in Blanchard and Giavazzi (2003), but on the aggregate consequences of undertaking these reforms in our monetary union model, in terms of the present value GDP gains derived from alternative sequencing strategies. Figure 13 and Table 2 provide some answers (in the interest of space, here we only present results for GDP, but the effects on consumption, investment, and employment are equivalent).

First, notice the large sizes of discounted output gains in Table 2, with gains as high as 35%. This number is the product of a gain of around 0.6% a year discounted in a world of low real interest rates (around 2%). We calibrated our discount factors to generate such low real interest rates because they correspond to the observations in Europe since the early 2000s. As emphasized by Blanchard (2019), in such an environment, any positive improvement in an economy's efficiency has a large discounted value. Our model simply reflects Blanchard's insight.

Second, under normal monetary conditions (left panel of Figure 13), delaying any of the reforms reduces the present discounted value of their positive effects. However, when the monetary union is at the ZLB (right panel of Figure 13; the baseline has negative demand and deleveraging shocks that take the nominal interest rate to the ZLB for one year). At the ZLB, price mark-up reforms have a negative impact on the core because of their deflationary effects. This, in turn,

Figure 13: Reform sequencing.

Marginal effects on GDP of structural reforms in goods and labor markets, depending on time of implementation, with two different baseline scenarios



moderates the positive response of activity in the periphery. Labor market reforms are instead almost inflation-neutral in the core (even moderately inflationary), so postponing wage mark-up reductions does not produce any positive differential effect.

Table 2: Present value of accumulated GDP gain

	Normal monetary conditions			At the ZLB		
	Periphery	Core	MU	Periphery	Core	MU
Simultaneous reforms	35.3	1.6	13.4	32.1	-0.8	10.7
Delay labor reform	34.5	1.6	13.1	31.4	-0.9	10.4
Delay prod. reform	34.2	1.6	13.0	34.1	1.6	13.0
Net gain from:						
1) delaying labor reform	-0.7	0.0	-0.3	-0.8	-0.1	-0.3
2) delaying prod. reform	-1.1	0.0	-0.4	2.0	2.4	2.3

Consequently, in a scenario in which negative shocks have pushed the monetary union into the ZLB, the present value of accumulated GDP gains is maximized when labor market reforms are implemented right away, but the goods markets reforms are delayed.

## 5.6 An alternative reform: More flexible wages

Our final experiment analyzes the effects of increasing the flexibility of wages in the periphery, a dimension of labor market policies that has been frequently advocated in some euro area countries (Galí and Monacelli, 2016). In particular, we lower the wage Calvo parameter,  $\theta_w$ , from 0.75 to 0.72. Notice that, as we did in previous experiments, we consider a marginal reform, not a radical one, since the former is likely to be politically more feasible.

Unlike the previous reforms, this change does not improve the steady state of the economy because a change in the flexibility of wages does not affect steady-state wage mark-ups. Instead, this reform affects how an economy absorbs shocks. Thus, the effects of such a reform can only

be gauged in scenarios in which the economy is hit by shocks. For the simulation below, we use the same scenario as when we enforced the ZLB: the whole monetary union suffers an exogenous negative demand shock and its periphery is hit by a deleveraging shock that brings nominal interest rates against the ZLB.

Figure 14: Making wages more flexible.

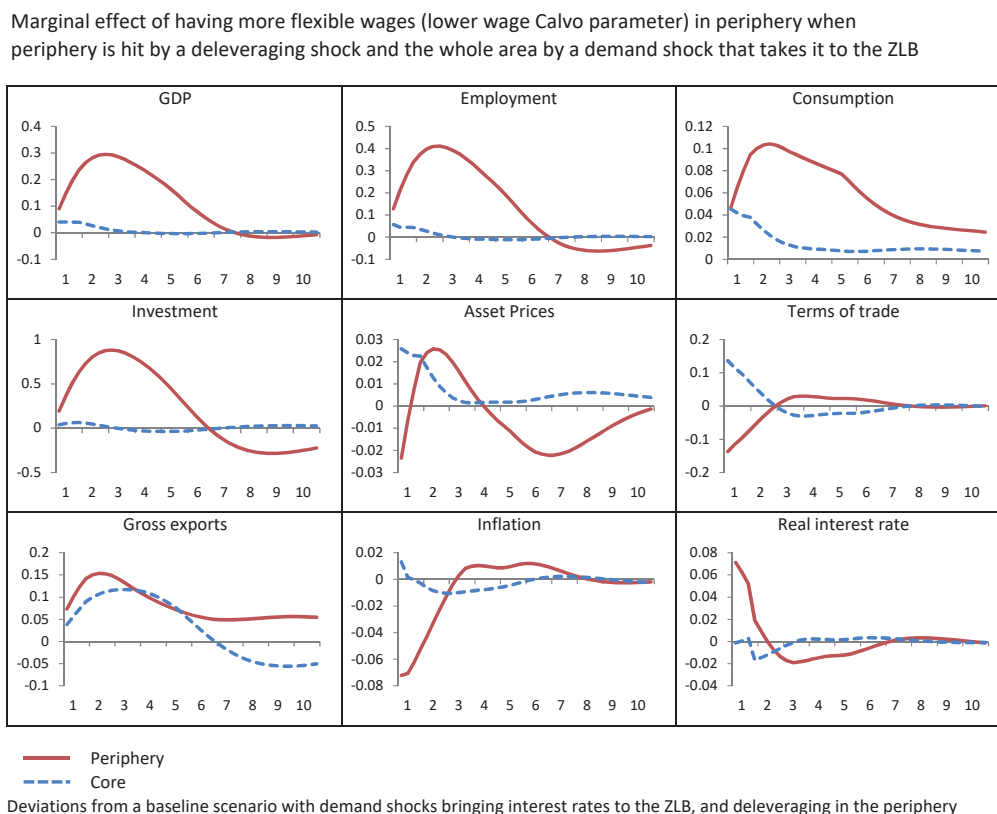


Figure 14 depicts the marginal effects (i.e., the difference with respect to the response with less flexible wages) of higher wage flexibility after the simultaneous occurrence of the two negative shocks described above. The positive effects in the panels of this figure mean that, while those shocks still have negative effects, they are smaller both in the periphery and in the core when the periphery's wages are more flexible. After the contractionary shocks, more flexible wages make the adjustment less harmful in employment, preventing a larger fall in consumption. Although wage flexibility facilitates a faster downward adjustment of prices (and hence higher real rates at the ZLB; this is in line with the intuition in De Long and Summers, 1986), wage flexibility also improves competitiveness and has a stronger positive effect on exports.

## 6 Concluding Remarks

In this paper, we have shown that, under conditions resembling those of the eurozone, internal devaluations by countries at the periphery have substantial long-run benefits for these countries.

These benefits carry over to the short run, even at the ZLB, thanks to the expectations channel. The gains in efficiency associated with goods and labor markets reforms outweigh a possible lack of monetary accommodation.

Interestingly, the core also benefits from the internal devaluations in the periphery, except when these are centered around goods market reforms and the eurozone is at the ZLB. Thus, in most cases, internal devaluations do not suffer from the “beggar-thy-neighbor” aspect of nominal devaluations. And even in the cases where they do, a euro-wide policy coordination can sequence the structural reforms to avoid most of the negative aspects of the absence of a response in nominal interest rates.

Our paper opens many avenues for future research, including exploring a richer set of structural reforms and analyzing how structural reforms and fiscal consolidation can be combined to hasten the recovery from the current COVID-19 crisis. We hope to address some of these questions in the near future.

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## Appendix

We provide now further details regarding how the labor market works in our model. Following Galí (2011), we assume that each representative household consists of a unit squared of individuals indexed by  $(i, j) \in [0, 1] \times [0, 1]$ , where  $i$  represents the variety of labor service provided by the individual and  $j$  indexes her disutility from working, given by  $\chi j^\varphi$ . Let  $n_t^x(i)$  denote the number of variety- $i$  workers in household  $x = u, c$  employed at time  $t$ . Total household disutility from working is given by:

$$\chi \int_0^1 \int_0^{n_t^x(i)} j^\varphi dj di = \chi \int_0^1 \frac{n_t^x(i)^{1+\varphi}}{1+\varphi} di.$$

Given the type-specific wage  $W_t(i)$ , the number of type- $i$  workers that each household would like to send to work is:

$$\arg \max_{n_t^x(i)} \left\{ \lambda_t^x \frac{W_t(i)}{P_t} n_t^x(i) - \zeta_t \chi \frac{n_t^x(i)^{1+\varphi}}{1+\varphi} \right\} = \left( \frac{\lambda_t^x W_t(i)}{\zeta_t \chi P_t} \right)^{1/\varphi} \equiv l_t^x(i),$$

where  $\lambda_t^x \equiv 1/c_t^x$ . Unemployment in the market for type- $i$  labor is just the number of workers willing to work at the going wage minus effective labor demand:  $u_t(i) \equiv \sum_{x=u,c} l_t^x(i) - \sum_{x=u,c} n_t^x(i)$ .

Let

$$l_t^x \equiv \int_0^1 l_t^x(i) di = \left( \frac{\lambda_t^x W_t}{\zeta_t \chi P_t} \right)^{1/\varphi} \int_0^1 \left( \frac{W_t(i)}{W_t} \right)^{1/\varphi} di = \left( \frac{\lambda_t^x W_t}{\zeta_t \chi P_t} \right)^{1/\varphi} \Delta_t^{w,l},$$

$$N_t^x \equiv \int_0^1 n_t^x(i) di = n_t^x \int_0^1 \left( \frac{W_t(i)}{W_t} \right)^{-\varepsilon_w} di = n_t^x \Delta_t^{w,n},$$

denote total household-specific labor supply and labor demand, respectively, where  $\Delta_t^{w,l} \equiv \int_0^1 (W_t(i)/W_t)^{1/\varphi} di$  and  $\Delta_t^{w,n} \equiv \int_0^1 (W_t(i)/W_t)^{-\varepsilon_w} di$  are indexes of wage dispersion. Then, aggregate unemployment is:

$$u_t \equiv \int_0^1 u_t(i) di = l_t - N_t.$$

where  $l_t \equiv \sum_{x=u,c} l_t^x$  and  $N_t \equiv \sum_{x=u,c} N_t^x$  are aggregate labor supply and labor demand, respectively. The unemployment rate is  $u_t^{rate} \equiv u_t/l_t$ .

Finally, notice that the total nominal wage income earned by each type- $x$  household equals  $\int_0^1 W_t(i) n_t^x(i) di = W_t n_t^x$ , where  $n_t^x \equiv n_t^{e,x} + n_t^{h,x}$ .

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