Deciphering the Macroeconomic Effects of Internal Devaluations in a Monetary Union*

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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. Nonetheless, when the ZLB binds, a sequencing of reforms that prioritizes labor policies over goods markets reforms might increase the present discounted value of output.

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1. Introduction

Many policymakers and economists have read the euro zone crisis of 2009–14 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 Organisation for Economic Co-operation and Development (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 COVID-19 health crisis, which has hit Italy and Spain particularly hard, is bound to revive this discussion as these countries struggle to rebuild their economies.

Since nominal devaluations are impossible within a monetary union, the periphery of the euro area has few short-run alternatives to restore competitiveness except through an internal devaluation.[1] In those internal devaluations, various policies push domestic prices and wages down in a persistent manner.

A straightforward policy to achieve this is to reduce production costs, for example, changing value-added tax or payroll taxes (Farhi, Gopinath, and Itskhoki 2014). Unfortunately, the delicate budgetary conditions and the high public debt-to-GDP ratios of the euro-periphery countries impose tight limits on this fiscal strategy.

A more promising alternative is to implement structural reforms that reduce the markups 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 euro zone and, thus, the existence of a "target-rich environment" for such reforms.

However, internal devaluations that reduce the markups in goods and labor markets bring risks of their own. An internal devaluation begets, by its very nature, deflationary pressures. If monetary policy

[1]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 (research and development). See, nevertheless, Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2014) for the importance of future improvements in productivity in short-term outcomes. Lastly, notice that the European Union law prohibits using optimal capital controls such as those suggested by Farhi and Werning (2012) and tariffs.

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 monetary union's aggregate variables much. Take the case of Malta, which accounts for around 0.1 percent of the euro area's gross domestic product (GDP). No Maltese internal devaluation will have any measurable effect on the euro-area aggregates and, thus, on the euro zone's nominal interest rate. Second, we might lack monetary policy accommodation 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, Ferrero, and Raffo (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 households' and firms' deleveraging process in countries with high private and public indebtedness (such as Italy and Spain in the 2010s). Lastly, 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 just discussed. 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 close to one, our model encompasses a closed economy. Conversely, by making the periphery's size 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 they rely on 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 markups. To make the internal devaluations empirically relevant, we explore "marginal" reforms that permanently reduce markups by 1 percent (we also consider, as a robustness analysis, a reform that makes wages marginally more flexible). Thus, we only consider policies that have a reasonable chance of being feasible within the periphery countries' political-economic game. Also, we gauge the effects of the internal devaluations under normal monetary conditions and at the ZLB. To reflect the situation of the euro zone circa 2010, we engineer a spell at the ZLB by hitting the economy with a sizable deleveraging shock (i.e., a tightening of the borrowing constraint) and a negative demand shock (i.e., a substantial discount factor shock).

In our model, internal devaluations stimulate output and consumption in the long run because they reduce the incidence of real frictions. Even the core is better off because of the monetary union's enhanced efficiency as a whole. This outcome does not occur with nominal devaluations, where the core usually loses. We show that the supply-side effect is generally more potent than the demand channels that operate through real exchange and real interest rates.

Our first 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 in the core—whether or not the ZLB binds. The mechanism is the expectations channel: higher long-run efficiency induces an increase in investment today. In models with monopolistic competition, entrepreneurs want to produce more and at a lower price when there is less market power. For that, they need more capital, even if the real rate increases at the ZLB. This result highlights the importance of using models that incorporate investment and capital to assess internal devaluations. Even with borrowing frictions, internal devaluations work mainly through changes in investment. This point was conjectured in Fernández-Villaverde (2014).

Our second result is that labor market reforms bring smaller output effects and more muted deflationary pressures than goods markets reforms. The cut in desired wage markups has to overcome two layers of nominal rigidities (wages and prices) to affect final goods prices. In comparison, the cut in intermediate goods markups only has to face the nominal rigidities in wages. 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 percent 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 percent threshold is well above the size of the euro area's periphery.

Our third result regards the sequencing of reforms. When the monetary union is outside the ZLB, the present discounted value of output in the periphery is higher when reforms in both goods and labor markets are implemented simultaneously. However, when the monetary union is at the ZLB, implementing first the labor market reform and delaying the goods market reform until the economy leaves the ZLB increases the present discounted value of output.

Thus, once the general equilibrium effects of internal devaluations within a monetary union are accounted for, the possibility of short-run reductions in output largely evaporates. While there are circumstances under which goods markets reforms lower the periphery's output in the short run, those cases are not empirically relevant given the actual size of the euro area's periphery. Nonetheless, when the ZLB binds, a sequencing of reforms that prioritizes labor policies over goods markets reforms might increase the present discounted value of output.

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, Arce, and Thomas (2017), Cacciatore and Fiori (2016), Cacciatore, Fiori, and Ghironi (2016), Campagne and Poissonnier (2016), Eggertsson, Ferrero, and Raffo (2014), Fernández-Vallaverde, Guerrón-Quintana, and Rubio-Ramírez (2014), Galí and Monacelli (2016), and Gerali, Notarpietro, and Pisani (2015), among others, we characterize the reforms as permanent reductions in price and wage markups.

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, by placing the previous union-wide general equilibrium channels at the heart of our analysis, we shed light on some key questions, 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.

The rest of the paper is organized as follows. Section 2 introduces the model and we calibrate it in Section 3. Section 4 uses the model to study the effects of internal devaluations in closed and small open economies, while Section 5 analyzes internal devaluations in a monetary union. Section 6 concludes.

2. A Core-Periphery Model of a Monetary Union

We model a monetary union with two countries: periphery and core. We will employ H (for home) to refer to the former and F (for foreign) to the latter since we will analyze the policy choices that countries at the periphery face.

A fraction s of the population in the monetary union (normalized to 1) lives in the periphery. There are three types of 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 new 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.

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.

We need two shocks to study the effects of internal devaluations: a discount factor shock, which works as a demand shock, and a "loan-to-value" (LTV) 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 for our investigation.

We now describe the model structure in the periphery country (the core country is analogous). Further details of the model, which builds on Andrés, Arce, and Thomas (2017) and Arce, Hurtado, and Thomas (2016), are laid out in the online appendices available at http://www.ijcb.org.

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.

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

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

where $c^x_{H,t} = \left(\int_0^1 c^x_{H,t}(z)^{(\varepsilon_p-1)/\varepsilon_p}\, dz\right)^{\varepsilon_p/(\varepsilon_p-1)}$ and $c^x_{F,t} = \left(\int_0^1 c^x_{F,t}(z')^{\left(\varepsilon^*_p-1\right)/\varepsilon^*_p}\, dz'\right)^{\varepsilon^*_p/\left(\varepsilon^*_p-1\right)}$ aggregate a continuum of home, $c^x_{H,t}(z)$, and foreign, $c^x_{F,t}(z')$, final good varieties, 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

$$c^x_{H,t} = \omega_H \left(\frac{P_{H,t}}{P_t}\right)^{-\varepsilon_H} c^x_t$$

$$c^x_{F,t} = (1-\omega_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\varepsilon_H} c^x_t$$

$$c^x_{H,t}(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}}\right)^{-\varepsilon_p} c^x_{H,t}$$

$$c^x_{F,t}(z') = \left(\frac{P_{F,t}(z')}{P_{F,t}}\right)^{-\varepsilon^*_p} c^x_{F,t},$$

where $P_t = \left(\omega_H P^{1-\varepsilon_H}_{H,t} + (1-\omega_H) P^{1-\varepsilon_H}_{F,t}\right)^{1/(1-\varepsilon_H)}$ 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 $P_{F,t} = \left(\int_0^1 P_{F,t}(z')^{1-\varepsilon^*_p}\, dz'\right)^{1/\left(1-\varepsilon^*_p\right)}$ is a price index of foreign goods. Nominal spending on home and foreign goods equals $P_{H,t}c^x_{H,t} = \int_0^1 P_{H,t}(z)\, c^x_{H,t}(z)\, dz$ and $P_{F,t}c^x_{F,t} = \int_0^1 P_{F,t}(z')\, c^x_{F,t}(z')\, dz'$, respectively, whereas $P_t c^x_t = P_{H,t}c^x_{H,t} + P_{F,t}c^x_{F,t}$ 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 $c^x_{H,t}$ and $c^x_{F,t}$. This symmetry gives rise to demand functions by the entrepreneur operating these technologies with the same form as the demand functions above.

2.1.1 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 ζ_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.

The budget constraint of this household is

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

where d_t is the real value of net holdings of riskless loanable funds, p_t^h is the real price of housing, δ_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, τ_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.

2.1.2 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:

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

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, our debt contracts are long term and generate 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 Iacoviello (2005) and Kiyotaki and Moore (1997), 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.

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:

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

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, $b_t^{new} \leq m_t R_t^{-1} \mathbb{E}_t \pi_{t+1} p_{t+1}^h h_t - \gamma b_{t-1}/\pi_t$.

If collateral values become sufficiently low, the economy switches to an alternative regime, with no new credit and debt restricted by the contractual amortization path. Importantly, changes between regimes occur endogenously, depending on 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:

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

where $\lambda_t^x = \zeta_t / c_t^x$ and ξ_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. See also Andrés, Arce, and Thomas (2017) for further discussion and motivation of this borrowing constraint.

2.1.3 The Entrepreneur

The entrepreneur operates three technologies under perfect competition. First, the entrepreneur produces an intermediate good with technology $y_t^e = k_{t-1}^{\alpha_k} \left(h_{t-1}^e\right)^{\alpha_h} \left(n_t^e\right)^{1-\alpha_k-\alpha_h}$, 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 mc_t (also the marginal cost). The entrepreneur owns the equipment, with unit price q_t and depreciation rate δ_k, and the commercial real estate, which has the same price, p_t^h, and depreciation rate, δ_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 $\Pi_t^r = mc_t y_t^e - \frac{W_t}{P_t} n_t^e - p_t^h \left[h_t^e - (1 - \delta_h) h_{t-1}^e\right] - q_t \left[k_t - (1 - \delta_k) k_{t-1}\right]$.

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

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

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).[2] 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 Π_t^r as the profits of the retailer's 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

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

[2] 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 steady-state real estate price, p_{ss}, is 1. If $\omega \neq 0$, $p_{ss}^h = (w_{ss})^\omega \omega^{-\omega} (1-\omega)^{-(1-\omega)}$.

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

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

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.

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

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

where ξ_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 that of 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):

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

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

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

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

where θ_p is the probability of not adjusting the price and τ_p is a tax rate on retailers' revenue. The retailer uses the stochastic discount factor of the entrepreneur to value its profits since 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 pick

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

where the desired price markup 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

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

As in Erceg, Henderson, and Levin (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

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

where θ_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 markup,

$$\frac{1}{1-\tau_w}\frac{\varepsilon_w}{\varepsilon_w-1}, \tag{6}$$

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

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 an inflation-based Taylor rule and subject to a ZLB constraint:

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

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.

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 $x_t(z) = \left(P_{H,t}(z)/P_{H,t}\right)^{-\varepsilon_p} x_t$, where real per capita exports equal

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

with ω_F^* and ε_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, 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 $y_t\Delta_t = k_{t-1}^{\alpha_k}\left(h_{t-1}^e\right)^{\alpha_h}\left(n_t^e\right)^{1-\alpha_h-\alpha_k}$, where $\Delta_t \equiv \int_0^1 \left(P_{H,t}\left(z\right)/P_{H,t}\right)^{-\varepsilon_p} dz$ is the 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: $h_t^u + h_t + h_t^e = I_t^h + \left(1-\delta_h\right)\left(h_{t-1}^u + h_{t-1} + h_{t-1}^e\right)$. The demand for equipment must equal supply: $k_t = I_t + \left(1-\delta_k\right)k_{t-1}$. 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

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

where in the second equality we used $z_{H,t} = \frac{P_t}{P_{H,t}}z_t - \frac{P_{F,t}}{P_{H,t}}z_{F,t}$ 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 $sP_t nfa_t + \left(1-s\right)P_t^* nfa_t^* = 0$, where the core's real per capita net foreign asset position, nfa_t^*, is defined in the same way as nfa_t. Combining all domestic market-clearing conditions and budget constraints, we obtain the periphery's current account identity:

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

3. Calibration

Table 1 summarizes the calibration of our model to the euro zone 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

Table 1. Calibration

Parameter	Value	Description
s	0.25	Size of periphery
		Preferences
β^u, β^{u*}	0.994	Unconstrained household discount factor
β, β^*	0.98	Constrained household discount factor
φ, φ^*	4	(Inverse) labor supply elasticity
ϑ, ϑ^*	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
ω_H, ω_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
α_h, α_h^*	0.21	Elasticity output w.r.t. real estate
α_k, α_k^*	0.11	Elasticity output w.r.t. equipment
ω, ω^*	0.43	Elasticity construction w.r.t. labor
δ_h, δ_h^*	0.01	Depreciation real estate
δ_k, δ_k^*	0.025	Depreciation equipment
μ, μ^*	0.5	Share of constrained households in labor baskets
Φ_h, Φ_h^*	6.1	Investment adjustment costs construction
Φ_k, Φ_k^*	2.4	Investment adjustment costs equipment
		Price/Wage Setting
θ_p, θ_p^*	0.67	Fraction of non-adjusting prices
θ_w, θ_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
γ, γ^*	0.98	Amortization rate household debt
γ^e, γ^{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

GDP per capita and already-flexible markets). Since these four countries constitute around 25 percent of the euro zone GDP, we make $s = 0.25$. We will present robustness scenarios for this parameter value to allow for different choices of which countries to include in the periphery.

The long-run inflation target $\bar{\pi}^{MU}$ is 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 β, 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 nominal rate at the start of 2007, right before the onset of the euro zone crisis, and roughly the average of the previous decade. We assume a standard value of 1.5 for the Taylor-rule coefficient ϕ. 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 select home-specific parameters using Spanish observations for 2007, rather than building consolidated aggregates for the peripheral euro zone economies, which involves complex non-linear weighting and comparability that would distract from the focus of our analysis with little additional insight.

In particular, we select ψ to replicate Spain's net foreign assets over GDP in 2007, $nfa^y_{ss} = -79.3\%$. The parameter ω_H is set to match gross exports over GDP in 2007 (26.9 percent). 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 percent) and the share of equipment in the total stock of productive capital (21.4 percent). The elasticity ω matches the construction share of total employment in 2007 (13.4 percent). The weight of utility from housing services, ϑ, helps to replicate gross household debt over annual GDP (80.2 percent), and we set $\mu_h = \mu_e \equiv \mu = 1/2$. The adjustment costs, Φ_h and Φ_k, are chosen such that the fall in construction and equipment investment in our baseline deleveraging scenario resembles their behavior during the euro zone crisis. The Calvo parameters $\theta_p = 2/3$ and $\theta_w = 3/4$ are 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 euro zone crisis were slightly below 70 percent. We thus set $\bar{m} = 0.70$ for the household's initial loan-to-value ratio. The entrepreneurial initial loan-to-value ratio $\bar{m}^e = 0.64$ is chosen to match the ratio of gross non-financial corporate debt to annual GDP (125.4 percent in 2007). 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 2008.

We set $\tau_p = \tau_w = 0$ because it allows us to isolate the effects of internal devaluations modeled as changes to ε_p and ε_w from additional fiscal effects operating through changes in the lump-sum taxes paid by the constrained households, T_t (see Andrés, Arce, and Thomas 2017 for a discussion of the effects of reforms implemented via reductions in τ_p and τ_w). We set $\varepsilon_p = 7$ to get an initial price markup 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 markups, we follow Galí (2011) and target an unemployment rate of 8.6 percent in 2007, which yields an initial wage markup of $(1 - \tau_w)^{-1} \varepsilon_w/(\varepsilon_w - 1) = 1.43$, which we achieve by setting $\varepsilon_w = 3.31$.

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 symmetric calibration, with two exceptions. First, we set ω_F^* to normalize the terms of trade in the initial steady state to 1. Unlike ω_H, which was calibrated to match an exports target for the home country (equivalently, an imports target, given the target for the ratio of net foreign assets to GDP), ω_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 make the interest rates in both countries equal in the initial steady state. This extra parameter allows us to match the observed minuscule country-specific risk premia within the euro zone in 2007. In particular, we assume $R_t^* = R_t^{MU} \exp\left[-\psi^* \left(P_t^* nfa_t^*/P_{F,t} gdp_t^*\right) + \psi_0^*\right]$, with $\psi^* = \psi$, and set ψ_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 encompasses both cases by setting s 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 markups. We call the former a goods markets reform and the latter a labor market reform. We gauge the consequences of a reduction in these markups by 1 percent 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 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 markup 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 markups 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.[3] 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, such as incentives to invest in research and development, fostering firm creation (Bilbiie, Ghironi, and Melitz 2012) and growth (Andrés and Burriel 2014, 2018). For example, Cacciatore and Fiori (2016) and Cacciatore, Fiori, and Ghironi (2016) study the effects of reforms in the product as well as in the labor market aimed at spurring firm entry, encouraging vacancy posting, inducing workers to intensify their search effort, and making the matching among vacancies and job seekers more efficient. Those policies have positive effects on the economy, some of which are missing in our exercises since we do not capture some channels operating through firm and labor market dynamics. More targeted reforms in goods and labor markets would have additional side effects that, in the interest of clarity, we prefer to skip. Instead, our simpler 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. These realignments are of critical importance in a deflation-prone period, like the one triggered by the euro zone crisis.

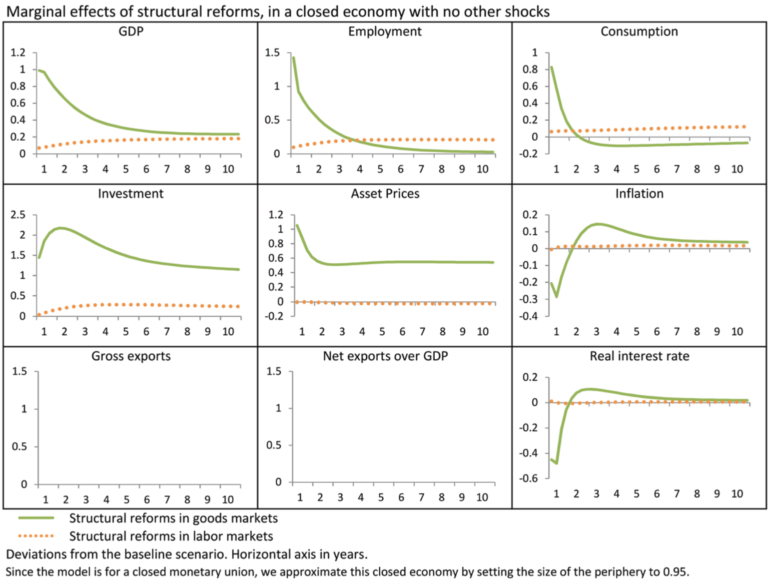
4.1 The Closed-Economy Case

Figure 1 plots the impact of goods and labor markets reforms on aggregate variables in a closed economy.[4] This case is closer to a policy-induced deflation than to an internal devaluation. We initialize the economy at its steady state and implement a marginal (i.e., 1 percent) permanent reduction in either prices (continuous lines) or wage markups (discontinuous lines). To compute the transition

[3] In this case, there is an offsetting effect on employment caused by the income effect that pushes the labor supply upward. When the markup 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.

[4] In all the figures, we use the label "Investment" to refer to fixed capital investment, whereas "Asset Prices" denotes real estate prices.

Figure 1. Internal Devaluations in a Closed Economy



between the original steady state with the original markups and the new steady state with lower markups, 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.

Figure 1 shows that 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. Notice that, in the case of goods market reforms, consumption takes longer than the 10 periods plotted in Figure 1 to reach its long-run positive level.

The boost to activity following lower price markups comes mainly through increased investment and the capital/labor ratio. When the economy is away from the ZLB, this reform's deflationary impact leads to a negative overreaction of the nominal interest rate (recall the Taylor-rule coefficient $\phi = 1.5$) that reduces the real rate and increases Tobin's q and investment. Also, lower price markups soften the distortion in the relative price of leisure versus consumption goods caused by market power and nominal rigidities and increase labor and capital demand. 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 markup reforms). Wages and the capital-labor ratio rise significantly but not consumption, reflecting the need to finance a persistently higher 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 lower price markups stems from the decline in the real interest rate and the significant increase in asset prices. These changes set in motion the expectations channel that leads to a substantial increase in investment and real estate demand by entrepreneurs. Also, higher housing prices ease the borrowing constraint and facilitate higher consumption by indebted agents. The wage markup reform has little impact on inflation. Thus, the real interest rate hardly reacts and asset prices remain flat. Absent this expectations channel, consumption and investment increase gradually over time as employment gathers momentum.

These differences are clearer by looking at the demand for labor:

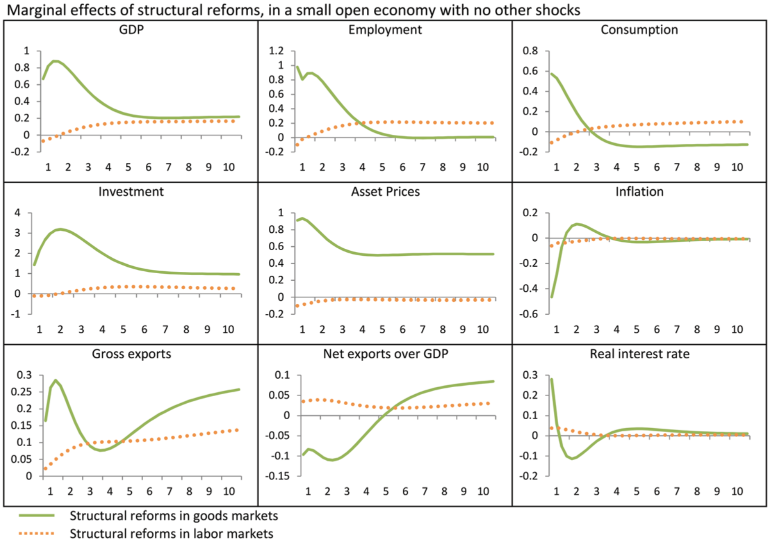
$$n_t^e = \left[\frac{mc_t \left(1 - \alpha_h - \alpha_k\right) k_{t-1}^{\alpha_k} \left(h_{t-1}^e\right)^{\alpha_h}}{w_t} \right]^{1/(\alpha_h + \alpha_k)}.$$

As ε_W increases, the labor market becomes more competitive and the real wage falls. The direct impact of this reform on output, marginal cost, investment, and housing demand is weak, so employment increases along with the sluggish downward adjustment in nominal and real wages, with little action in other aggregate variables. The permanent reduction in real wages shifts relative factor demand towards labor and away from capital and housing. Hence, the contribution of investment to aggregate demand is small even in the long run.

In comparison, with a higher ε_P, firms face a more competitive market, reducing their markups and pushing production along

Figure 2. Internal Devaluations in a Small Open Economy

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



Deviations from the baseline scenario. Horizontal axis in years.

Since the model is for a closed monetary union, we approximate this small open economy by setting the size of the periphery to 0.01.

an upward-sloping marginal cost curve. The subsequent increase in labor demand is sustained by the growth in k and h^e, which react promptly due to the overshooting of asset prices. As time goes by, the relatively inelastic labor supply begets significantly higher real wages, wiping out most short-run employment gains.

4.2 The Open-Economy Case

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

4.3 Taking Stock

Although goods and labor markets reforms have similar effects on long-term GDP, their dynamics and the channels through which they operate are different. In the long run, wage moderations are more employment friendly, but they hardly affect investment. In contrast, the rise in output after a reduction in price markups is mainly driven by an increase in investment and the capital/labor ratio. The central difference between both reforms is in the short term, when the price markup reform shows an overshooting of GDP and employment with respect to their long-run levels, whereas the labor reform has a minimal impact during the first two to three 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

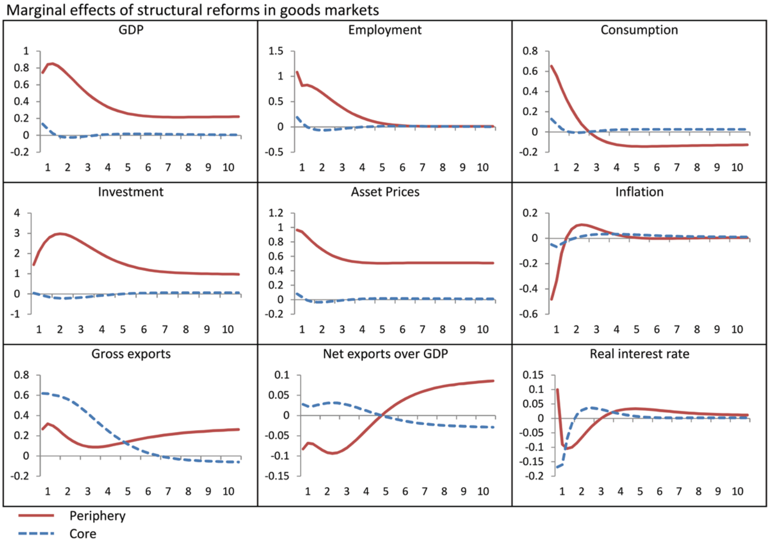
We revisit now the goods and labor markets reforms but in a monetary union. Since the periphery has a calibrated weight of 25 percent, there are sizable spillovers between regions, and dimensions other than the reform itself matter to assess the impact of such reforms. In particular, we vary, in the short and long run: (i) the country we focus on (periphery versus the core); (ii) the macroeconomic scenario (normal monetary conditions versus 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 percent) permanent reduction in price markups in the periphery (continuous lines) and its impact on the core (discontinuous lines).

In the periphery, this reform's effect is positive both in the short and medium run, except for employment, which goes back to its pre-reform value after a few quarters, and consumption, which falls

Figure 3. Goods Markets Reform in the Periphery of a Monetary Union



Deviations from a baseline scenario with no other shocks. Horizontal axis in years.

below its pre-reform value quickly. Lower price markups 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. These responses replicate those in Section 4. As in the small open-economy case, the real interest rate increases in the periphery. Still, this channel's contractionary effects are limited and overwhelmed by the expansionary forces of net exports and investment. Regarding the latter, the permanent rise in capital causes a sharp increase in real estate prices and investment already in the short run.

The effects on 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

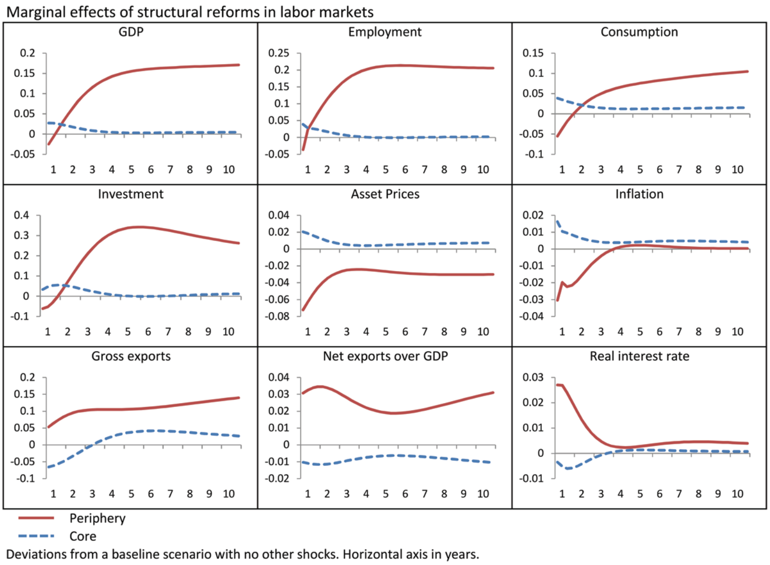


Figure 4 shows the effects of a marginal (i.e., 1 percent) permanent reduction in wage markups in the periphery (continuous lines) and its impact on the core (discontinuous lines). The consequences are similar to the ones from a price markup reduction. The effects on inflation and the terms of trade are around 10 times smaller since the cut in desired wage markups 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, yielding higher GDP, employment, consumption, and investment in the periphery.

The effects in the core are again small but positive. The core's loss of competitiveness 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.[5] 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.

Online Appendix B complements the discussion by plotting the impact of goods and labor market reforms in the periphery with our calibrated price and wage rigidity ($\theta_p = 0.67$ and $\theta_w = 0.75$) and with near full price and wage flexibility ($\theta_p = \theta_w = 0.05$).[6] Figures B.1 and B.2 show that, while the long-run effects are the same with and without nominal rigidities, the short-run effects differ. In the case of a goods market reform, the short-run impact is much more muted. In comparison, the short-run impact of a labor market reform is larger.

What accounts for these differences? When the markup in the goods market is reduced, firms react, in the absence of nominal rigidity, by increasing their prices: demand will be higher due to the expectations channel and, therefore, also marginal costs. This effect is sufficiently strong that it overcomes the reduction in markups. With a lower wage markup, wages and prices go down and labor demand increases at impact, raising consumption, investment, net exports, and output. Nominal rigidities slow this effect as prices and wages take time to respond to the reduction in the wage markup.

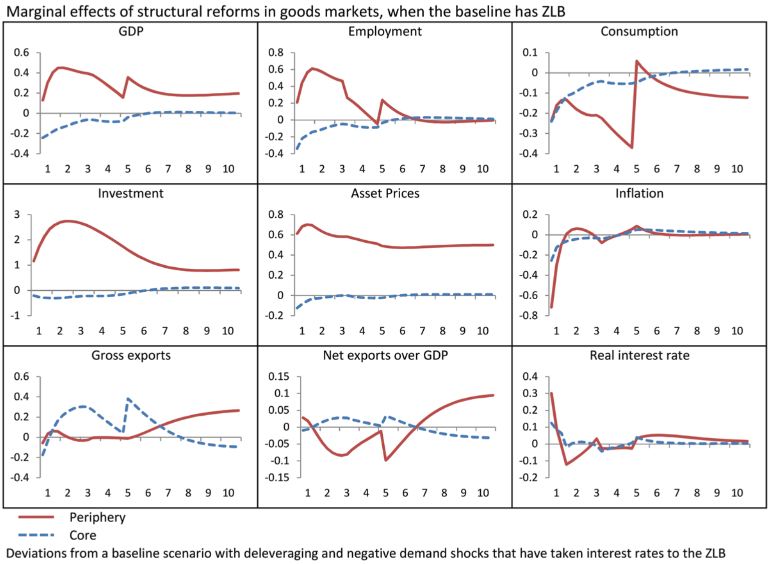
5.2 Internal Devaluations at the ZLB

What happens when we undertake an internal devaluation at the ZLB when the nominal interest rates cannot react to further deflationary shocks? To generate a ZLB scenario that resembles the state of the euro zone during the early 2010s, the worst years of the financial crisis, we combine two shocks. First, we permanently lower the

[5]For the positive effect on the core's GDP to be significant, the reform must be permanent: a temporary reduction in wage markups (not shown in the interest of space) has a much smaller effect.

[6]Notice that $\theta_p = \theta_w = 0.05$ means that prices and wages last 1.05 quarters on average instead of lasting one quarter (the period in the model) with full price and wage flexibility. Numerically, the solution of the model with $\theta_p = \theta_w = 0$ would require a different solution approach than the one used in our baseline calibration. By pushing $\theta_p = \theta_w$ as close to zero as possible, we enhance numerical comparability.

Figure 5. The ZLB: Goods Markets Reform



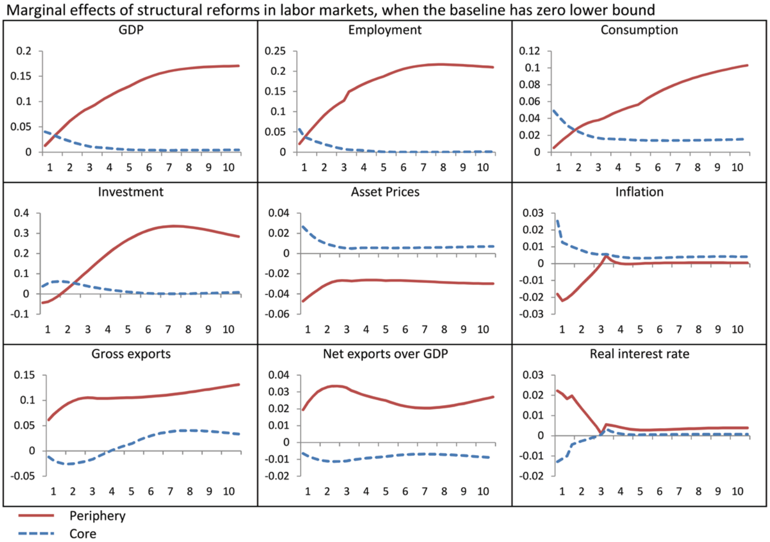
"loan-to-value" ratios by 7.5 percentage points ($\bar{m}$ goes from 0.70 to 0.625 and $\bar{m}^e$ from 0.64 to 0.565) to trigger a credit crunch and push the periphery into a lengthy deleveraging. Second, the whole monetary union is hit by a large negative demand shock (i.e., a transitory discount factor 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.[7]

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 5), the response in the periphery is more muted than outside the ZLB. Since the

[7]Fernández-Villaverde et al. (2015) show that, to generate endogenous spells at the ZLB that last for more than four quarters, we need to introduce 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 6. The ZLB: Labor Market Reform



Deviations from a baseline scenario with deleveraging and negative demand shocks that have taken interest rates to the ZLB

reform is strongly deflationary, the real interest rate increases. 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 fact that the reform brings forward the end of the deleveraging process in the periphery. 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 to that outside the bound, both in the periphery and in the core, with significant increases in output, employment, and consumption.

These results show that, at the ZLB, there are other forces at work besides the real interest rate channel. Our findings are in line with much of the literature. Debortoli, Galí, and Gambetti (2019), using several approaches, find that the response of the U.S. economy to shocks has not changed much as a consequence of a binding ZLB between 2009:Q1 and 2015:Q4. A similar result is reported by Wieland (2019), who finds that being at the ZLB does not matter much for the effects of supply shocks on output despite their deflationary bias. Cohen-Setton, Hausman, and Wieland (2017) find evidence that negative supply shocks at the ZLB (particularly those observed in France during the Great Depression) were indeed inflationary—as a New Keynesian model would predict—but they did not increase output. All of these findings suggest that positive supply shocks (reforms) might be deflationary but not contractionary. Related positive short-term effects of structural reforms are reported by Andrés, Arce, and Thomas (2017), Bordon, Ebeke, and Shirono (2016), and the International Monetary Fund (2016).

Online Appendix B reports the comparison of the impact of the goods and labor market reforms in the periphery when we are at the ZLB in Figures B.3 and B.4. The results are very similar to those in Figures B.1 and B.2. The short-run effects of a goods market reform are more muted with price and wage flexibility, while the opposite occurs in the case of labor market reforms.[8] The intuition is the same as that in Figures B.3 and B.4.

5.3 Internal Devaluations and the Size of the Periphery

How important is the size of the periphery for the effects of internal devaluations? This question addresses both what occurs when the size of the periphery changes (e.g., a new country joins the euro zone) and the differences triggered by how many peripheral countries undertake an internal devaluation (e.g., just Spain doing so or Spain and Italy simultaneously?).

Figures 7–10 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 diamonds) as the relative size of the former increases from 5 percent to 60 percent of the monetary union.

[8]This exercise must be read, though, with caution. The flexible economy required different shocks to generate a comparable-length ZLB episode. These different shocks muddle the comparison in the first few quarters, particularly for the reform in goods markets.

Figure 7. The Size of the Periphery: Goods Markets Reform

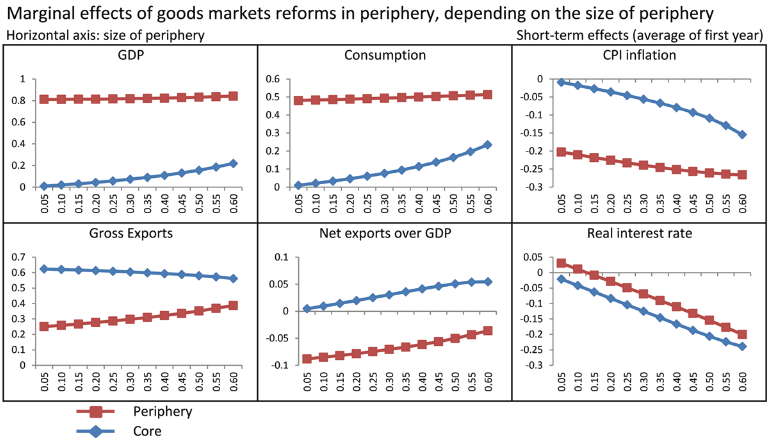
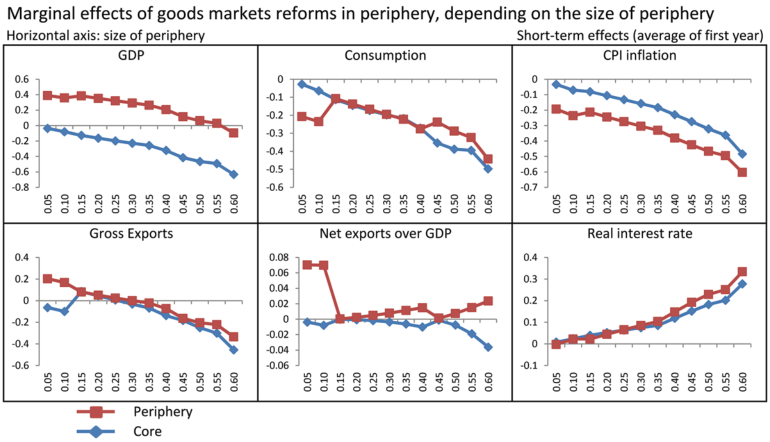


Figure 7 shows the effect of a marginal (i.e., 1 percent) permanent reduction in price markups when the economy is away from the ZLB. The size of the periphery has little impact on the response of aggregate variables at the periphery, except inflation, the terms of trade, and the real interest rate,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

As the size of the periphery increases, several forces operate 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 deflationary impact is more prominent, the central bank implements 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. Nonetheless, it is 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. As the periphery’s size grows, deflationary pressures become larger, and so does the real interest rate. If the periphery is large enough, the negative

Figure 8. The Size of the Periphery: Goods Markets Reform at the ZLB

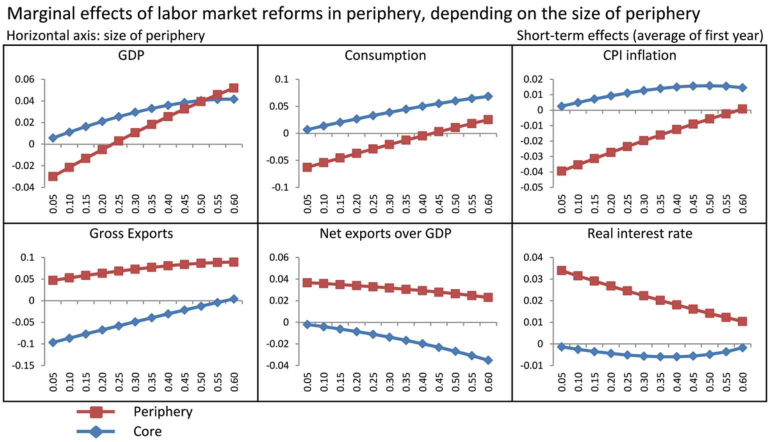


real interest rate channel dominates and output, employment, consumption, and investment fall in the core and in the periphery.

As in Andrés, Arce, and Thomas (2017), our model predicts that an internal devaluation achieved through goods markets reforms increases output, even at the ZLB. As discussed in Gerali, Notarpietro, and Pisani (2015), capital accumulation is key to strengthening the expectations channel following the implementation of structural reforms. The increase in current investment, and hence in demand, triggers a positive output response in the short run or, at least, shortens the duration of the ZLB. This is confirmed by the sharp appreciation of asset prices that is followed by a boost in domestic investment depicted in Figure 5. This result differs from that of Eggertsson, Ferrero, and Raffo (2014), who find that, in the absence of investment, such reforms at the ZLB reduce output in the domestic economy and the monetary union as a whole. In other words: the expectations channel is a key element of the transmission mechanism that we want to include in models that evaluate internal devaluations.

Figure 8 also illustrates why, at the ZLB, the positive output effects of goods markets reforms are circumscribed to the periphery and, in comparison with the findings in Gerali, Notarpietro, and Pisani (2015), do not reach the rest of the monetary union. The

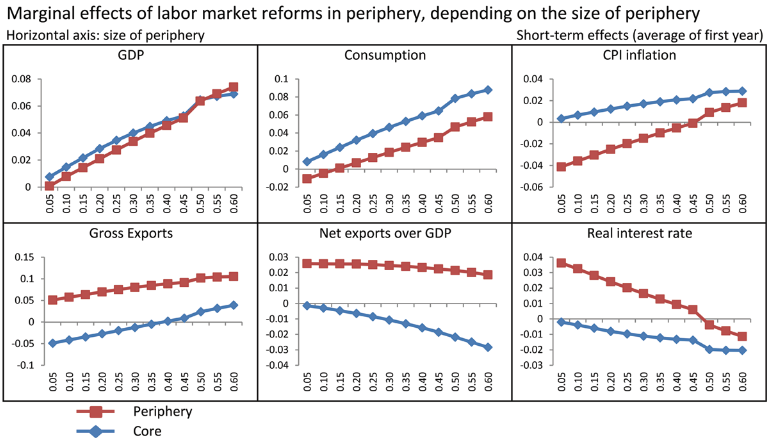
Figure 9. The Size of the Periphery: Labor Market Reform



critical difference is that we only implement the internal devaluation in one region, and thus its effects are asymmetric across the monetary union. Thus, 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 that depends positively on the size of the periphery.

Figure 9 shows that the positive effects of the wage markup reform under normal monetary conditions are enhanced for both the core and the periphery when the periphery's size increases because the long-term benefits of the reform become larger. For sizes of the periphery below 20 percent, 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 periphery increases beyond 25 percent and the accommodative reaction of monetary policy gets bigger. Consumption is the primary 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.

Figure 10. The Size of the Periphery: Labor Market Reform at the ZLB

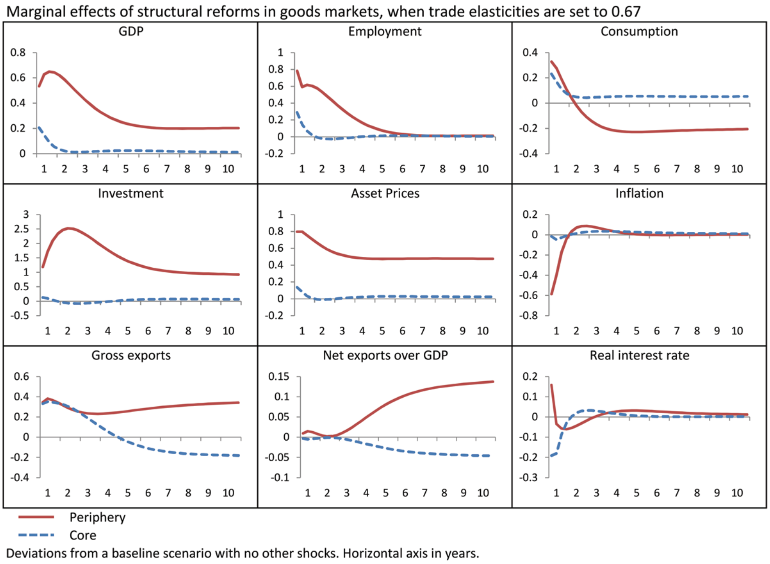


Since the labor reform is barely deflationary in the short term, the results described above remain mostly unchanged even at the ZLB (Figure 10). Even without accommodative monetary policy, the union-wide efficiency gain grows with the size of the periphery.

Summing up: internal devaluations in the periphery through goods markets reforms have union-wide expansionary effects when the real interest rate can fall. This positive impact may turn negative in the short run only if the central bank is constrained by the ZLB and the size of the periphery is large. However, the periphery's required size is quite larger than the actual 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 markups imposed by wage setters into final goods prices is low for this reform due to the double layer of nominal rigidities, 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 11. Lower Trade Integration: Goods Markets Reform



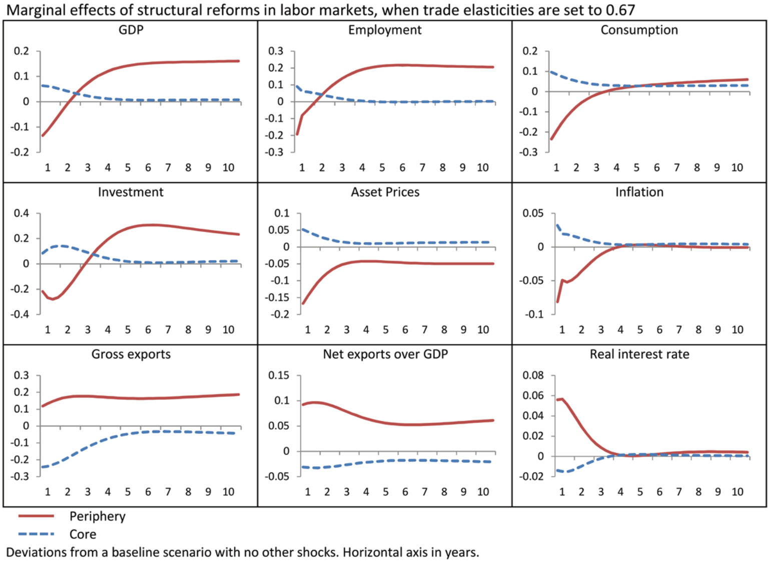
5.4 *Internal Devaluations and the Degree of Trade Integration*

How does the degree of trade integration between the core and the periphery change our results? We can answer this question by lowering ε_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.

Figures 11 and 12 document that the positive effects of goods and labor markets reforms (under normal monetary conditions) become smaller (symmetrically, a higher ε_H makes the responses stronger) and have longer 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. The real interest rate channel creates a demand effect that ends up being stronger than the relative price effect.

Figure 12. Lower Trade Integration: Labor Market Reform

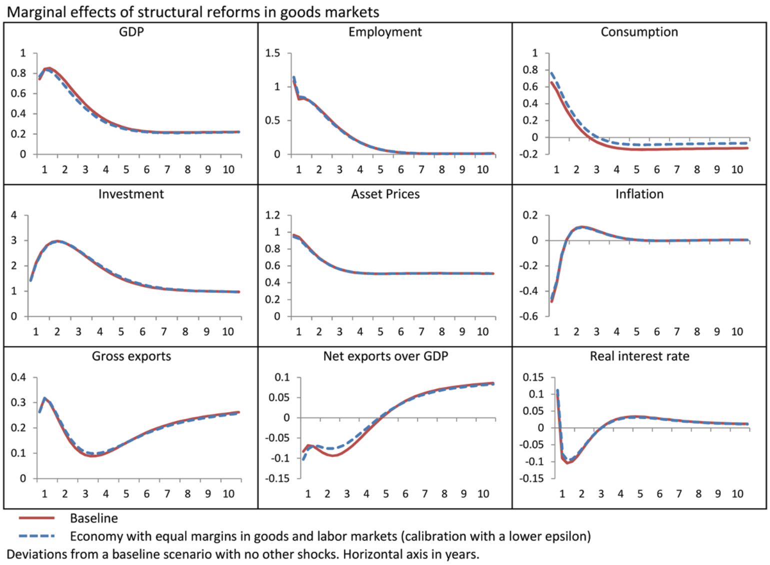


When $\varepsilon_H = 0.67$, both reforms are more deflationary in the periphery and more inflationary in the core, but the monetary union-wide inflation rate is roughly unchanged. Thus, the rise in the nominal rate is also the same across different elasticities of substitution. This makes for a larger 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.

5.5 *Internal Devaluations and the Elasticity of Substitution*

An interesting exercise is to analyze the effect of varying the elasticity of substitution among consumption and labor varieties. We report the results from equating both elasticities of substitution to the lower level of the elasticity of substitution among labor varieties, i.e., $\varepsilon_p = \varepsilon_w = 3.31$. This calibration can be reconciled with the data regarding firms' profits if the fixed costs of production are high. This case has the additional advantage of eliminating the differences in initial goods and wage markups (recall that $\tau_p = \tau_w = 0$,

Figure 13. Different Elasticities of Substitution: Baseline vs. $\varepsilon_p = 3.31$. Goods Market Reform



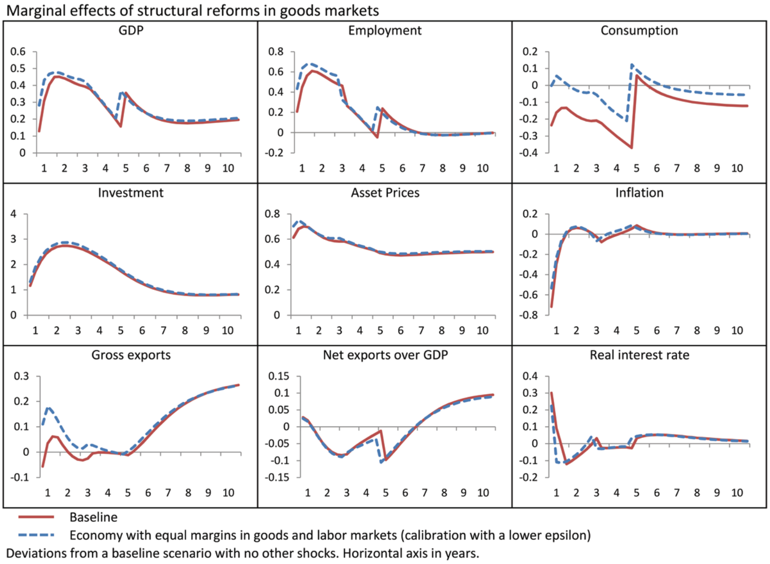
so now goods and wage markups are both 1.43). Thus, our experiment illustrates the potential role that those differences can play in our baseline exercises.

Figure 13 compares the results of this exercise with the baseline case with $\varepsilon_p = 7$ and $\varepsilon_w = 3.31$. The results are nearly identical (except, as intuition would suggest, somewhat smaller). The key reason is that the level of the goods markup is not driving much the shape of the effects but the presence of distortions and its interaction with nominal rigidities. Figure 14 repeats the same exercise but at the ZLB. For completeness, online Appendix B reports the results of this exercise for the case of labor market reforms (Figures B.4 and B.5). Again, the differences are minimal.

5.6 Reform Sequencing

A concern for policymakers is whether the sequencing of reforms (e.g., implementing goods and labor markets reforms simultaneously

Figure 14. Different Elasticities of Substitution at the ZLB: Baseline vs. $\varepsilon_p = 3.31$. Goods Market Reform



or delaying one or both reforms) has an impact on the path of aggregate variables. To study this issue, we compute for any aggregate variable x_t:

$$PV(x_t, r) = 100 * \sum_{t=0}^{600} (\beta^u)^t \left(\frac{x_t^r}{x_{ss}} - 1 \right),$$

where x_t^r is the path of the variable with the sequencing of policy reform r and x_{ss} is the initial condition (the steady state without any policy reform). We multiply by 100 to express this present value, as units are percentage points of each variable (e.g., 70.4 means 0.704 of quarterly GDP). We stop the sum at 600 quarters, the time limit of our numerical solution. By then, $(\beta^u)^{600}$ is sufficiently small that further periods do not change materially any number below.[9]

[9] We use β^u as the discount factor because, in the tradition of marginal analysis, it reflects the highest valuation in society of the additional resources and the value that pins down the steady-state real interest rate. Nonetheless, using β instead would not change any of the conclusions below.

Table 2 reports $PV(x_t, r)$ for three different sequences of policy reform: (i) simultaneous reforms in the goods and labor markets; (ii) delaying the labor reform; and (iii) delaying the goods reform. Both delays are for four quarters: in the baseline ZLB scenario, the monetary union is at the ZLB for one year. Other sequencings are possible but, since there are no significant interactions between the goods and labor markets reforms, these three sequences are informative representatives of the whole set of reforms.

When the monetary union is outside the ZLB, delaying the labor market reform reduces $PV(GDP_t, r)$ by 0.4 in the periphery without counterbalancing gains in the core. Given that the quarterly GDP of the periphery was around €750 billion in 2019 (before COVID-19), 0.4 amounts to roughly €3 billion. Delaying the goods market reform lowers $PV(GPD_t, r)$ by 1.5 (around €11.3 billion) without, again, offsetting gains in the core. When the monetary union is at the ZLB, delaying the labor market reform leads to a reduction of $PV(GDP_t, r)$ of 0.8 (around €6 billion) in the periphery and 0.6 (around €13.5 billion) in the core (the core GDP was around €2.25 trillion). Delaying the goods market reform increases $PV(GPD_t, r)$ by 0.3 (around €2.25 billion) in the periphery and 1.1 in the core (around €24.75 billion).

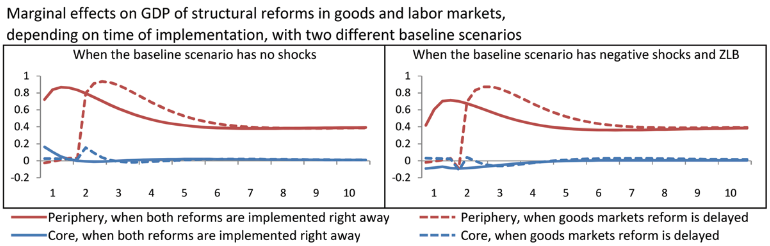
However, output is not a welfare measure: we have heterogeneous agents and a core and periphery, complicating any welfare analysis. Table 2 only tells us that a government at the periphery that implements both labor and goods markets reforms simultaneously under normal monetary conditions induces a $PV(x_t, r)$ that is higher than delaying one reform or the other. However, when the monetary union is at the ZLB, a government that prioritizes the labor market reform today and delays the goods markets reform causes a higher $PV(x_t, r)$ than by implementing both reforms simultaneously. Since this conclusion is subject to the usual caveats regarding uncertainty with respect to the parameter values and model misspecification, it points to future investigations that assess the robustness of the result.

Figure 15 shows the paths of the output that account for these changes in $PV(GDP_t, r)$. In the left panel, we see how, outside the ZLB, delaying both reforms moves the reaction of output to the right with minimal changes in the shape of this reaction. Thus, the $PV(GDP_t, r)$ is lower: we discount more because the increases in

Table 2. $PV(x_t, r)$ of Three Different Sequences of Policy Reform

	Normal Monetary Conditions									At the ZLB								
	Periphery			Core			MU			Periphery			Core			MU		
	GDP	Cons.	Emp.	GDP	Cons.	Emp.	GDP	Cons.	Emp.	GDP	Cons.	Emp.	GDP	Cons.	Emp.	GDP	Cons.	Emp.
Simultaneous Reforms	70.4	9.4	39.7	2.0	8.7	0.4	19.1	8.9	10.2	68.2	6.5	38.2	0.4	7.2	–0.7	17.4	7.0	9.1
Delay Labor Reform	70.0	9.1	39.4	1.9	8.6	0.3	19.0	8.7	10.1	67.4	4.7	37.2	–0.2	5.4	–1.6	16.7	5.2	8.1
Delay Goods Reform	68.9	9.5	39.3	2.0	8.6	0.4	18.7	8.8	10.1	68.5	8.0	38.5	1.5	7.0	–0.4	18.3	7.3	9.3
Net Gain From:																		
Delaying Labor Reform	–0.4	–0.2	–0.3	0.0	–0.1	–0.1	–0.1	–0.2	–0.1	–0.8	–1.8	–1.0	–0.6	–1.8	–0.9	–0.7	–1.8	–1.0
Delaying Goods Reform	–1.5	0.1	–0.4	0.0	–0.2	0.0	–0.4	–0.1	–0.1	0.3	1.5	0.3	1.1	–0.2	0.3	0.9	0.2	0.3

Figure 15. Reform Sequencing



output are further into the future. In the right panel, when we are at the ZLB, we see that the reaction of output is more significant when the reforms are delayed because we avoid the deflationary pressures that are so costly when the nominal interest rate cannot react. Thus, we face a trade-off: we either have a larger increase of output in the future or a smaller increase today.

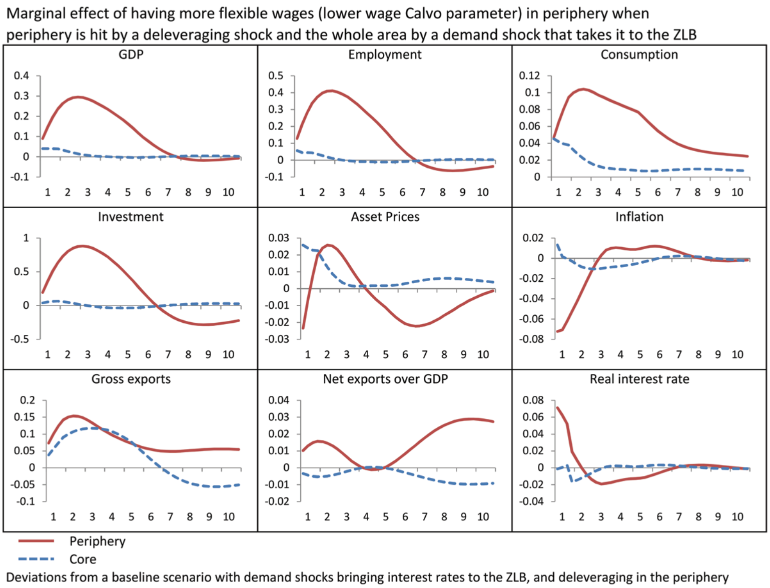
5.7 An Alternative Reform: More Flexible Wages

Our final experiment analyzes the effects of increasing the flexibility of wages in the periphery, a labor market policy frequently advocated in the euro area (Galí and Monacelli 2016). In particular, we lower the wage Calvo parameter, θ_w, from 0.75 to 0.72. As we did in previous experiments, we consider a marginal reform, not a radical one, since the former is likely to be politically feasible.

Unlike the previous reforms, this change does not improve the economy's steady state because a change in the flexibility of wages does not affect steady-state wage markups. Instead, this reform affects how an economy absorbs shocks. Thus, 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 to the ZLB.

Our main finding is that more flexible wages make the adjustment to the adverse shocks less harmful. Figure 16 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 adverse shocks described above. Employment is higher when wages are more flexible, as wages fall more

Figure 16. Making Wages More Flexible



quickly after the shocks. Therefore, consumption is also higher. And although higher wage flexibility increases deflation and, hence, generates higher real rates at the ZLB, it also has a stronger positive effect on gross and net exports.

6. Concluding Remarks

In this paper, we have shown that, under conditions resembling those of the euro zone, 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 periphery's internal devaluations, except when these are centered around goods markets reforms and the euro zone is at the ZLB. Thus, in most cases, internal devaluations do not suffer from the "beggar-thy-neighbor" aspect of nominal devaluations. Even in the cases where they do, a euro-wide policy coordination can sequence the structural reforms to avoid the most damaging elements of the absence of a nominal interest rate response.

Our paper opens many avenues for future research, including exploring a richer set of structural reforms and analyzing how countries can combine structural reforms and fiscal consolidation. We hope to address some of these questions shortly.

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