Structural Reforms in a Debt Overhang[*]

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September 2014

Abstract

We assess the effects of reforms in product and labor markets in a model economy featuring credit restrictions and pre-existing long-term debt. Both elements, which are core features of the current scenario faced by some Euro area countries, combine to produce a slow deleveraging of the private sector and a persistent recession following a negative financial shock. In this environment, we show that structural reforms may stimulate output and employment even in the short run, despite their deflationary effects. Furthermore, by favoring a faster recovery of investment and collateral values, product market reforms bring forward the end of deleveraging.

Keywords: deleveraging, collateral constraints, long-run debt, structural reforms

1   Introduction

More than six years after the beginning of the crisis, economic growth in the periphery of the Euro area remains weighed down by weak domestic demand, in a context of high levels of private debt. Therein, the lack of room for maneuver to apply expansionary fiscal and (conventional) monetary policies is drawing a scenario of protracted private sector deleveraging amid low growth, with few policy options to bring some relief. Among the available options, structural reforms in product and labor markets have attracted much attention by governments, multilateral bodies and commentators. In official circles, a consensus has arisen on the desirability of making markets more efficient in order to increase the overall competitiveness of the weakest European economies and improve their future growth prospects.[1]

Common wisdom suggests that internal devaluation processes, fostered by reforms leading to lower and/or more flexible prices and wages, should help the external sector lead the recovery in the short term. Likewise, growth potential should benefit from more competitive markets, with the resulting permanent income effects having a positive impact on current expenditure of forward-looking households and firms (expectations channel). However, absent the margin for expansionary monetary and fiscal policies, more competitive markets are likely to unchain contractionary forces in the short term arising from higher real interest rates and debt-deflation effects due to lower prices and/or wages (deflationary channel).

Which of the two previous forces -international competitiveness and expectations versus deflationary channels- dominates remains an open question and, in principle, well-intended reforms could end-up worsening the recession and postponing the recovery. This paper tries to shed light on this issue. To this aim, we construct a macroeconomic model upon two core elements that are suggested by the recent experience of the European periphery countries: (i) a widespread tightening of the

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[1]See e.g. OECD (2012), European Commission (2013) and International Monetary Fund (2013).

financing conditions faced by households and firms, and (ii) a slow and protracted process of deleveraging.

In particular, we build a general equilibrium model of a small open economy inside a monetary union. Households and entrepreneurs obtain new credit subject to collateral constraints, as in Kiyotaki and Moore (1997). Following Iacoviello (2005), their outstanding debt cannot exceed a fraction ('loan-to-value') of the value of their real estate. A key point of departure from most recent papers in the macrofinance area, aimed at producing an empirically plausible slow deleveraging path, is that we consider long term debt contracts. As in Woodford (2001), we assume that nominal debt outstanding is amortized at a constant contractual rate. This creates an asymmetry in the dynamics of the debt stock. In 'normal times', when collateral values are high enough so as to allow for new credit flows, the value of available collateral restricts the size of the debt stock. By contrast, following an adverse shock that reduces debtors' collateral values sufficiently, new credit is frozen and outstanding loans are amortized mechanically at the contractual rate. Therefore, the model features two debt regimes with asymmetric speeds of debt accumulation and deleveraging, among which the economy switches endogenously as collateral values fall below or rise above some critical thresholds.

In order to construct a baseline deleveraging scenario motivated by the financial origin of the recent crisis, we introduce a 'credit crunch' shock that takes the form of an unexpected and permanent fall in the loan-to-value ratios of both households and entrepreneurs. The shock produces a sharp fall in real estate prices. As a result, collateral values fall sufficiently so as to move the economy into the debt regime in which gross new credit suddenly stops and the stock of debt starts decaying at the contractual amortization rate. The credit freeze depresses domestic demand. The ensuing fall in production prices and improvement in international competitiveness lead to an increase in net exports, which is not sufficient however to avoid a prolonged recession. At some point, the value of collateral relative to debt recovers sufficiently to justify new credit flows. This gives rise to an expansionary phase, characterized by a virtuous circle of higher borrowers' net worth, increasing asset prices and new lending, that ultimately lead to positive growth and higher employment. Importantly, the

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time at which the economy switches from the deleveraging phase to the recovery one is endogenous.

We simulate the effects of structural reforms against the backdrop of the baseline deleveraging scenario just discussed. In particular, we consider unexpected, permanent reductions in desired price and wage markups. As expected, reforms that enhance competition in product and labor markets produce long run gains in GDP. More interestingly, we also find that this set of reforms can mitigate the *short-run* output and employment losses caused by the deleveraging shock, although the effectiveness of the reform in this respect varies depending on the market at hand.

In the case of the product market reform, stronger competition and the ensuing long-run gains in consumption and output lead (forward-looking) households and firms to increase their investment in the short run, vis-à-vis the baseline (no-reform) scenario. Stronger investment demand in turn alleviates the fall in real estate prices produced by the deleveraging shock. This reinforces the short-run gains in investment in two related ways. First, borrowers anticipate higher collateral values from the period in which they regain access to credit onwards. Second, a faster recovery in collateral values allows borrowers to receive new credit at an earlier date. That is, the reform *brings forward* the end of the deleveraging process and hence of the recession. These effects (more collateralized credit at an earlier date, and an earlier exit from recession) leads borrowers to further increase their investment demand today, with the resulting boost to asset prices, collateral values, and so on.

By contrast, the labor market reform, which yields long-run gains similar to those from the product market reform, produces only modest improvements in GDP in the short-run. Two factors explain this difference. First, this reform makes labor cheaper relative to capital (equipment and commercial real estate), and hence does not produce a significant rise in the demand for real estate or in its price. As a consequence, neither collateral values, nor investment, nor the end of deleveraging are much affected. Second, unlike a reduction in price markups, a reduction in wage markups needs to overcome a double layer of nominal rigidities (wages and prices) before affecting actual production prices. Motivated by this observation, we also consider a broader labor market reform that includes an increase in nominal wage

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flexibility. We find that the latter reform does generate sizable short-run gains in economic activity.

The presence of collateral constraints and long-term debt in our model plays an important role, essentially by buffering the short term impact of reform-driven changes in various prices, such as consumption and real estate prices, and the real interest rate. On the one hand, credit restrictions and long term debt mitigate the (negative) deflationary effects induced by the reforms. First, the fact that borrowers do not obtain new credit and simply amortize their debts during the deleveraging phase implies that the increase in real interest rates brought by the reforms has little effect on domestic demand. Second, since under long-term contracts debtors pay back only a small fraction of their outstanding debt each period, the deflation produced by the reform has only a second order effect on borrowers' net debt flows and hence on their spending capacity.

On the other hand, long-run debt also attenuates the impact of real estate prices on economic activity, by decoupling debt capacity from collateral values during the deleveraging phase. In the case of the product market reform, the positive effect of higher real estate prices (relative to the no-reform scenario) on expenditure is watered down by the fact that borrowers cannot pledge the higher collateral to obtain new loans while deleveraging. In fact, we show that the short-run gains from the reform are lower than they would be in a setup with short-term (one-period) debt. On the contrary, in the case of labor market reforms, since asset prices are barely affected, long-term debt improves the short-run response of GDP by eroding the aforementioned debt-deflation and real interest rate channels.

Finally, the foreign sector plays an important role in shaping the short-run effects of reforms. In this regard, we show that higher elasticities of exports and imports with respect to the terms of trade lead to larger short-run gains from reforms. In particular, labor market reforms may lead to negative short-run effects on GDP and employment if price elasticities of trade flows are sufficiently low. Thus, the short-run effects of structural reforms depend to an important extent on the intensity with which the resulting gains in international competitiveness carry over to actual trade flows.

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The paper is organized as follows. We briefly describe the related literature in Section 2. The model and the baseline calibration are presented in Section 3. The baseline deleveraging scenario is analyzed in Section 4. Section 5 is devoted to analyzing the impact of several reforms in product and labor markets, with further inspection of the relevant channels in Section 6. Section 7 concludes.

2 Related literature

Our paper is related to several strands of literature. First, a number of recent contributions analyze the macroeconomic impact of structural reforms, with special attention to the short run, in situations in which monetary policy cannot accommodate the deflationary effects of such reforms. In the context of a standard New Keynesian (NK) framework that abstracts from financial frictions, Eggertsson, Ferrero and Raffo (2014) show that permanent reductions in product and labor market markups may be contractionary if monetary policy is constrained by the zero lower bound (ZLB), due to the deflationary impact of the reforms and the resulting increase in real interest rates. Our model adds a relatively rich financial apparatus to the standard NK framework, with the aim of studying the role of reforms in a scenario of widespread tightening of financing constraints and slow deleveraging, which we consider as core elements of the current situation in the Euro Area periphery. In our setup, reforms are deflationary as well, but the resulting negative short-run effects (which in our framework include the Fisherian debt-deflation channel) are generally dominated by the positive effects of reforms.

Fernández-Villaverde, Guerrón-Quintana and Rubio-Ramírez (2012) also study the effects of supply-side reforms when monetary policy is constrained by the ZLB, in the framework of a stylized two-period NK model. They offer some quantitative examples showing that credible announcements of future increases in product market competition unchain positive wealth effects that may raise consumption and output today. In the context of a fully dynamic open-economy model with financing constraints and long-run debt, we show that increases in product and labor market competition may deliver short-run gains in output even if implemented unexpectedly.

Galí and Monacelli (2014) analyze the employment effects of a temporary reduction in payroll taxes (which has similar effects to those of a temporary contraction in desired wage markups) in the context of a standard NK small open economy model. In their framework, the monetary authority is constrained not by the ZLB but by its concern for nominal exchange rate stabilization. They find that the impact of wage adjustments on employment is smaller the more the central bank seeks to stabilize the exchange rate. Here we consider a small open economy inside a monetary union, and thus we do not study the interaction between supply-side policy measures and the degree of monetary policy accommodation. Instead, we focus on the effects of structural reforms (implemented on a permanent basis) in a context of slow and protracted deleveraging of the private sector, showing that such reforms may yield sizeable short-run gains in economic activity and employment.[2]

More generally, our paper also contributes to the growing literature on the macroeconomic effects of deleveraging processes. Fornaro (2012) and Benigno and Romei (2012) report a sharp, though short-lived, drop in output and employment after a negative financial shock in an economy with nominal inertia, fixed exchange rates and a constant nominal interest rate. Guerreri and Iacoviello (2014) find that recessions driven by asset price deflations have a significant negative impact on spending and output. Eggertsson and Krugman (2012), and Calvo, Coricelli, and Ottonello (2012) find similar effects of deleveraging on output and employment. Our paper also sheds light on some of these issues although it differs with respect both to its motivation, which here is on the impact of structural reforms, and to some modeling assumptions, especially the one concerning long-term debt, which is a centerpiece in our analysis. Regarding this last issue, Justiniano, Primiceri and Tambalotti (2013) also consider the existence of long-term debt in a setup in which a deleveraging shock has a relatively minor effect on economic activity, as it gives rise to a wealth redistribution effect from debtors to creditors that essentially washes out at the aggregate

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[2]More loosely related to our paper and the above contributions is the work of Cacciatore and Fiori (2013). In a model featuring endogenous product creation and labor market frictions, they discuss the effects of deregulation in the form of permanent reductions in producer entry costs, firing restrictions and unemployment benefits. In a related environment, Cacciatore, Fiori and Ghironi (2013) analyze the design of optimal monetary policy.

level. Besides targeting a different motivating question, our model gives rise to a deleveraging scenario that entails a protracted and costly recession, in line with the evidence summarized by Reinhart and Rogoff (2009).

3   Model

We now present a general equilibrium model of a small open economy that belongs to a monetary union. The real side of the economy is fairly standard. Households obtain utility from consumption goods and from housing units. Consumption goods are produced using a combination of household labor, commercial real estate and equipment capital goods. Construction firms build real estate (both for residential and commercial purposes) using labor and consumption goods; the latter are also used as inputs by equipment capital goods producers. Consumption-goods and labor markets are both characterized by monopolistic competition and nominal rigidities.

On the financial side, the structure is as follows. There are three types of consumers: patient households, impatient households, and (impatient) entrepreneurs. In equilibrium, the latter two borrow from the former and from the rest of the world. Debt contracts are long-term. In periods in which borrowers are able to receive new credit flows, they do so subject to collateral constraints. Real estate is the only collateralizable asset. We will henceforth refer to impatient and patient households as 'constrained' and 'unconstrained' households, respectively.

All variables are in real terms unless otherwise specified, with the consumption goods basket acting as the numeraire.

3.1   Households

There is a representative constrained household and a representative unconstrained household, denoted respectively by superscripts c and u.

3.1.1 Cost minimization

Before analyzing dynamic household optimization, we first derive the static cost minimization problem, which is common to both households types. Households consume a basket of home and foreign goods, denoted respectively by subscripts H and F,

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

for $x = c, u$, where $c_{H,t}^x$ is a basket of domestic good varieties,

$$c_{H,t}^x = \left(\int_0^1 c_{H,t}^x (z)^{(\varepsilon^p - 1)/\varepsilon^p} \, dz \right)^{\varepsilon^p/(\varepsilon^p - 1)}, \qquad (2)$$

where $\varepsilon^p > 1$ is the elasticity of substitution across consumption varieties $z \in [0, 1]$. Let $P_{H,t}(z)$ denote the price of home good variety z, and $P_{F,t}$ the price of the foreign goods basket. Household $x = c, u$ minimizes nominal consumption expenditure, $\int_0^1 P_{H,t}(z) c_{H,t}^x(z) \, dz + P_{F,t} c_{F,t}^x$, subject to (1) and (2). The first order conditions can be expressed as

$$c_{H,t}^x = \omega_H \left(\frac{P_{H,t}}{P_t} \right)^{-\varepsilon_H} c_t^x, \quad c_{F,t}^x = (1 - \omega_H) \left(\frac{P_{F,t}}{P_t} \right)^{-\varepsilon_H} c_t^x, \quad c_{H,t}^x (z) = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\varepsilon^p} c_{H,t}^x,$$
$$(3)$$

where

$$P_t = \left(\omega_H P_{H,t}^{1-\varepsilon_H} + (1 - \omega_H) P_{F,t}^{1-\varepsilon_H} \right)^{1/(1-\varepsilon_H)}, \quad P_{H,t} = \left(\int_0^1 P_{H,t}(z)^{1-\varepsilon^p} \, dz \right)^{1/(1-\varepsilon^p)}$$

are the *consumer price index* (CPI) and the *producer price index* (PPI), respectively. Nominal spending in domestic goods equals $\int_0^1 P_{H,t}(z) c_{H,t}^x(z) \, dz = P_{H,t} c_{H,t}^x$, whereas total nominal consumption spending equals $P_{H,t} c_{H,t}^x + P_{F,t} c_{F,t}^x = P_t c_t^x$.

As noted before, consumption goods are also used as inputs by construction firms and equipment capital producers. The latter are assumed to combine home and foreign goods analogously to households, and similarly for domestic good varieties. This gives rise to investment demand functions analogous to (3).

3.1.2 Unconstrained households

The unconstrained household maximizes

$$E_0 \sum_{t=0}^{\infty} (\beta^u)^t \left\{ \log(c_t^u) + \vartheta \log(h_t^u) - \chi \int_0^1 \frac{n_t^u(i)^{1+\varphi}}{1+\varphi} di \right\},$$

where $n_t^u(i)$ are labor services of type $i \in [0,1]$ and h_t^u are housing units, subject to the following budget constraint (expressed in units of the consumption goods basket),

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

where d_t is the real value of net holdings of riskless nominal debt, R_t is the gross nominal interest rate,[3] δ_h is the depreciation rate of real estate, p_t^h is the real price of real estate, $\pi_t \equiv P_t/P_{t-1}$ is gross CPI inflation, and $W_t(i)$ is the nominal wage for labor services of type i. The first order conditions are standard. They are listed in Appendix A, together with all other equilibrium conditions.

3.1.3 Constrained households

The constrained household's preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log(c_t^c) + \vartheta \log(h_t) - \chi \int_0^1 \frac{n_t^c(i)^{1+\varphi}}{1+\varphi} di \right\},$$

where $\beta < \beta^u$, i.e. the constrained household is relatively impatient. The household faces the following budget constraint,

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

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

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[3]In order to guarantee stationarity in the net foreign asset position, we assume $R_t = R^* \exp(-\psi nfa_t^y)$, where R^* is the world gross nominal interest rate and nfa_t^y is the net foreign asset position as a fraction of GDP (to be derived below).

Unlike in most of the literature, which typically assumes short-term (one-period) debt, we assume that debt contracts are *long-term*. In the interest of tractability, we assume that at the beginning of time t the household repays a fraction $1 - \gamma$ of all nominal debt outstanding at the end of period $t - 1$, regardless of when that debt was issued. This type of perpetual debt is similar to the one proposed by Woodford (2001) as a tractable way of modelling long-term debt. In *real* terms, the outstanding principal of household debt then evolves as follows,

$$b_t = \frac{b_{t-1}}{\pi_t} + b_t^{new} - (1 - \gamma)\frac{b_{t-1}}{\pi_t} = b_t^{new} + \gamma\frac{b_{t-1}}{\pi_t}, \tag{4}$$

where b_t^{new} denotes new debt issuance net of *voluntary* amortizations, i.e. amortizations beyond the contractual debt repayment $(1 - \gamma)b_{t-1}/\pi_t$.

We assume that, in 'normal times' (in a sense to be specified below), household borrowing is subject to collateral constraints, as in Kiyotaki and Moore (1997). Following Iacoviello (2005), outstanding debt b_t cannot exceed a fraction m_t (the 'loan-to-value ratio', which we assume to be exogenously time-varying) of the expected discounted value of the household's residential stock: $b_t \leq m_t R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t$. For brevity, we will refer to such pledgeable value of collateral as *collateral value*. This 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*. Indeed, if the collateral value falls below such path, lowering b_t to the value of collateral would require lenders not only to reduce gross new credit to zero (its lower bound), but also to *impose* additional amortizations beyond those agreed in the contract (i.e. $b_t^{new} < 0$). Since lenders cannot force borrowers to pay back faster than the contractual amortization rate, the contractual amortization path becomes the effective debt limit. Therefore, long run debt implies the following *asymmetric borrowing constraint*,

$$b_t \leq R_t^{-1} m_t E_t \pi_{t+1} p_{t+1}^h h_t, \text{ if } \frac{m_t}{R_t} E_t \pi_{t+1} p_{t+1}^h h_t \geq \gamma\frac{b_{t-1}}{\pi_t}, \tag{5}$$

$$b_t \leq \gamma\frac{b_{t-1}}{\pi_t}, \qquad\qquad \text{if } \frac{m_t}{R_t} E_t \pi_{t+1} p_{t+1}^h h_t < \gamma\frac{b_{t-1}}{\pi_t}. \tag{6}$$

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This asymmetry gives rise to a *double debt regime*. In 'normal times' in which collateral values exceed the contractual amortization path, debt is restricted by the former. In this baseline 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.[4] However, in the face of shocks that reduce collateral values sufficiently, the economy switches to an alternative regime, in which new credit disappears and debt is restricted instead by the contractual amortization path. Notice that changes from one regime to the other take place *endogenously*. This is an important element of our framework, as will become clear when we analyze the effects of structural reforms.

The Appendix contains the first order conditions of the constrained household's optimization problem. For future reference, we show here the optimal choice of housing,

$$\frac{p_t^h}{c_t^c} = \frac{\vartheta}{h_t} + \beta E_t \frac{(1 - \delta_h) \, p_{t+1}^h}{c_{t+1}^c} + \xi_t \frac{m_t}{R_t} E_t \pi_{t+1} p_{t+1}^h, \tag{7}$$

where ξ_t is the Lagrange multiplier associated to the collateral constraint (eq. 5). Equation (7) illustrates that, when the collateral constraint is binding ($\xi_t > 0$), the marginal value of housing is higher due to the possibility of borrowing against it. This possibility disappears once the economy enters into the alternative debt regime, in which the collateral constraint ceases to be effective.

3.2 Production

Entrepreneurs produce an intermediate good and sell it to retailers, who transform it into consumption good varieties. Entrepreneurs and retailers conform the consumption goods sector. In addition, construction firms produce real estate, both for residential and commercial use, whereas equipment capital is produced by capital goods producers. All sectors operate under perfect competition, except retailers who enjoy monopolistic power.

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[4]Indeed, from (4) and (5) we obtain $b_t^{new} \leq m_t R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t - \gamma b_{t-1}/\pi_t$.

3.2.1 Entrepreneurs

A representative entrepreneur produces an intermediate product and sells it to retailers at a perfectly competitive real (CPI-deflated) price mc_t. The entrepreneur maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \log c_t^e,$$

with the consumption basket c_t^e defined analogously to (1), subject to

$$c_t^e + p_t^h \left[h_t^e - (1 - \delta_h) h_{t-1}^e \right] + q_t \left[k_t - (1 - \delta_k) k_{t-1} \right] = mc_t y_t^e - \frac{W_t}{P_t} n_t^e + b_t^e - \frac{R_{t-1}}{\pi_t} b_{t-1}^e + \sum_{s=r,h,k} \Pi_t^s,$$

$$y_t^e = k_{t-1}^{\alpha_k} \left(h_{t-1}^e \right)^{\alpha_h} (n_t^e)^{1-\alpha_k-\alpha_h},$$

where y_t^e is output of the intermediate good, k_{t-1} is equipment capital, δ_k is the depreciation rate of equipment capital, h_{t-1}^e is commercial real estate, n_t^e is a basket of labor services, W_t is a nominal wage index, b_t^e is the real value of entrepreneurial debt outstanding at the end of period t, and $\{\Pi_t^s\}_{s=r,h,k}$ are real profits from the retail, construction and equipment goods-producing sectors.[5]

Entrepreneurs' maximization is also subject to an asymmetric borrowing constraint analogous to the one on constrained households,

$$b_t^e \leq R_t^{-1} m_t^e E_t \pi_{t+1} p_{t+1}^h h_t^e, \quad \text{if } \frac{m_t^e}{R_t} E_t \pi_{t+1} p_{t+1}^h h_t^e \geq \gamma^e \frac{b_{t-1}^e}{\pi_t}, \tag{8}$$

$$b_t^e \leq \gamma^e \frac{b_{t-1}^e}{\pi_t}, \qquad\qquad \text{if } \frac{m_t^e}{R_t} E_t \pi_{t+1} p_{t+1}^h h_t^e < \gamma^e \frac{b_{t-1}^e}{\pi_t}, \tag{9}$$

where we allow for a different loan-to-value ratio (m_t^e) and contractual amortization rate $(1 - \gamma^e)$ for entrepreneurs. Again, it is instructive to analyze here the optimal

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[5]Notice that entrepreneurs are assumed to own the firms in the latter sectors. We adopt this specification because we are interested in analyzing how profit accumulation affects productive investment decisions, which in our model are made by the entrepreneurs.

demand for commercial real estate,

$$\frac{p_t^h}{c_t^e} = \beta E_t \left\{ \frac{mc_{t+1}\alpha_h y_{t+1}^e / h_t^e + (1 - \delta_h) p_{t+1}^h}{c_{t+1}^e} \right\} + \xi_t^e \frac{m_t^e}{R_t} E_t \pi_{t+1} p_{t+1}^h, \qquad (10)$$

where ξ_t^e is the Lagrange multipliers associated to constraint (8). Analogously to the case of constrained households, in periods in which the collateral constraint binds ($\xi_t^e > 0$) the marginal value of commercial real estate is higher thanks to the possibility of borrowing against it.

3.2.2 Retailers

A continuum of monopolistically competitive retailers indexed by $z \in [0, 1]$ purchase the intermediate input from entrepreneurs at the real price mc_t, and transform it one for one into final good varieties. Retailers' real marginal cost is thus mc_t. Each retailer z faces a demand curve

$$y_t(z) = \left(\frac{P_{H,t}(z)}{P_{H,t}} \right)^{-\varepsilon^p} y_t \equiv y_t^d(P_{H,t}(z)), \qquad (11)$$

where y_t is aggregate demand of the consumption basket (to be derived below). Assuming Calvo (1983) price-setting, a retailer that has the chance of setting its nominal price at time t solves

$$\max_{P_{H,t}(z)} E_t \sum_{s=0}^{\infty} (\beta\theta_p)^s \frac{c_t^e}{c_{t+s}^e} \left[\frac{P_{H,t}(z)}{P_{t+s}} - mc_{t+s} \right] y_{t+s}^d(P_{H,t}(z)),$$

where θ_p is the probability of not adjusting the price. The first-order condition is standard (see Appendix), with all time-t price setters choosing a common optimal price $\tilde{P}_{H,t}$. In the case of flexible prices ($\theta_p = 0$), retailers set $\tilde{P}_{H,t} = \frac{\varepsilon^p}{\varepsilon^p - 1} P_t mc_t$, i.e. they charge a markup $\varepsilon^p / (\varepsilon^p - 1)$ over nominal marginal costs. Therefore, the markup factor $\varepsilon^p / (\varepsilon^p - 1)$ measures the degree of monopolistic distortions in product markets.

3.2.3 Construction firms

A representative construction firm maximizes its expected discounted stream of profits, $E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_0^e}{c_t^e} \Pi_t^h$, where $\Pi_t^h = p_t^h I_t^h - \frac{W_t}{P_t} n_t^h - i_t^h$, subject to the production 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 are labor services, i_t^h are consumption goods, and I_t^h are new real estate units.[6]

3.2.4 Equipment capital producers

A representative equipment capital producer maximizes its expected discounted stream of profits, $E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_0^e}{c_t^e} \Pi_t^k$, where $\Pi_t^k = q_t I_t - i_t$, subject to 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 are consumption goods, and I_t are new equipment capital goods.

3.3 Wage setting

Both entrepreneurs and construction firms use a basket of labor services by constrained and unconstrained households,

$$n_t^s = \left(n_t^{s,c} \right)^{\mu_s} \left(n_t^{s,u} \right)^{1-\mu_s},$$

where $n_t^{s,x}$ are labor services provided by type-x household, $x = c, u$, to each sector $s = e, h$. We assume that both worker types (constrained and unconstrained) earn the same wage. Cost minimization then implies $(1 - \mu_s) n_t^{s,c} = \mu_s n_t^{s,u}$, for $s = e, h$.

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[6] We include labor services in the production function of construction firms so as to allow for long-run changes in real estate prices. Without labor in construction ($\omega = 0$), real estate prices are always unity in the long run. More generally, it can be shown that $p_{ss} = (w_{ss})^{\omega} \omega^{-\omega} (1 - \omega)^{-(1-\omega)}$.

From each household type, each sector demands in turn a basket of labor service varieties,

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

for $x = c, u$ and $s = e, h$, where $\varepsilon^w > 1$ is the elasticity of substitution across labor varieties $i \in [0, 1]$. Demand for each labor variety by each sector of production is thus given by $n_t^{s,x}(i) = (W_t(i)/W_t)^{-\varepsilon^w} n_t^{s,x}$, for $x = c, u$ and $s = e, h$, 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

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

for $x = c, u$. 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 $n_t^x \equiv n_t^{e,x} + n_t^{h,x}$.

As in Erceg, Henderson and Levin (2000; EHL), nominal wages are set *à la* Calvo (1983). In particular, a union representing all type-i workers maximizes the utility of the households to which such workers belong. Let $\lambda_t^x \equiv 1/c_t^x$ denote the marginal utility of real income for each household type $x = c, u$. Then a union that has the chance to reset the nominal wage at time t chooses $W_t(i)$ to maximize

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

where θ_w is the probability of not adjusting the wage and $\beta^c = \beta$. All time-t wage-setters choose a common optimal wage $\tilde{W}_t$; see the first-order condition in the Appendix. In the case of flexible wages ($\theta_w = 0$), workers charge a markup $\varepsilon^w/(\varepsilon^w - 1)$ over a weighted average of constrained and unconstrained households' marginal rates of substitution between consumption and labor. Therefore, the markup factor $\varepsilon^w/(\varepsilon^w - 1)$ measures the degree of monopolistic distortions in the labor market.

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3.4 Foreign sector

A representative exporter produces the following basket of domestic consumption goods: $x_t = (\int_0^1 x_t(z)^{(\varepsilon^P - 1)/\varepsilon^P} dz)^{\varepsilon^P/(\varepsilon^P - 1)}$, where $x_t(z)$ is demand for each domestic good variety. Cost minimization implies that the exporter's demand for each variety is $x_t(z) = (P_{H,t}(z)/P_{H,t})^{-\varepsilon^P} x_t$, and total spending is $\int_0^1 P_{H,t}(z) x_t(z) dz = P_{H,t} x_t$. The exporter sells the basket x_t in export markets under perfect competition. The zero profit condition implies that the market price of the export basket is exactly $P_{H,t}$. Assuming that foreign consumers' preferences are analogous to those of domestic consumers, foreign demand for the basket of domestic goods is given by

$$x_t = \zeta \left(\frac{P_{H,t}}{P_{F,t}} \right)^{-\varepsilon_F} y_{F,t},$$

where $P_{F,t}$ and $y_{F,t}$ are the foreign price level and aggregate demand (both exogenous) and ε_F is the price elasticity of exports. Defining the *terms of trade* $p_t^* \equiv P_{H,t}/P_{F,t}$, the latter evolve according to $p_t^* = p_{t-1}^* \pi_{H,t}/\pi_{F,t}$, where $\pi_{F,t} \equiv P_{F,t}/P_{F,t-1}$ is foreign inflation.

3.5 Aggregation and market clearing

Each retailer z demands $y_t^d(P_{H,t}(z))$ units of the intermediate input, as given by (11). Total demand for the latter equals $\int_0^1 y_t^d(P_{H,t}(z)) dz = y_t \Delta_t$, where $\Delta_t \equiv \int_0^1 (P_{H,t}(z)/P_{H,t})^{-\varepsilon_P} dz$ denotes relative price dispersion. Market clearing in the intermediate good market thus requires

$$k_{t-1}^{\alpha_k} \left(h_{t-1}^e \right)^{\alpha_h} (n_t^e)^{1 - \alpha_h - \alpha_k} = y_t \Delta_t.$$

As noted before, investment-goods producers and exporters demand the same combination of domestic consumption goods as consumers. Therefore, aggregate demand for the basket of domestic consumption goods is given by,

$$y_t = c_{H,t}^c + c_{H,t}^u + c_{H,t}^e + i_{H,t} + i_{H,t}^h + x_t. \tag{12}$$

Total demand for real estate must equal total supply,

$$h_t + h_t^u + h_t^e = I_t^h + (1 - \delta_h)\left(h_{t-1} + h_{t-1}^u + h_{t-1}^e\right).$$

Total demand for equipment capital must equal total supply: $k_t = I_t + (1 - \delta_k) k_{t-1}$. Labor market clearing requires $n_t^c + n_t^u = n_t^e + n_t^h$. This completes the model. We may combine all market clearing conditions and budget constraints to obtain the current account identity (which is redundant as a result of Walras' Law),

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

where $nfa_t \equiv d_t - b_t - b_t^e$ is the real (CPI-deflated) net foreign asset position. We finally define real (PPI-deflated) GDP as

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

where in the second equality we have used (12) and $z_{H,t} = \frac{P_t}{P_{H,t}} z_t - \frac{P_{F,t}}{P_{H,t}} z_{F,t}$ for $z = c^c, c^u, c^e, i, i^h$, and where $c_t^{tot} \equiv c_t^c + c_t^u + c_t^e$ is total consumption (total consumption imports $c_{F,t}^{tot}$ are defined analogously). The net foreign asset position as a fraction of GDP is then simply $nfa_t^y \equiv P_t nfa_t / P_{H,t} gdp_t$.

3.6   Calibration

We calibrate the model to the Spanish economy. As explained in the introduction, we are motivated by the recent experience of the peripheral EMU economies, for which structural reforms in product and labor markets have been advocated as a means of fostering economic recovery. Spain's labor market has traditionally been considered as particularly inefficient within the EMU context, while some room for improved competitiveness also exists in its product markets.[7] This feature, together

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[7]See e.g. European Commission (2011) and International Monetary Fund (2011).

with the on-going deleveraging process of Spanish households and firms, make Spain an ideal case study for the purpose of our analysis.

The time period is a quarter. We match the model's steady state to a number of empirical targets in 2007, the year prior to the start of the financial crisis. We do not claim, however, that the Spanish economy was in (or close to) a steady state in 2007. Instead, our model's steady state should be interpreted as the economy's initial condition for the purpose of our simulation exercises.

The discount factor of the impatient agents is set to $\beta = 0.98$, following Iacoviello (2005). For patient households, we choose $\beta^u = 1.025^{-1/4}$, which is consistent with a steady state nominal interest rate of $R_{ss} = 1.025^{1/4} \pi_{ss} = R^* e^{-\psi(nfa_{ss}^y)}$. We set world inflation to $\pi_{F,ss} = 1$, which implies $\pi_{H,ss} = \pi_{ss} = 1$ in a stationary equilibrium. Choosing $R^* = 1.02^{1/4}$ for the world nominal interest rate, we then set ψ to replicate net foreign assets over GDP in 2007, $nfa_{ss}^y = -79.3\%$. The inverse labor supply elasticity is set to $\varphi = 4$, consistently with a large body of micro evidence. The weight parameter in the consumption basket, ω_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 scale parameter in export demand, ζ, is chosen such that steady-state terms of trade p_{ss}^* are normalized to 1.

The elasticities of substitution across varieties of consumption goods and labor services, ε_p and ε_w, control the degree of market power in product and labor markets, respectively. We set $\varepsilon_p = 7$, implying an initial price markup of $\varepsilon_p/(\varepsilon_p - 1) = 1.17$, which is broadly consistent with estimates by Montero and Urtasun (2013) based on Spanish firm-level data. Wage markups are hard to estimate empirically, so we adopt an alternative calibration strategy. We follow Galí (2011) in reinterpreting the EHL model of wage-setting in a way that delivers equilibrium unemployment (see Appendix B for details). Targeting an unemployment rate of 8.6% in 2007, we obtain $\varepsilon_w = 3.31$, i.e. an initial wage markup of $\varepsilon_w/(\varepsilon_w - 1) = 1.43$.

The elasticity of entrepreneurial output with respect to equipment capital and commercial real estate are set to $\alpha_k = 0.11$ and $\alpha_h = 0.21$, which are chosen to replicate the labor share of GDP in 2007 (61.6%) and the share of equipment capital

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Table 1: Baseline calibration

Parameter	Value	Description
Preferences		
β^u	0.994	unconstrained household discount factor
β	0.98	constrained household discount factor
φ	4	(inverse) labor supply elasticity
ϑ	0.38	weight on housing utility
ε_p	7	elasticity of subst. across consumption varieties
ε_w	3.31	elasticity of substitution across labor varieties
ω_H	0.72	weight home goods in consumption basket
ε_H	1	elasticity of imports wrt terms of trade
ε_F	1	elasticity of exports wrt terms of trade
ζ	0.87	scale parameter export demand
Technology		
α_h	0.21	elasticity output wrt real estate
α_k	0.11	elasticity output wrt equipment
ω	0.43	elasticity construction wrt labor
δ_h	0.01	depreciation real estate
δ_k	0.025	depreciation equipment
μ_e, μ_h	0.5	share of constr. households in labor baskets
Φ_h	6.1	investment adjustment costs construction
Φ_k	2.4	investment adjustment costs equipment
Price/wage setting		
θ_p	0.67	fraction of non-adjusting prices
θ_w	0.75	fraction of non-adjusting wages
Debt constraints		
$\bar{m}$	0.70	household LTV ratio
$\bar{m}^e$	0.64	entrepreneur LTV ratio
γ	0.98	amortization rate household debt
γ^e	0.97	amortization rate entrepreneurial debt

in the total stock of productive capital.[8] As in Iacoviello and Neri (2010) we set $\delta_h = 0.01$, whereas δ_k is set to a standard value of 0.025. The elasticity of construction output with respect to labor ω is set to match the construction share of total employment in 2007 (13.4%). The weight of utility from housing services, ϑ, is chosen to replicate gross household debt over annual GDP (80.22%). The share of constrained and unconstrained workers in the labor baskets are set to $\mu_h = \mu_e = 1/2$. The scale parameters of convex investment adjustment costs, Φ_h and Φ_k, are chosen such that the fall in construction and equipment capital investment in our baseline deleveraging scenario resembles their behavior during the crisis.[9]

The Calvo parameters are set to $\theta_p = 2/3$ and $\theta_w = 3/4$, such that prices and wages are adjusted every 3 and 4 quarters on average, respectively. This is consistent with survey evidence for the Spanish economy (see e.g. Druant et al., 2009).

The parameters that regulate the debt constraints are calibrated as follows. According to data from the Spanish Land Registry office, loan-to-value ratios (LTV) for new mortgages prior to the 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 is chosen to match the ratio of gross non-financial corporate debt to annual GDP (125.4% in 2007), which yields $\bar{m}^e = 0.64$. Finally, we calibrate the contractual amortization rates, $1-\gamma$ and $1-\gamma^e$, in order to replicate the average age of the stock of outstanding mortgage debt prior to the crisis. This yields $1-\gamma = 0.02$ and $1-\gamma^e = 0.03$ per quarter.[10] Table 1 summarizes the calibration.

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[8]Using data from BBVA Research, we obtain that the value of equipment capital was 21.4% of the total value of productive capital in 2007.

[9]In particular, we set Φ_h and Φ_k such that the accumulated fall in construction and equipment capital investment 8 quarters after the financial shock replicate their accumulated fall 8 quarters after their peak in 2007:Q4 (24.5% and 28% respectively).

[10]Under our debt contracts (with a constant fraction of outstanding debt amortized each period), the average age of the debt stock converges in the steady state to $\gamma/(1-\gamma)$ and $\gamma^e/(1-\gamma^e)$ for households and entrepreneurs, respectively. According to calculations by Banco de España, based on data from the Land Registry office and large financial institutions, the average age of outstanding mortgage debt prior to the crisis was close to 12.5 years for households and 8 years for nonfinancial corporations and entrepreneurs. This yields $\gamma = 12.5 \times 4/(12.5 \times 4 + 1) = 0.98$ and $\gamma^e = 8 \times 4/(8 \times 4 + 1) = 0.97$.

4 Baseline scenario: adjustment to a deleveraging shock

As our baseline scenario, we subject the model economy to a severe financial contraction that reduces the availability of credit for borrowers. Our 'credit crunch' consists of an unexpected, gradual, permanent drop in the LTV ratios of both households and entrepreneurs, m_t and m_t^e respectively. In particular, we assume an autoregressive process for both LTV ratios: $x_t = (1 - \rho^x) \bar{x} + \rho^x x_{t-1}$, $x = m, m^e$, where we set $\rho^m = \rho^{m^e} = 0.75$. We then simulate an unanticipated fall in the long-run LTV ratios $(\bar{m}, \bar{m}^e)$ of 10 percentage points from their baseline values in Table 1, which accords well with recent experience in Spain.[11]

We assume perfect foresight in all our simulations. We solve for the fully nonlinear equilibrium path, using a variant of the Newton-Raphson algorithm developed by Laffargue (1990), Boucekkine (1995) and Juillard (1996) (LBJ).[12] As discussed in the previous section, our assumption of long-run debt contracts gives rise to two debt regimes for households and entrepreneurs. If collateral values are above the contractual debt amortization paths, then debt levels are restricted by the former, according to equations (5) and (8). If the opposite holds, then new credit flows collapse to zero and debt is restricted by the contractual amortization path (equations 6 and 9). We have thus modified the LBJ algorithm to allow for endogenous change of debt regime. In particular, the dates at which the regime changes take place are solved as equilibrium objects.

Figure 1 displays the response to the credit crunch of collateral values (dashed lines) and contractual amortization paths (thin solid lines), together with the actual equilibrium path of outstanding debt (thick solid lines), both for entrepreneurs and households. Before the shock ($t = 0$), the economy rests in the steady state of the baseline regime, where debt levels equal pledgeable collateral values.[13] The

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[11]Data from the Spanish Land Registry office shows that average LTV ratios declined by 7.7 percentage points in the 6 years between 2007:Q3 and 2013:Q3.

[12]See also Juillard et al. (1998) for an application of the LBJ variant of the Newton-Raphson algorithm.

[13]Indeed, the fact that constrained households and entrepreneurs are both more impatient than

credit crunch shock drives collateral values *below* the contractual amortization paths already on impact $(t = 1)$. Therefore, the economy switches on impact to the alternative regime in which entrepreneurial and household debt stocks decay at the contractual amortization rates. In this phase, the economy undergoes a gradual and prolonged deleveraging process.

Eventually, collateral values rise again above the contractual amortization path, at which point borrowers are able to regain access to fresh funds. We denote by T^* and T^{**} the time at which the endogenous regime change takes place for entrepreneurs and households, respectively. Notice that collateral values and debt both experience a surge at the time of the regime change. This is because real estate becomes again valuable as collateral (see equations 7 and 10), which pushes up borrowers' demand for real estate, and hence its price. Thus, T^* and T^{**} also represent the *duration* of the deleveraging phase for entrepreneurs and households. In our baseline simulation, deleveraging lasts longer for households $(T^{**} = 22$ quarters) than for entrepreneurs $(T^* = 13$ quarters), which mainly reflects the slower amortization rate assumed for the former $(1 - \gamma < 1 - \gamma^e)$.[14]

Figure 2 shows the economy's response to the deleveraging shock. Total consumption declines as a result of the deleveraging process, and then experiences successive recoveries when first entrepreneurs and then households regains access to new loans. The shock has also a negative impact on total investment, driven by lower expenditure in both real estate and equipment capital. Interestingly, investment starts recovering at $t = 11$, i.e. before the period in which entrepreneur debt actually starts increasing $(t = 14)$. This initial *creditless recovery* in investment is financed with an increase in borrowers' internal saving.[15] Such a self-financed investment re-

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unconstrained households, $\beta < \beta^u$, guarantees that the collateral constraint binds for both agents in the steady state.

[14]Figure 1 shows that the debt constraints (6) and (9) are binding during $t = 1, ..., T^{**} - 1$ and $t = 1, ..., T^* - 1$, respectively, whereas the collateral constraints (5 and 8) are binding for $t \geq T^{**}$ and $t \geq T^*$, respectively. We have verified that the corresponding Lagrange multipliers are indeed strictly positive in the relevant periods, both in the baseline scenario and in all subsequent simulations. Results are available upon request.

[15]In particular, between the impact period and T^* entrepreneurs continuously reduce their consumption, which in our framework may be interpreted as dividend payments, thus increasing their retained earnings.
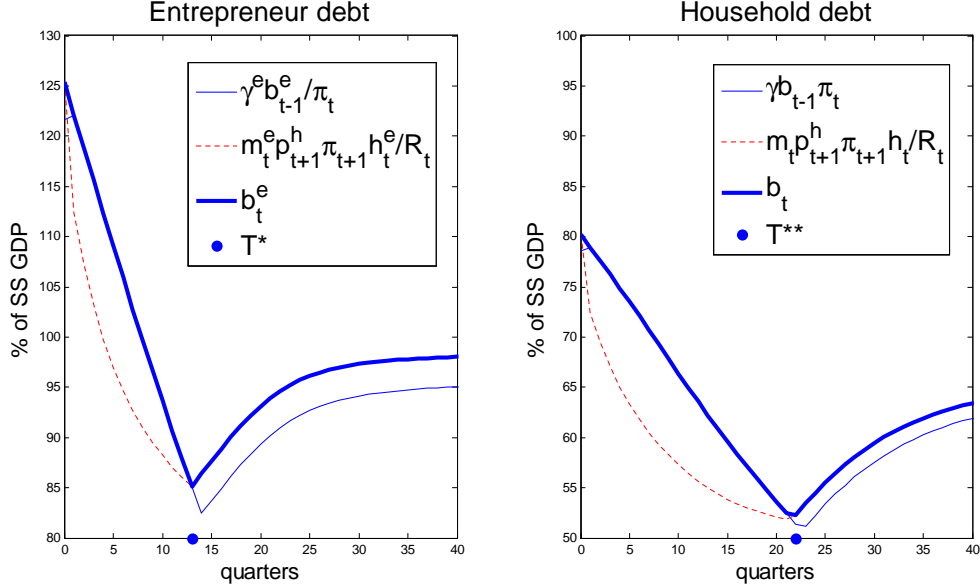
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Figure 1: Baseline deleveraging scenario: debt dynamics

covery is akin to those observed in some emerging and advanced economies in similar economic conditions (see e.g. Abiad, Dell'Ariccia and Li, 2011).

The deflationary process caused by the financial shock leads to a temporary depreciation of the terms of trade, which fosters gross exports. On the other hand, imports fall due to the combined effect of the terms-of-trade depreciation and a severe contraction in domestic demand. Both effects give rise to a substantial improvement in net exports during the deleveraging period. The positive contribution of the external sector, however, is not sufficient to avoid a protracted recession that lasts for 13 quarters. This recession produces a significant reduction in employment, despite the induced moderation of real wages.

5   Structural reforms

Despite the fact that financial crises evolve into mostly demand-driven recessions, policy makers and academics have advocated supply-side measures, most notably
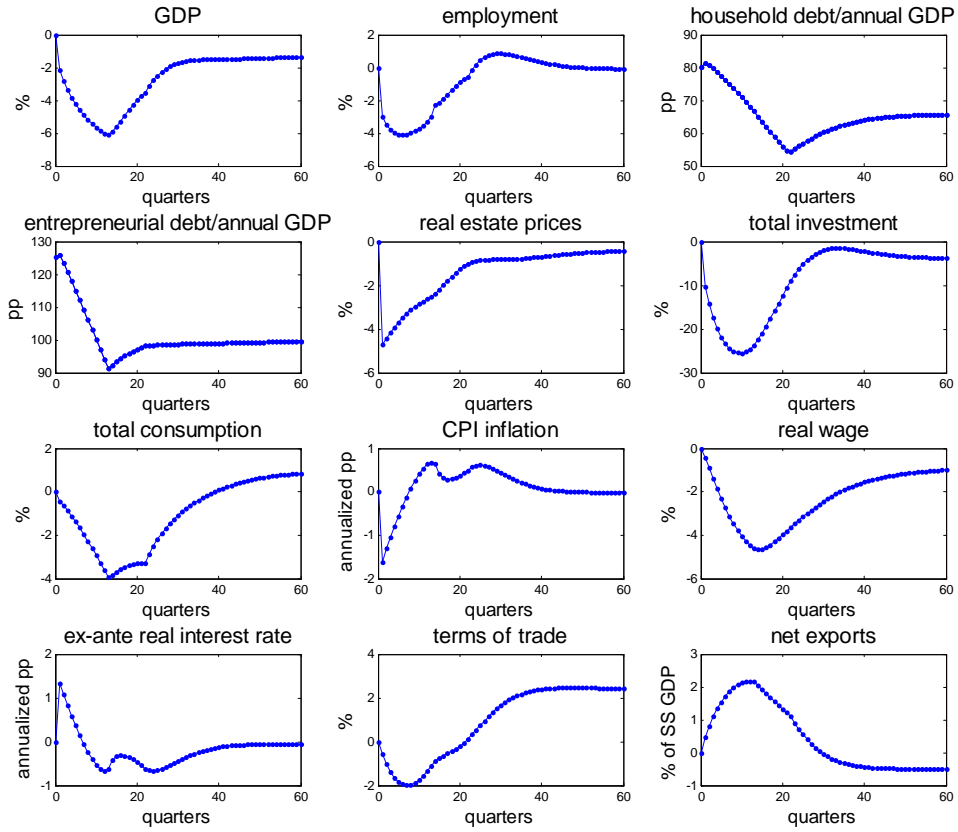
Figure 2: Baseline deleveraging scenario: macroeconomic adjustment

reductions in monopolistic distortions in labor and product markets, as a way of expanding output and employment. These structural reforms are more strongly recommended for those economies in which such distortions were larger during the upswing, as was the case in the periphery of the euro area. In this section we investigate the short run and long run effects of product and labor market reforms within the context of our model and against the background of the deleveraging scenario described in the previous section.

5.1   Product market reform

We first implement a measure aimed at strengthening competition in goods markets. In particular, we consider an unanticipated, instantaneous and permanent reduction in the gross desired price markup, $\varepsilon^p / (\varepsilon^p - 1)$, of 5%. The latter thus falls from 1.17 to 1.11. This measure is assumed to take place contemporaneously to the deleveraging shock. The effects of this reform (relative to the baseline, no-reform scenario) are displayed in Figure 3.

The main message from the figure is that the assumed product market reform has a positive differential effect on GDP not only in the long run, as one would expect, but *also* in the short and medium run. Indeed, the reform reduces both the severity and the duration of the recession caused by the deleveraging shock. This improvement in the short/medium run is clearly driven by investment. Intuitively, agents anticipate the long-run gains in economic activity, which leads them to increase their demand for investment goods already in the short run. Both construction and equipment capital investment benefit from this effect.

The short/medium-run improvement in investment is reinforced by two related channels. First, due to stronger demand for real estate, the reform scenario features a much smaller drop in real estate prices. Thus, borrowers anticipate higher collateral values (relative to the no-reform scenario) from the period in which they will regain access to new credit. To see how this affects asset demand, consider the entrepreneur's optimal demand for real estate, equation 10 (the argument for constrained households is analogous). Integrating it forward, rescaling it by c_t^e, normalizing the
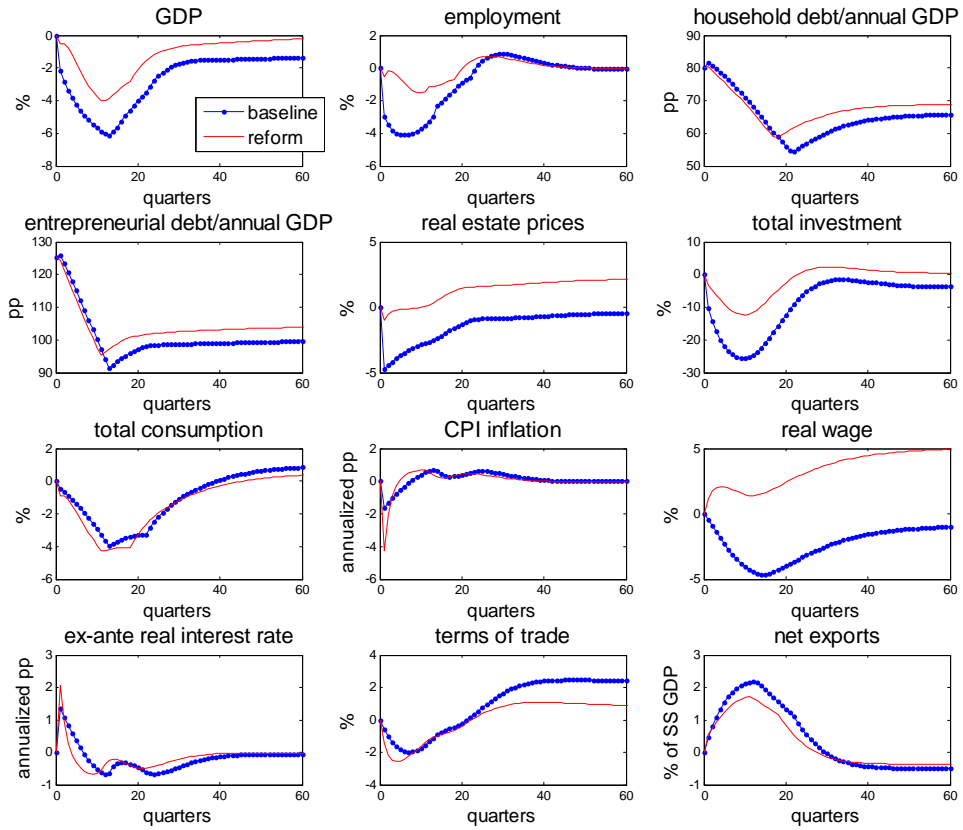
Figure 3: Effects of the product market reform

impact period to $t = 1$, and finally using the fact that the collateral constraint does not bind during the deleveraging phase ($\xi_s^e = 0$ for $s = 1, ..., T^* - 1$), we obtain the following expression,

$$
\begin{aligned}
p_1^h &= E_1 \sum_{s=1}^{\infty} \beta^s (1 - \delta_h)^{s-1} \frac{c_1^e}{c_{s+1}^e} mc_{s+1}\alpha_h \frac{y_{s+1}^e}{h_s^e} \\
&\quad + c_1^e E_1 \sum_{s=T^*}^{\infty} \beta^{s-1} (1 - \delta_h)^{s-1} \xi_s^e \frac{m_s^e}{R_s} \pi_{s+1}p_{s+1}^h.
\end{aligned} \tag{13}
$$

As illustrated by the term in the second line of (13), the fact that asset prices p_{s+1}^h are higher in the reform scenario implies that so is the marginal collateral value of real estate, $\xi_s^e \frac{m_s^e}{R_s}\pi_{s+1}p_{s+1}^h$, from the end of deleveraging onwards, $s \geq T^*$. This effect shifts up entrepreneur's demand for real estate, thus raising investment demand ceteris paribus.

Second, the reform *brings forward* the end of the deleveraging phase for entrepreneurs and households. Indeed, we now have $(T^*, T^{**}) = (11, 18)$, versus $(T^*, T^{**}) = (13, 22)$ in the no-reform scenario. The reason is simple: since the reform scenario features a smaller drop in collateral values, the latter catch up earlier with the contractual debt amortization paths, allowing borrowers to regain access to new credit at an *earlier* date.[16] This implies that real estate becomes valuable as collateral also at an earlier date (i.e. T^* happens sooner in equation 13). In addition, since consumption experiences a surge after the end of both deleveraging processes, agents also anticipate an earlier recovery in economic activity. Both effects (possibility of borrowing against real estate at a sooner date and an earlier exit from recession) feed back into higher investment demand today, leading to higher real estate prices, higher collateral values, and so on.[17] In sum, by accelerating the end of the delever-

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[16]Graphically, in Figure 1 the collateral values (the dashed lines) cross the contractual amortization paths (the thin solid lines) at an earlier date. We note that the contractual amortization paths, $\gamma b_{t-1}/\pi_t$ and $\gamma^e b_{t-1}^e/\pi_t$, look very similar with and without reform, such that the change in T^* and T^{**} is driven essentially by the effect of the reform on the collateral values.

[17]In the case of entrepreneurs, the higher investment demand (relative to the baseline scenario) is partially financed by a fall in their consumption, which as mentioned before may be interpreted as a cut in dividend payments.

aging phase, the product market reform fosters investment and GDP in the short run even further.

We note that neither consumption nor net exports are much affected in the short run by the product market reform. In the case of consumption, one reason is that, while the deflationary effect of the reform produces an additional increase in real interest rates and a rise in the real value of debt payments, this is largely compensated by the positive income effect stemming from the anticipation of the long run gains and by the lower fall in current asset prices. Moreover, as we will see later on, the negative debt deflation effect produced by the reform turns out to be substantially weakened by the presence of long-term debt. As regards the external balance, the increase in gross exports, due to the additional depreciation in the terms of trade, is mostly dominated by the increase in the real (PPI-deflated) value of imports, due both to stronger domestic demand and the terms-of-trade depreciation itself.

Finally, notice that the long-run gains in GDP do not carry over to employment. The reason is that the reform permanently increases the consumption of both household types.[18] This produces an upward shift in the labor supply schedule (i.e. a negative income effect on labor supply) that essentially undoes the upward shift in labor demand due to stronger activity. As a result, the reform raises the long-run real wage while keeping employment unchanged.

5.2   Labor market reform

Analogously to the product market reform, we implement an improvement in labor market competition by means of an unexpected, instantaneous and permanent fall of 5% in the desired wage markup, $\varepsilon^w / (\varepsilon^w - 1)$, which falls from 1.43 to 1.36. This simulation proxies for a labor market reform that affects unions' bargaining power. The effects of this reform are depicted in Figure 4.

Unlike in the case of the product market reform, here the impact effects on GDP and employment are essentially nil. From then on, the reform gathers momentum

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[18]The product market reform raises the long-run consumption of constrained and unconstrained households by 6,1% and 6,4%, respectively, relative to the baseline scenario.
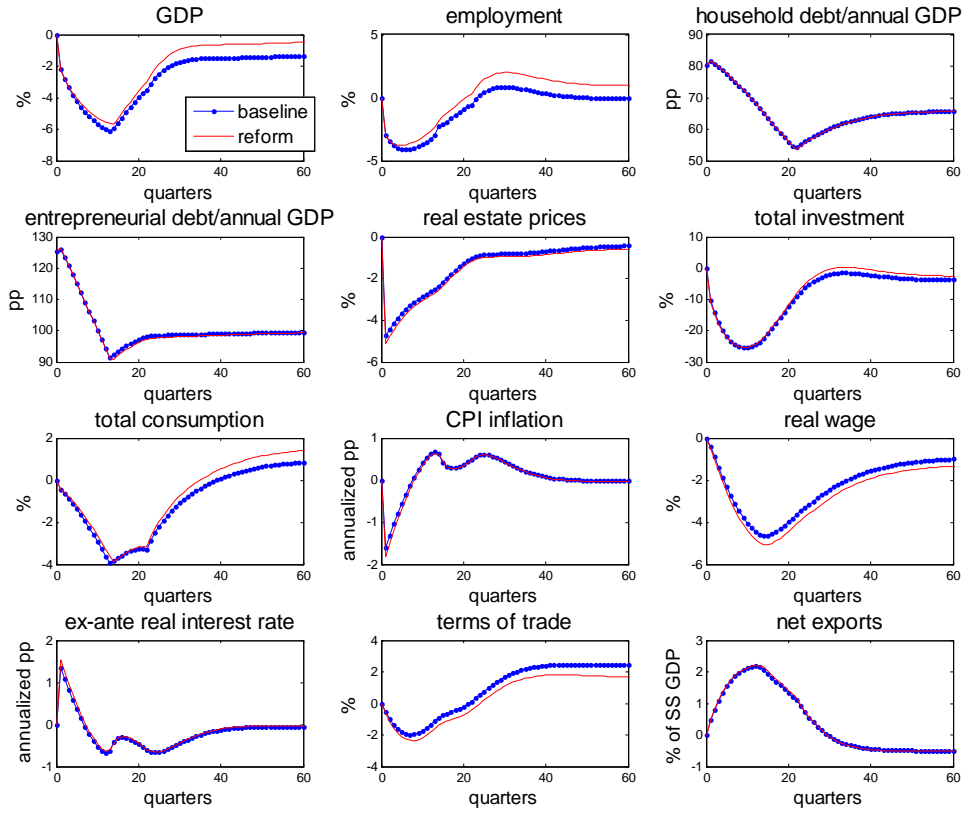
Figure 4: Effects of the labor market reform

over time and eventually generates a long run positive effect on GDP nearly identical to that from the product market reform. This long-run gain extends also to employment, in contrast with the case of the product market reform. This difference stems from the fact that real wages now experience a long-run decline (as opposed to an increase), a logical consequence of permanently stronger labor market competition.

Unlike in the case of a product market reform, the labor market reform does not have a noticeable effect on investment or on the duration of the deleveraging process. One reason is that the permanent reduction in real wages shifts relative factor demand towards labor and away from capital, which offsets the positive effect on investment from the anticipation of long-run gains in economic activity. The absence of an improvement in the demand for investment goods carries over to asset prices, and hence to collateral values. As a result, the duration of the deleveraging phases are not affected by this reform.

Instead, the gradual improvement in GDP relative to the baseline scenario is driven mostly by consumption. On the one hand, Ricardian (unconstrained) households enjoy a positive income effect stemming from the anticipation of long-run gains. This effect dominates the negative substitution effect coming from the increase in real interest rates, which results from the reform-driven deflation. On the other hand, constrained households' wage income increases as times go by, as the increase in employment gradually overcomes the decline in real wages.

Another reason why the labor market reform is not as growth-friendly in the short run as the product market reform is that, unlike the reduction in price markups, the reduction in wage markups must overcome a double layer of nominal rigidities (first wages, then prices) before affecting actual production prices and hence international competitiveness. To visualize this more clearly, Figure 5 displays the *differential* effect of each reform on the terms of trade. As is clear from the figure, the product market reform (dotted line) improves the economy's competitiveness much more quickly than the labor market reform (thin-solid line). Motivated by this observation, the next subsection considers a broader labor market reform that also facilitates nominal wage adjustment.
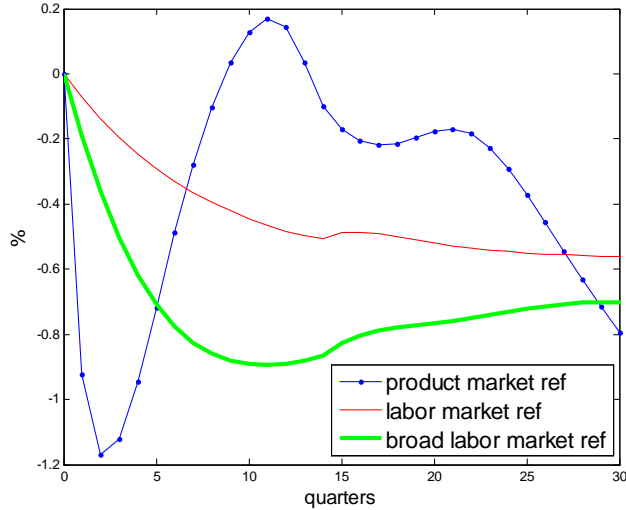
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Figure 5: Diferential effect of reforms on terms of trade

5.2.1 Broader labor market reform: increased wage flexibility

In the previous section we considered a reduction in desired wage markups, in analogy with the product market reform analyzed in section 5.1. However, labor market reforms typically affect not only desired markups over reservation wages (as a reduced-form measure of workers' bargaining power), but also the speed or *flexibility* with which nominal wages adjust to changes in these reservation wages.[19] In this section, we consider a broader labor market reform that includes both a reduction in wage markups *and* a simultaneous increase in wage flexibility. In particular, we reduce the Calvo wage parameter θ_w from 0.75 (its baseline value) to 0.66, such that the average wage duration falls from 4 to 3 quarters.

The results are displayed in Figure 6. Comparing the latter with Figure 4, it is clear that adding higher wage flexibility increases significantly the short/medium-run gains in GDP and employment from a labor market reform. The reason is that higher wage flexibility allows a faster adjustment of nominal wages, production

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[19]A clear example is the labor market reform of 2012 in Spain. The latter included modifications in the regulation of collective bargaining agreements aimed at facilitating nominal wage adjustments in response to changing economic conditions.

prices, and ultimately terms of trade, with the resulting improvement in international competitiveness.[20] This last effect becomes apparent in Figure 5: under this broader labor market reform (thick solid lines), the pass-through from lower wage markups to terms of trade is much stronger than under the basic labor market reform. Of course, in the long-run the gains in economic activity are the same in both cases, because by then wages have fully adjusted to their flexible levels.

6   Inspecting the mechanisms

6.1   The role of the foreign sector

An important channel in the transmission of the effects of structural reforms is the foreign sector. Figures 3, 4 and 6 suggest that reforms have little effect (or even a negative one) on the trade balance in the short/medium run. In fact, this hides two counteracting forces: structural reforms foster gross exports (and depress imports) by further depreciating the terms of trade relative to the baseline scenario, but they also boost imports by improving domestic demand. This suggests that the short/medium run effects of structural reforms may depend on the sensitivity of trade flows to the terms of trade depreciation produced by such reforms.

To analyze this question, we compute and display in Figure 7 the *differential* effect of each type of reform on GDP for different values of the terms-of-trade elasticity of exports, ε_F, and imports, ε_H. The message from the figure is clear: higher price elasticities of trade flows lead to larger positive effects from structural reforms. In the case of the product market reform, lower elasticities yield smaller gains. In the case of the labor market reforms (both the baseline and the broader one), lower elasticities actually change the sign of the short-run effects. That is, a reform aimed at reducing wages may be counterproductive if exports and imports do not respond sufficiently to the resulting depreciation of the terms of trade. These results bear

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[20]Notice that this is not incompatible with the lack of improvement in net exports in Figure 6. Indeed, output can be expressed both net of imports and gross of imports. In the latter case, output is just the sum of gross exports and domestic demand of domestic goods. Both components improve *ceteris paribus* as a result of the additional terms-of-trade depreciation.
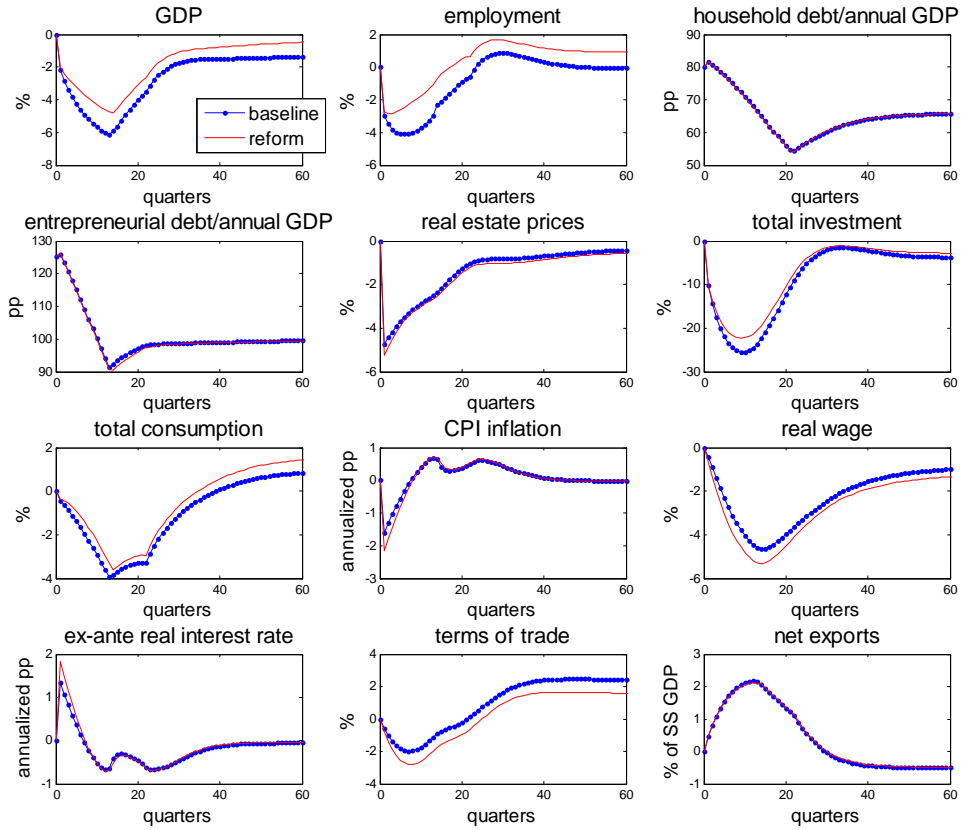
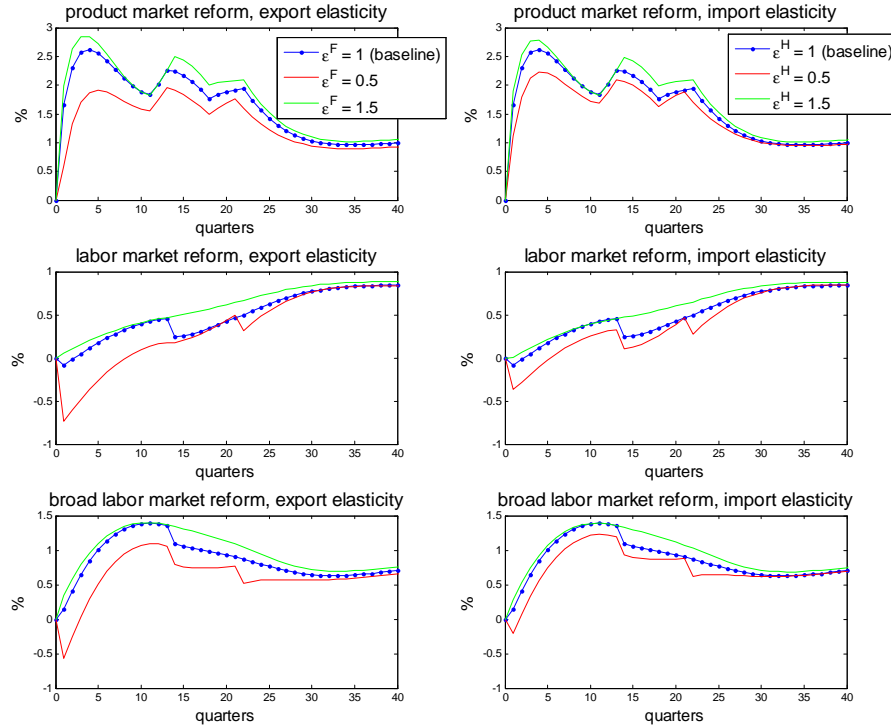Figure 6: Broader labor market reform (wage markups and wage flexibility)

Figure 7: GDP effects of reforms for different terms-of-trade elasticities

an important message: the short-run effects of structural reforms on economic activity are dependent on the intensity with which trade flows react to the ensuing improvement in international competitiveness.

6.2   Long-term versus one-period debt

The presence of long term mortgaged debt is one of the main departures of our model from most previous analysis of the macroeconomic implications of deleveraging. In this subsection we take a close look at the implications of this financial assumption as compared with the more standard one based on one-period debt contracts.

6.2.1 The baseline scenario with long-term vs one-period debt

Our main motivation for introducing long-run debt is to allow our model to produce a realistic scenario of private-sector deleveraging, i.e. one that features a slow reduction in debt stocks and a protracted recession. To shed light on how long-term debt shapes things in this regard, Figure 8 compares the effects of the credit crunch under long-term debt with those that would follow in the case of one-period debt contracts ($\gamma = 0$). Under this last assumption, the deleveraging shock produces a much faster reduction in debt ratios.[21] This is because debt in that scenario is always directly linked to collateral values, which fall sharply on impact, mostly as a result of the sudden drop in real estate prices. The abrupt reduction in debt carries over to total consumption, GDP and employment, all of which fall sharply on impact and then recover very quickly. By contrast, with long-term debt, the fact that collateral constraints cease to bind for a number of periods implies an initial decoupling between asset prices and debt levels. In the short term, this provides some relief to borrowers' expenditure capacity, giving rise to a much smoother and more persistent decline in consumption, GDP and employment. In this way, long term debt produces a realistic scenario of prolonged recession caused by a slow process of debt reduction, consistently with most observed deleveraging episodes.[22]

6.2.2 How long-term debt influences the effects of reforms

The exercises in the previous section show that, in our setup, structural reforms are generally positive for GDP and employment even in the short run. Specifically, a product market reform (via lower price markups; see Figure 3) and an encompassing labor market reform (via lower wage markups and higher wage flexibility; see Figure 6) both reduce already on impact the output and employment losses caused by the deleveraging shock. These positive short-run effects of reforms obtain despite the fact that markup reductions unleash deflationary forces, which both increase the real

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[21]Actual debt levels (rescaled e.g. by initial GDP) fall even more abruptly than the debt-to-GDP ratios displayed in Figure 8, due to the sharp fall in GDP.

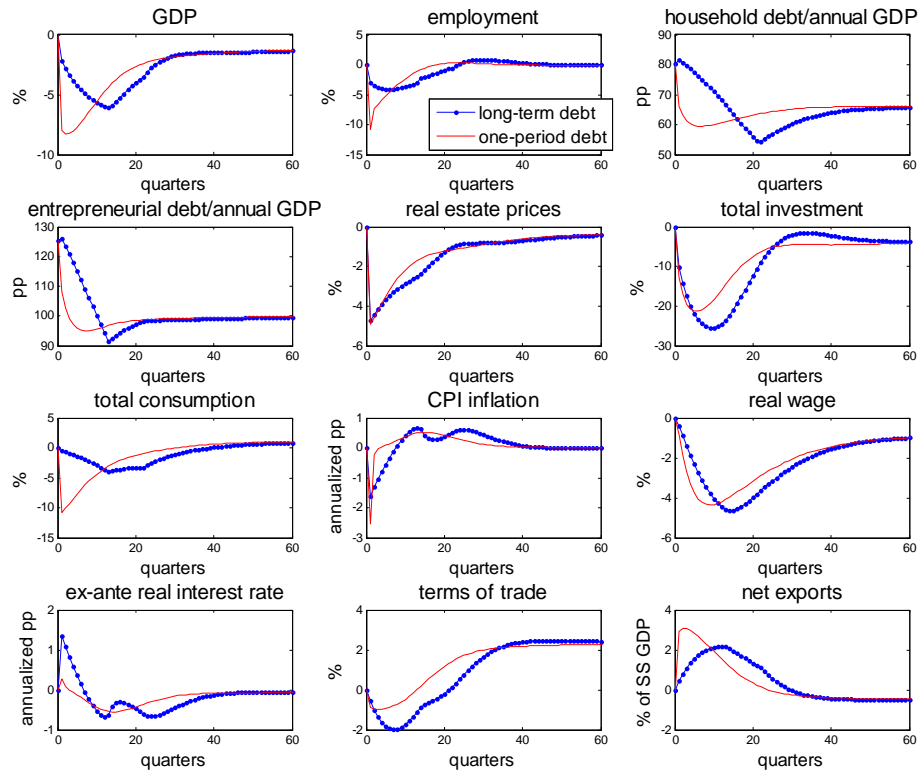[22]See, e.g., Garrote et al. (2013) for an international comparison of historical episodes of deleveraging.

Figure 8: Baseline deleveraging scenario: long-term vs. one-period debt

value of debt repayments and (coupled with a constant nominal policy rate) raise the real interest rate. We next discuss how the presence of borrowing constraints and long-term debt affect the short-term negative deflationary channel.

First, the presence of long-term debt substantially weakens the effect of reforms-driven deflation on borrowers' spending capacity. To see this, consider the entrepreneur's real debt cash flows (net of interest payments) prior to T^*, i.e. when she cannot obtain new credit and simply repays her debt according to the contractual rate $(b_t^e = \gamma^e b_{t-1}^e / \pi_t)$,[23]

$$b_t^e - \frac{R_{t-1}}{\pi_t} b_{t-1}^e = -\frac{R_{t-1} - \gamma^e}{\pi_t} b_{t-1}^e.$$

We learn from this expression that the negative effects of deflation on real debt cash flows are mitigated by the existence of long-term debt, i.e. the fact that γ^e is positive and typically close to 1. In particular, notice that $R_{t-1} - \gamma^e$ equals $(R_{t-1} - 1) + (1 - \gamma^e)$, i.e. the sum of the net interest rate and the amortization rate of the long-term contract. Both terms are first-order in magnitude, as is their sum. As a result, a first-order effect of reforms on inflation will only have *second-order* effects on borrowers' spending capacity.

Second, the existence of debt constraints (whether linked to collateral values or to contractual amortization paths) mitigates the intensity of the intertemporal substitution effects through which real interest rates affect consumption. For instance, in the regime in which outstanding debt levels decay mechanically at the contractual rates, the direct impact of changes in real interest rates on the consumption decisions of constrained debtors is very small, given that they do not obtain new loans.[24]

Thus, borrowing constraints and long-term debt together mitigate the short-term impact of the deflationary forces unchained by structural reforms, which typically affect demand negatively through a combination of Fisherian debt deflation and rising real interest rates.

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[23]A similar argument applies to the case of constrained households.

[24]In fact, in the debt regime in which debtors are constrained by the (binding) contractual amortization path, their consumption Euler equations only serve to determine the Lagrange multipliers on the latter constraints.
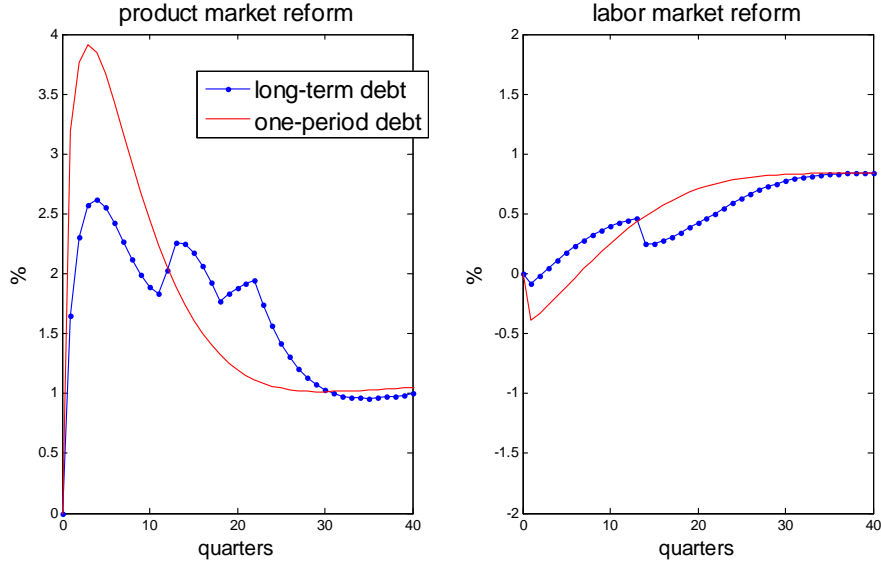
Figure 9: GDP effects of reforms: long-term vs. one-period debt

However, the presence of long term debt also attenuates one of the main channels through which structural reforms foster economic activity in the long-run. As we showed in section 5.1, the product market reform has quite a strong positive effect on real estate prices, and hence on borrowers' collateral values. However, long-term debt produces a decoupling between collateral values and debt capacity for the entire duration of the deleveraging processes ($t \leq T^*, T^{**}$). This impedes households' and entrepreneurs' spending capacity from benefiting from higher collateral values in the short run. Thus, long term debt weakens the impact of asset prices on economic activity, which is a key component of the expectations channel of structural reforms.

To see how the above effects all combine together, we compute and show in Figure 9 the GDP effects of the product market and (baseline) labor market reforms, relative to the no-reform scenario, both under long-term and one-period debt. Focusing first on the product market reform (left panel), we learn that long-term debt *dampens* the short-run GDP gain, as compared with the scenario of one period debt. Thus, the attenuation of the asset price channel just discussed clearly dominates the mitigation of the deflationary channel.

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On the contrary, long-term debt *improves* the short-run effects of the labor market reform (right panel of Figure 9). The reason is simple. The latter reform has, if anything, a small negative effect on real estate, in addition to a deflationary effect (see Figure 4). Thus, long-term debt works towards dampening both negative effects on economic activity.

Summing up, the role played by long term debt on the short run impact of reforms is important but by no means mechanical. Importantly, its presence waters down the impact of asset prices, providing a more realistic picture of the path to recovery following a credit crunch, when limited access to new loans reduces the relevance of available collateral temporarily.

7   Concluding Remarks

In this paper we assess the effects of reforms in product and labor markets in a small open economy undergoing a protracted deleveraging of the private sector, with no room for fiscal or monetary stimuli. We argue that in a context of widespread credit restrictions and pre-existing long-term debt, which are core features of the current deleveraging processes faced by the periphery countries of the Euro area, reducing desired markups in product markets mitigates the short-run output and employment losses caused by the deleveraging shock. Furthermore, by stimulating a faster recovery of investment and, hence, of collateral values, such a reform brings forward the end of the contractionary deleveraging phase. A reduction in desired wage markups, complemented by enhanced nominal wage flexibility, is found to have also the potential to moderate the output and employment losses in the short-run, although with little effects on investment and, hence, on the duration and intensity of deleveraging.

The foreign sector plays an important role in the short-run effects of reforms: the deflationary effect of the reforms lead to a terms-of-trades depreciation, with the resulting expansion in gross exports. In this regard, we find that the intensity with which improved international competitiveness carries over to actual trade flows is an important determinant of the short-run effects of structural reforms. In the case

of labour market reforms aimed at moderating wages, a low responsiveness of net exports to the ensuing gains in competitiveness may render the reform negative for GDP and employment in the short term.

Appendix

A. Equilibrium conditions

Let $\tilde{p}_t \equiv \tilde{P}_{H,t}/P_{H,t}$, $p_{H,t} \equiv P_{H,t}/P_t$, $w_t \equiv W_t/P_t$, $\tilde{w}_t \equiv \tilde{W}_t/W_t$, $\pi_{wt} \equiv W_t/W_{t-1}$. Equilibrium conditions:

- Unconstrained household budget constraint and first-order conditions (d_t, h_t^u),

$$c_t^u + d_t + p_t^h \left[h_t^u - (1 - \delta_h) h_{t-1}^u \right] = \frac{R_{t-1}}{\pi_t} d_{t-1} + w_t n_t^u, \tag{14}$$

$$\frac{1}{c_t^u} = \beta^u E_t \frac{R_t}{\pi_{t+1}} \frac{1}{c_{t+1}^u}, \tag{15}$$

$$\frac{p_t^h}{c_t^u} = \frac{\vartheta}{h_t^u} + \beta^u E_t \frac{(1 - \delta_h) p_{t+1}^h}{c_{t+1}^u}. \tag{16}$$

- Constrained household budget constraint, debt constraints, and first-order conditions (b_t, h_t),

$$c_t^c + \frac{R_{t-1}}{\pi_t} b_{t-1} + p_t^h \left[h_t - (1 - \delta_h) h_{t-1} \right] = b_t + w_t n_t^c, \tag{17}$$

$$b_t \leq \begin{cases} R_t^{-1} m_t E_t \pi_{t+1} p_{t+1}^h h_t, & \text{if } m_t R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t \geq \gamma b_{t-1}/\pi_t, \\ \gamma b_{t-1}/\pi_t, & \text{if } m_t R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t < \gamma b_{t-1}/\pi_t, \end{cases} \tag{18}$$

$$\frac{1}{c_t^c} = \beta E_t \frac{R_t}{\pi_{t+1}} \frac{1}{c_{t+1}^c} + \xi_t \mathbf{1} (\vartheta_t \geq 0) + \mu_t \mathbf{1} (\vartheta_t < 0) - \beta \gamma E_t \frac{\mu_{t+1}}{\pi_{t+1}} \mathbf{1} (\vartheta_{t+1} < 0), \tag{19}$$

$$\frac{p_t^h}{c_t^c} = \frac{\vartheta}{h_t} + \beta E_t \frac{(1 - \delta_h) p_{t+1}^h}{c_{t+1}^c} + \xi_t \mathbf{1} (\vartheta_t \geq 0) \frac{m_t}{R_t} E_t \pi_{t+1} p_{t+1}^h, \tag{20}$$

where μ_t is the Lagrange multiplier on constraint (6) in the text, $\mathbf{1}(\cdot)$ is the indicator function and $\vartheta_t \equiv R_t^{-1} m_t E_t \pi_{t+1} p_{t+1}^h h_t - \gamma b_{t-1}/\pi_t$.

- Entrepreneur budget constraint, debt constraints, and first-order conditions $(b_t^e,\ h_t^e,\ n_t^e,\ k_t)$,

$$
\begin{aligned}
c_t^e &= mc_t k_{t-1}^{\alpha_k} \left(h_{t-1}^e\right)^{\alpha_h} \left(n_t^e\right)^{1-\alpha_h-\alpha_k} - w_t n_t^e - p_t^h \left[h_t^e - (1-\delta_h) h_{t-1}^e\right] \\
&\quad + b_t^e - \frac{R_{t-1}}{\pi_t} b_{t-1}^e - q_t \left[k_t - (1-\delta_k) k_{t-1}\right] + \Pi_t + \Pi_t^h + \Pi_t^k, \quad (21)
\end{aligned}
$$

$$
b_t^e \leq \begin{cases} R_t^{-1} m_t^e E_t \pi_{t+1} p_{t+1}^h h_t^e, & \text{if } m_t^e R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t^e \geq \gamma^e b_{t-1}^e / \pi_t, \\ \gamma^e b_{t-1}^e / \pi_t, & \text{if } m_t^e R_t^{-1} E_t \pi_{t+1} p_{t+1}^h h_t^e < \gamma^e b_{t-1}^e / \pi_t, \end{cases} \quad (22)
$$

$$
\frac{1}{c_t^e} = \beta E_t \frac{R_t}{\pi_{t+1}} \frac{1}{c_{t+1}^e} + \xi_t^e \mathbf{1}\left(\vartheta_t^e \geq 0\right) + \mu_t^e \mathbf{1}\left(\vartheta_t^e < 0\right) - \beta \gamma^e E_t \frac{\mu_{t+1}^e}{\pi_{t+1}} \mathbf{1}\left(\vartheta_{t+1}^e < 0\right), \quad (23)
$$

$$
\frac{p_t^h}{c_t^e} = \beta E_t \frac{mc_{t+1} \alpha_h k_t^{\alpha_k} \left(h_t^e\right)^{\alpha_h-1} \left(n_{t+1}^e\right)^{1-\alpha_h-\alpha_k} + (1-\delta_h) p_{t+1}^h}{c_{t+1}^e} + \xi_t^e \frac{m_t^e}{R_t} E_t \pi_{t+1} p_{t+1}^h \mathbf{1}\left(\vartheta_t^e \geq 0\right),
$$
$$(24)$$

$$
w_t = mc_t \left(1 - \alpha_h - \alpha_k\right) k_{t-1}^{\alpha_k} \left(h_{t-1}^e\right)^{\alpha_h} \left(n_t^e\right)^{-\alpha_h-\alpha_k}, \quad (25)
$$

$$
\frac{q_t}{c_t^e} = \beta E_t \frac{mc_{t+1} \alpha_k k_t^{\alpha_k-1} \left(h_t^e\right)^{\alpha_h} \left(n_{t+1}^e\right)^{1-\alpha_h-\alpha_k} + (1-\delta_k) q_{t+1}}{c_{t+1}^e}, \quad (26)
$$

where μ_t^e is the Lagrange multiplier on constraint (6) in the text, and $\vartheta_t^e \equiv R_t^{-1} m_t^e E_t \pi_{t+1} p_{t+1}^h h_t^e - \gamma^e b_{t-1}^e / \pi_t$.

- Retailers' optimal price decision, and aggregate profits,

$$
E_t \sum_{s=0}^{\infty} (\beta \theta_p)^s \frac{c_t^e}{c_{t+s}^e} \left[\frac{\tilde{p}_t}{\prod_{j=1}^s \pi_{H,t+j}} p_{H,t+s} - \frac{\varepsilon^p}{\varepsilon^p - 1} mc_{t+s} \right] \left(\frac{\prod_{j=1}^s \pi_{H,t+j}}{\tilde{p}_t} \right)^{\varepsilon^p} y_{t+s} = 0,
$$
$$(27)$$

$$
\Pi_t^r = y_t \left(p_{H,t} - mc_t \Delta_t\right), \quad (28)
$$

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- Dynamics of PPI inflation and price dispersion,

$$1 = (1 - \theta) \tilde{p}_t^{1-\varepsilon^p} + \theta \pi_{H,t}^{\varepsilon^p-1}, \tag{29}$$

$$\Delta_t \equiv (1 - \theta) \tilde{p}_t^{-\varepsilon^p} + \theta \pi_{H,t}^{\varepsilon^p} \Delta_{t-1}. \tag{30}$$

- Construction firm output, first order conditions (n_t^h, i_t^h), and profits,

$$I_t^h = \left(n_t^h\right)^\omega \left\{ i_t^h \left[1 - \frac{\Phi_h}{2} \left(\frac{i_t^h}{i_{t-1}^h} - 1 \right)^2 \right] \right\}^{1-\omega}, \tag{31}$$

$$w_t = p_t^h \omega \left(n_t^h\right)^{\omega-1} \left\{ i_t^h \left[1 - \frac{\Phi_h}{2} \left(\frac{i_t^h}{i_{t-1}^h} - 1 \right)^2 \right] \right\}^{1-\omega}, \tag{32}$$

$$\begin{aligned}
1 &= p_t^h \left(n_t^h\right)^\omega (1-\omega) \left\{ i_t^h \left[1 - \frac{\Phi_h}{2} \left(di_t^h\right)^2 \right] \right\}^{-\omega} \left[1 - \frac{\Phi_h}{2} \left(di_t^h\right)^2 - \Phi_h \left(di_t^h\right) \frac{i_t^h}{i_{t-1}^h} \right] \\
&\quad + \beta \frac{\lambda_{t+1}^e}{\lambda_t^e} p_{t+1}^h \left(n_{t+1}^h\right)^\omega (1-\omega) \left\{ i_{t+1}^h \left[1 - \frac{\Phi_h}{2} \left(di_{t+1}^h\right)^2 \right] \right\}^{-\omega} \Phi_h di_{t+1}^h \left(\frac{i_{t+1}^h}{i_t^h} \right)^2 \tag{33}
\end{aligned}$$

$$\Pi_t^h = p_t^h I_t^h - w_t n_t^h - i_t^h, \tag{34}$$

for $di_t^h \equiv i_t^h / i_{t-1}^h - 1$.

- Equipment capital producers output, first order condition (i_t), and profits,

$$I_t = i_t \left[1 - \frac{\Phi_k}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right], \tag{35}$$

$$1 = q_t \left[1 - \frac{\Phi_k}{2} \left(di_t\right)^2 - \Phi_k \left(di_t\right) \frac{i_t}{i_{t-1}} \right] + E_t \frac{\lambda_{t+1}^e}{\lambda_t^e} q_{t+1} \Phi_k di_{t+1} \frac{i_{t+1}^2}{i_t^2}, \tag{36}$$

$$\Pi_t^k = q_t I_t - i_t, \tag{37}$$

for $di_t \equiv i_t / i_{t-1} - 1$.

- Optimal wage decision,

$$\sum_{x=c,u} E_t \sum_{s=0}^{\infty} (\beta^x \theta_w)^s \left[\frac{\tilde{w}_t}{\prod\limits_{j=1}^{s} \pi_{w,t+j}} \frac{w_{t+s}}{c_{t+s}^x} - \frac{\varepsilon^w \chi \left(n_{t+s}^x\right)^{\varphi}}{\varepsilon^w - 1} \left(\frac{\tilde{w}_t}{\prod\limits_{j=1}^{s} \pi_{w,t+j}} \right)^{-\varepsilon^w \varphi} \right] \left(\frac{\prod\limits_{j=1}^{s} \pi_{w,t+j}}{\tilde{w}_t} \right)^{\varepsilon^w} n_{t+s}^x = 0,$$
(38)

with $\beta^c = \beta$.

- Dynamics of wage inflation and wage dispersion,

$$1 = (1 - \theta_w) \tilde{w}_t^{1-\varepsilon^w} + \theta_w \pi_{wt}^{\varepsilon^w - 1}, \tag{39}$$

$$\Delta_t^{w,n} = (1 - \theta_w) \tilde{w}_t^{-\varepsilon^w} + \theta_w \pi_{wt}^{\varepsilon^w} \Delta_{t-1}^{w,n}. \tag{40}$$

- Aggregate employment,

$$N_t^c = n_t^c \Delta_t^{w,n}, \tag{41}$$

$$N_t^u = n_t^u \Delta_t^{w,n}, \tag{42}$$

$$N_t = N_t^c + N_t^u, \tag{43}$$

- Export demand,

$$x_t = \zeta \left(p_t^*\right)^{-\varepsilon_F} y_{F,t}. \tag{44}$$

- Intermediate good market clearing,

$$y_t \Delta_t = k_{t-1}^{\alpha_k} \left(h_{t-1}^e\right)^{\alpha_h} \left(n_t^e\right)^{1-\alpha_h-\alpha_k}, \tag{45}$$

- Labor market clearing,

$$n_t^c + n_t^u = n_t^e + n_t^h. \tag{46}$$

- Consumption goods basket market clearing,

$$y_t = c_{H,t}^c + c_{H,t}^u + c_{H,t}^e + i_{H,t} + i_{H,t}^h + x_t. \tag{47}$$

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- Real estate market clearing,

$$h_t + h_t^u + h_t^e = I_t^h + (1 - \delta_h) \left(h_{t-1} + h_{t-1}^u + h_{t-1}^e \right). \tag{48}$$

- Equipment capital market clearing,

$$k_t = (1 - \delta_k) k_{t-1} + I_t. \tag{49}$$

- Real wages,

$$w_t = w_{t-1} \frac{\pi_{wt}}{\pi_t}, \tag{50}$$

- Terms of trade,

$$p_t^* = p_{t-1}^* \frac{\pi_{H,t}}{\pi_{F,t}}. \tag{51}$$

- Relative demand for domestic goods,

$$p_{H,t} c_{H,t}^c = \omega_H c_t^c, \tag{52}$$

$$p_{H,t} c_{H,t}^u = \omega_H c_t^u, \tag{53}$$

$$p_{H,t} c_{H,t}^e = \omega_H c_t^e, \tag{54}$$

$$p_{H,t} i_{H,t} = \omega_H i_t, \tag{55}$$

$$p_{H,t} i_{H,t}^h = \omega_H i_t^h, \tag{56}$$

- Relative demand for constrained/unconstrained household labor,

$$(1 - \mu) n_t^c = \mu n_t^u, \tag{57}$$

where $\mu \equiv \mu_e = \mu_h$.

- Relative domestic producer prices,

$$p_{H,t} = p_{H,t-1} \frac{\pi_{H,t}}{\pi_t}, \tag{58}$$

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- CPI inflation,

$$\pi_t^{1-\varepsilon_H} = \frac{\omega_H \left(p_{t-1}^*\right)^{1-\varepsilon_H}}{\omega_H \left(p_{t-1}^*\right)^{1-\varepsilon_H} + 1 - \omega_H} \pi_{H,t}^{1-\varepsilon_H} + \frac{1 - \omega_H}{\omega_H \left(p_{t-1}^*\right)^{1-\varepsilon_H} + 1 - \omega_H}, \qquad (59)$$

- Real (PPI-deflated) GDP,

$$gdp_t = y_t + \frac{1}{p_{H,t}} \left(q_t I_t - i_t\right) + \frac{1}{p_{H,t}} \left(p_t^h I_t^h - i_t^h\right), \qquad (60)$$

- Gross nominal interest rate,

$$R_t = R^* \exp\left(-\psi \frac{d_t - b_t - b_t^e}{p_{H,t} gdp_t}\right). \qquad (61)$$

B. Equilibrium unemployment

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 χj^φ. Let $n_t^x(i)$ denote the number of variety-i workers in household $x = c, u$ employed at time t. Total household disutility from working is given by

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

for $x = c, u$. Given the type-specific wage $W_t(i)$, the number of type-i workers that each household *would like to* send to work is given by

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

for $x = c, u$, 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: $u_t(i) \equiv \sum_{x=c,u} l_t^x(i) - \sum_{x=c,u} n_t^x(i)$. Let

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

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

denote total household-specific labor supply and labor demand, respectively, for $x = c, u$, 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 $l_t \equiv \sum_{x=c,u} l_t^x$ and $N_t \equiv \sum_{x=c,u} N_t^x$ are aggregate labor supply and labor demand, respectively. Finally, the unemployment rate is $u_t^{rate} \equiv u_t/l_t$.

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