

# Market Reforms in the Time of Imbalance

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## Abstract

We study the consequences of product and labor market reforms in a two-country model with endogenous producer entry and labor market frictions. We focus on the role of business cycle conditions and external constraints at the time of reform implementation (or of a credible commitment to it) in shaping the dynamic effects of such policies. Product market reform is modeled as a reduction in entry costs and takes place in a non-traded sector that produces services used as input in manufacturing production. Labor market reform is modeled as a reduction in firing costs and/or unemployment benefits. We find that business cycle conditions at the time of deregulation significantly affect adjustment. A reduction of firing costs entails larger and more persistent adverse short-run effects on employment and output when implemented in a recession. By contrast, a reduction in unemployment benefits boosts employment and output by more in a recession compared to normal times. The impact of product market reforms is less sensitive to business cycle conditions. Credible announcements about future reforms induce sizable short-run dynamics, regardless of whether the announcement takes place in normal times or during an economic downturn. Whether the immediate effect is expansionary or contractionary varies across reforms. Finally, lack of access to international lending in the wake of reform can amplify the costs of adjustment.

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## 1 Introduction

Labor and product market reforms are at the heart of the structural reform agenda advocated by many economists and international institutions to lift economic performance in advanced economies, notably in Europe and Japan (e.g., IMF, 2015a,b, and OECD, 2015). Calls for easing of market regulation have predominantly focused on barriers to market entry, firing restrictions, and the generosity of unemployment benefits (OECD, 2005). The theoretical case has been laid out by an extensive literature that highlights the long-term gains from structural reforms. Thus far, however, no consensus has been established on their short-term impact, and even less is known on whether short-run effects depend on the state of the business cycle or other initial conditions, such as the stringency of external borrowing constraints, when reforms are implemented.

The fallout from the 2008-2009 global financial crisis has given fresh importance to such transitional dynamics issues. The central question is whether implementing reforms in a time of crisis—the “time of imbalance” we refer to in our title, with a slight abuse of language—and/or when external borrowing is constrained weakens or instead strengthens the short-term impact of market reform. For instance, for given long-term impact of re-designing unemployment benefits and employment protection legislation, do such reforms entail larger short-run costs when aggregate demand is low, further deepening the recession by increasing job destruction and reducing aggregate income? Or, in contrast, do they speed up the recovery by facilitating wage adjustment? Does the removal of barriers to entry in product markets trigger more or less entry by new firms in a depressed economy, and what are the consequences for transition dynamics? Are the effects of reforms stronger or weaker when countries have limited access to international financial markets—as was the case to different degrees in euro area periphery countries throughout the recent eurozone crisis? The purpose of this paper is to address these questions.

Our contribution to the literature is two-fold. First, we add to a fast-growing literature on the short-run effects of labor and product market reforms by addressing this issue in a model that captures empirical features of product and labor market regulation and reform as well as the narrative of policymakers. Second, and most important, this paper is the first to use such a theoretical framework to assess how the short-term effects of market reforms vary according to the economy’s cyclical position—and how the stringency of its external borrowing constraint further shapes these effects.

We build a two-country, two-sector model featuring endogenous producer entry and search and

matching market frictions in the labor market. Endogenous variation in the number of monopolistically competitive firms builds on Bilbiie, Gironi, and Melitz (2012) and Gironi and Melitz (2005). Labor markets are characterized by search-and-matching frictions with endogenous job creation and destruction as in Mortensen and Pissarides (1994) and den Haan, Ramey, and Watson (2000).

We calibrate the model using parameter values from the literature and to match features of macroeconomic data for the euro area. We then study the dynamic response of the economy to three distinct types of reforms: (1) product market reform, modeled as a reduction in regulatory costs of entry in the non-tradable sector; (2) easing of employment protection legislation, in the form of a decline in firing costs; and (3) a decline in the generosity of unemployment benefits. We consider two alternative scenarios, assuming that reforms are either implemented in the aftermath of a large adverse productivity shock that temporarily depresses the economy or in normal times, assuming that the economy is at the steady state. This allows us to explore how business cycle conditions affect the dynamic response to market reform. To assess the role of external borrowing constraints—an important feature of the crisis in the euro area periphery—we also consider the case in which the deregulating economy faces international financial autarky. Finally, we discuss the implications of credible commitment to future market deregulation as an interesting contrast to implementing unanticipated reforms.

In line with existing literature, we find that deregulation increases output and employment in the long run. Moreover, when reforms are implemented in normal times, their short-term effects on output and employment vary, and can be negative in some cases. Product market deregulation involves gradual and costly reallocation of resources from incumbents to new entrants; along the way, sunk entry costs need to be financed by (partly) reducing consumption and physical capital accumulation. The removal of firing restrictions triggers an immediate lay-off of less productive workers, while their re-employment takes time, also because this reform does not foster much entry of new firms. By contrast, a reduction in unemployment benefits entails no significant short-term costs because the reduction in the workers' outside option leads to wage moderation, which ultimately boosts job creation without triggering a significant increase in job destruction. Across all the various reforms we consider, the deregulating economy always experiences a current account deficit along the transition, as market reforms stimulate domestic investment.

The key new finding of our paper is that the business cycle conditions prevailing at the time of deregulation significantly affect the adjustment to market reform. A reduction of firing costs

entails larger and more persistent adverse short-run effects on employment and output when implemented in a recession. The reason is that, for a given level of aggregate productivity, positive firing costs imply that relatively unprofitable jobs survive job destruction. When aggregate productivity is below trend, the share of unprofitable matches is greater compared to the steady state. As a consequence, the removal of firing costs leads to much larger job destruction, which further depresses aggregate demand and output. By contrast, a reduction in the generosity of unemployment benefits boosts employment and output by more in a recession compared to normal times. The additional positive effect is due to the fact that, at times of high unemployment, a larger pool of workers is searching for jobs. As a result, the probability of filling a vacancy is higher, and thus the expected cost of job creation is lower in a recession. Furthermore, since real wages are already low relative to the steady state, the same reduction in unemployment benefits generates more job creation by firms. Importantly, these positive effects on job creation prevail even when we allow the unemployment benefits reform to reduce aggregate income and demand directly.<sup>1</sup> Finally, the impact of product market reforms is less sensitive to business cycle conditions. The reason is that a recession has offsetting effects on the present discounted value of product creation. On one side, lower aggregate demand reduces the expected stream of profits. On the other side, when productivity is below trend, a reduction in the number of producers causes markups to be higher, which encourages product creation. These two opposite effects largely cancel out, unless the recession is very persistent. If so, the reduction in aggregate demand prevails, and product market deregulation becomes more costly relative to the steady state in the short term.

Credible announcements about future deregulation induce sizable short-run dynamics, regardless of whether the announcement takes place in normal times or during an economic downturn. Whether the immediate effect of committing to future deregulation is expansionary or contractionary varies across reforms. For instance, the announcement of future product market deregulation has contractionary effects in the short run, while the opposite is true for an unemployment benefits reform. The effects of reform announcements in general do not significantly depend on the state of the business cycle. However, credible commitment about lowering firing costs can significantly reduce the adverse short-run effects of this reform during a recession. Intuitively, since the announcement stimulates job creation without triggering immediate job destruction, a smaller

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<sup>1</sup> As discussed below, unemployment benefits can be either modeled as a transfer from the government financed by lump sum taxes or as an exogenous income endowment distributed to unemployed workers. In the former case, unemployment benefits do not directly affect aggregate demand in our representative household setup because benefits and lump sum taxes offset each other in the household's budget constraint.

number of workers are displaced when the reform is actually implemented.

Finally, the existence of binding borrowing constraints in the wake of deregulation can amplify the costs of adjustment to market reform. This is the case for product market deregulation: With a closed current account, domestic households must reduce consumption and investment in physical capital by more to finance product creation, leading to lower aggregate demand in the short run.

In the above discussion, we focused on the comparison between the adjustment to market reform in normal and recession times. Our analysis also offers an assessment of the effectiveness of market deregulation as a tool to boost economic performance in response to recession. From this perspective, our findings suggest that a reduction in firing costs that is not accompanied by a reduction in barriers to producer entry and unemployment benefits can significantly deepen recessions and delay the recovery. To a lesser extent, the same is true of a reduction in barriers to producer entry.

Our paper contributes to the large and varied literature on market regulation and reform. A large strand of this literature focuses mostly on the long-run consequences of market reforms, without addressing the transition dynamics from short- to long-run effects of product and labor market reforms. In this literature, our study is most closely related to the seminal paper by Blanchard and Giavazzi (2003), who study the effects of market deregulation in a two-period model with entry costs and Nash wage bargaining.<sup>2</sup>

A more recent literature studies the fully dynamic adjustment to market reform. The closest antecedent is Caciattore and Fiori (2016), who study, both theoretically and empirically, the short-run effects of the types of reforms discussed in this paper. We extend their theoretical framework to a two-country, two-sector model, and focus on the consequences of business cycle conditions for the effects of market deregulation.<sup>3</sup> Caciattore, Duval, Fiori, and Ghironi (2016a) and Caciattore, Fiori, and Ghironi (2016) study the role of monetary policy for the short-run adjustment to market deregulation in normal times. A significant difference between this paper and our earlier work is that we focus on producer entry dynamics and market deregulation in a non-traded sector that produces services used as inputs in manufacturing. This allows us to capture a key aspect of the policy debate on market reforms, much of which revolves around the deregulation of access to non-traded services and professions, and to study whether product market reform in upstream service

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<sup>2</sup>See Caciattore and Fiori (2016) for a more complete list of references.

<sup>3</sup>Caciattore and Fiori (2016) study how market deregulation affects business cycle fluctuations in the long-run, post-reform environment, i.e., once the economy has already reached the new steady state with respect to market regulation. By contrast, in this paper, we focus on the short-run relationship between business cycle fluctuations and market reforms.

sectors can be beneficial for external competitiveness by reducing traded sector costs.<sup>4</sup>

Some recent contributions address the consequence of product and labor market reforms when the zero lower bound on the nominal interest rate is binding. In such a situation, depending on whether they are inflationary or deflationary, reforms can affect the real interest rate and thereby either mitigate or exacerbate the recession. For instance, in a benchmark New Keynesian model with price and wage rigidities, Eggertsson, Ferrero, and Raffo (2014) argue that market reforms are contractionary when monetary policy cannot offset the deflationary effects of falling price and wages. Importantly, Eggertsson, Ferrero, and Raffo treat reforms as exogenous cuts in price and wage markups in a model that abstracts from deeper product and labor market dynamics. In their basic New Keynesian framework, reforms are automatically deflationary. Building on this, Gerali, Notarpietro, and Pisani (2015) and Vogel (2014) show that investment dynamics affect the response of inflation to exogenous markup reductions. Andres, Arce and Thomas (2014) model reforms similarly as exogenous markup cuts and study their consequences in an environment of debt deleveraging. They find that product market reforms have a positive effect on output and employment even when they are deflationary. Explicit modeling of product and labor market dynamics and regulation differentiates our exercise from these recent studies.

We show that modeling primitive features of market regulation and the underlying frictions in the creation of products and jobs are crucial elements to further our understanding of the consequences of market reform at times of imbalance—consider again, for instance, the opposite effects of reforming firing costs and unemployment benefits. Moreover, we find significant differences between implementing market deregulation in normal and crisis times, even in the absence of nominal rigidities and zero-lower-bound considerations.<sup>5</sup> Our analysis shows that micro-level product and labor market dynamics and frictions introduce key elements not captured by “reduced-form” models of structural reforms.<sup>6</sup>

Our analysis of the impact of changes in unemployment benefit provisions in a recession versus normal times bears some connection to the recent, unsettled literature on optimal unemployment insurance over the business cycle. In our model, a change in unemployment benefits affects the workers’ outside option, and thereby wages, with consequences for job creation. By contrast, a

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<sup>4</sup>In Cacciatore, Duval, Fiori, and Ghironi (2016a) and Cacciatore, Fiori, and Ghironi (2016), product market deregulation takes place in tradable production and causes terms of trade appreciation rather than depreciation as increased entry puts upward pressure on costs.

<sup>5</sup>For analysis of market reforms at the zero lower bound, see Cacciatore, Duval, Fiori, and Ghironi (2016b).

<sup>6</sup>A number of large-scale DSGE models have been used to explore the dynamic impact of reforms in normal times. See Varga and in ’t Veld (2011), Everaert and Schule (2008), and Gomes (2014). Market reforms are modeled in reduced-form fashion also in these studies, focusing on exogenous reductions in price and wage markups.

number of recent papers on optimal unemployment insurance over the cycle either ignore firm hiring behavior altogether (Kroft and Notowidigdo, 2011) or incorporate it but ultimately consider its relevance limited because recessions are periods when the number of available jobs tends to be rationed (Landais, Michaillat, and Saez, 2010), or periods when hiring is less responsive to benefit policy changes more broadly (Jung and Kuester, 2015). Our contribution to this literature is to highlight the relevance of the firm hiring channel, highlighted also by Mitman and Rabinovich (2015). In so doing we stress, more broadly, the beneficial effects of labor market policies promoting wage flexibility (through reductions in the generosity of wage replacement) as opposed to employment flexibility during downturns. This result is consistent with the empirical evidence in Gnocchi, Lagerborg, and Pappa (2015) and echoes the discussion in Boeri and Jimeno (2015). However, our assumptions of full insurance within the representative household and constant job search effort imply that we do not incorporate the traditional insurance versus moral hazard tradeoff that is central in the optimal unemployment insurance literature.<sup>7</sup>

Finally, our results about the positive effects of relaxing unemployment benefits on job creation during a recession are consistent with the empirical evidence in Hagedorn, Karahan, Manovskii, and Mitman (2013), who show that benefit extensions during the Great Recession raised equilibrium wages and led to a sharp contraction in vacancy creation and employment, and a rise in unemployment in the U.S. economy. Hagedorn, Manovskii, and Mitman (2015) find positive effects on job creation of the 2014 benefit cut.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 describes the calibration and discusses the performance of the model in relation to the data. Section 4 studies the adjustment to unanticipated market deregulation in normal times. Section 5 focuses on unanticipated market reforms during recessions. Section 6 discusses the consequences of credible commitment to future market reform. Section 7 focuses on constraints on external borrowing and conducts additional experiments. Section 8 concludes.

## 2 The Model

We model a world economy that consists of two countries, Home and Foreign. Foreign variables are denoted with a superscript star. We use the subscript  $D$  to denote quantities and prices of a country's own goods consumed domestically, and the subscript  $X$  to denote quantities and prices

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<sup>7</sup>We leave this extension of our framework for future work. Promising directions in this vein include Atkeson and Kehoe (1996), Krusell, Mukoyama, and Sahin (2010), and Nakajima (2012).

of exports. We focus on the Home economy in presenting our model, with the understanding that analogous equations hold for Foreign. We abstract from monetary frictions that would motivate a demand for currency in each country, and we resort to a cashless economy following Woodford (2003). Money serves the purpose of a convenient unit of account in the presence of endogenous product variety. All prices and wages are flexible, so we will focus only on real variables in the solution of the model.

## Household Preferences

Each economy is populated by a unit mass of atomistic, identical households. Each household is thought of as a large extended family containing a continuum of members along a unit interval. The household does not choose how many family members work; the measure of family members who work is determined by a labor matching process. Unemployed workers receive a fixed amount  $h_p > 0$  of household production units. Following Andolfatto (1996), Merz (1995), and much of the subsequent literature, we assume full consumption insurance between employed and unemployed individuals, so that there is no ex-post heterogeneity across individuals in the household. We assume habit persistence in consumption utility as this improves the quantitative performance of the model by slowing down the response of consumption to shocks.

The representative household maximizes expected intertemporal utility,

$$E_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} \frac{(C_s^H - h_C C_{s-1}^H)^{1-\gamma}}{1-\gamma} \right],$$

where the discount factor  $\beta$  and habit parameter  $h_C$  both lie between 0 and 1, and  $\gamma > 0$ . Household consumption  $C_t^H$  is defined as

$$C_t^H \equiv C_t + h_p(1 - L_t),$$

where  $C_t$  is consumption of market goods, and  $L_t$  denotes the number of employed workers.

Market consumption is a composite of tradable and non-tradable baskets,  $C_t^T$  and  $C_t^{NT}$ :

$$C_t = \left[ (1 - \alpha_N)^{\frac{1}{\phi_N}} (C_t^T)^{\frac{\phi_N-1}{\phi_N}} + \alpha_N^{\frac{1}{\phi_N}} (C_t^{NT})^{\frac{\phi_N-1}{\phi_N}} \right]^{\frac{\phi_N}{\phi_N-1}}, \quad 0 < \alpha_N < 1,$$

where  $\alpha_N \in (0, 1]$  is the share of non-tradables in total market consumption, and  $\phi_N$  denotes the

constant elasticity of substitution. The consumption-based price index is

$$P_t = \left[ (1 - \alpha_N) (P_t^T)^{1-\phi_N} + \alpha_N (P_t^N)^{1-\phi_N} \right]^{\frac{1}{1-\phi_N}},$$

where  $P_t^T$  is the price of the tradable basket, and  $P_t^N$  is the price of the non-tradable basket. The domestic demand for tradables is  $C_t^T = (1 - \alpha_N) (P_t^T/P_t)^{-\phi_N} C_t$ ; the domestic demand for non-tradables is  $C_t^N = \alpha_N (P_t^N/P_t)^{-\phi_N} C_t$ .

The tradable consumption basket  $C_t^T$  aggregates homogenous Home and Foreign consumption goods in Armington form with elasticity of substitution  $\phi_T > 0$ :

$$C_t^T = \left[ (1 - \alpha_X)^{\frac{1}{\phi_T}} (C_{D,t}^T)^{\frac{\phi_T-1}{\phi_T}} + \alpha_X^{\frac{1}{\phi_T}} (C_{X,t}^{T*})^{\frac{\phi_T-1}{\phi_T}} \right]^{\frac{\phi_T}{\phi_T-1}}, \quad 0 < \alpha_X < 1.$$

A similar basket describes consumption in the Foreign country. Importantly, in each country's tradable consumption basket,  $1 - \alpha_X$  is the weight attached to the country's own good. Therefore, preferences are biased in favor of domestic goods whenever  $\alpha_X < 1/2$ . The tradable consumption-based price index that corresponds to the basket  $C_t^T$  is given by

$$P_t^T = \left[ (1 - \alpha_X) (P_{D,t}^T)^{1-\phi_T} + \alpha_X (P_{X,t}^{T*})^{1-\phi_T} \right]^{\frac{1}{1-\phi_T}}.$$

The demand for Home tradable consumption is  $C_{D,t}^T = (1 - \alpha_X) (P_{D,t}^T/P_t^T)^{-\phi_T} C_t^T$ , while the demand for Foreign tradable consumption is  $C_{X,t}^T = \alpha_X (P_{X,t}^{T*}/P_t^T)^{-\phi_T} C_t^T$ .

At any given point in time, only a subset of non-tradable goods  $\Omega_t \in \Omega$  is available. We assume that the aggregator  $C_t^N$  takes a translog form following Feenstra (2003). As a result, the elasticity of substitution across varieties within the basket  $C_t^N$  is an increasing function of the number of goods available. The translog assumption allows us to capture the pro-competitive effect of deregulating in the goods market on markups, documented by the empirical literature—see Griffith, Harrison, and Macartney (2007). Translog preferences are characterized by defining the unit expenditure function (i.e., the price index) associated with the preference aggregator. Let  $p_{\omega,t}^N$  be the nominal price for the good  $\omega \in \Omega_t$ . The unit expenditure function on the basket of goods  $C_t^N$  is given by:

$$\ln P_t^N = \frac{1}{2\sigma} \left( \frac{1}{N_t} - \frac{1}{\tilde{N}} \right) + \frac{1}{N_t} \int_{\omega \in \Omega_t} \ln p_t^N(\omega) d\omega + \frac{\sigma}{2N_t} \int_{\omega \in \Omega_t} \int_{\omega' \in \Omega_t} \ln p_t^N(\omega) (\ln p_t^N(\omega) - \ln p_t^N(\omega')) d\omega d\omega', \quad (1)$$

where  $\sigma > 0$  denotes the price-elasticity of the spending share on an individual good,  $N_t$  is the

total number of products available at time  $t$ , and  $\tilde{N}$  is the mass of  $\Omega$ .

## Production

In each country, there are two vertically integrated production stages. At the upstream level, perfectly competitive firms use capital and labor to produce a non-tradable intermediate input. At the downstream level, there are two sectors producing final consumption goods. In one sector, monopolistically competitive firms purchase intermediate inputs and produce differentiated non-tradable varieties. In the second sector, perfectly competitive firms combine intermediate inputs and non-tradable goods to produce a consumption good that is sold to consumers in both countries. This production structure is consistent with the evidence provided by Boeri, Castanheira, Faini, and Galasso (2006), who document how service industries are a key supplier of the manufacturing sector.

### *Intermediate Goods Production*

There is a unit mass of perfectly competitive intermediate producers. Production requires capital and labor. Within each firm there is a continuum of jobs; each job is executed by one worker. Following Gertler and Trigari (2009) and den Haan, Ramey, and Watson (2000), we assume that capital is perfectly mobile across firms and jobs and that there is a competitive rental market in capital. While firms are “large” as they employ a continuum of workers, firms are still of measure zero relative to the aggregate size of the economy.

A filled job  $i$  produces  $Z_t z_t^i (k_t^i)^a$  units of output, where  $Z_t$  denotes aggregate productivity,  $z_t^i$  represents a random disturbance that is specific to match  $i$ , and  $k_t^i$  is the stock of capital allocated to the job. Within each firm, jobs with identical productivity  $z_t^i$  produce the same amount of output. For this reason, in the remainder of the paper we suppress the job index  $i$  and identify a job with its idiosyncratic productivity  $z_t$ . As common practice in the literature, we assume that  $z_t$  is a per-period *i.i.d.* draw from a time-invariant distribution with c.d.f.  $G(z)$ , positive support, and density  $g(z)$ . When solving the model, we assume that  $G(z)$  is lognormal with log-scale  $\mu_{z_i}$  and shape  $\sigma_{z_i}$ . Aggregate productivity  $Z_t$  is exogenous and common to all firms. We assume that  $Z_t$  and  $Z_t^*$  follow a bivariate  $AR(1)$  process in logs, with Home (Foreign) productivity subject to innovations  $\epsilon_{Zt}$  ( $\epsilon_{Zt}^*$ ). The diagonal elements of the autoregressive matrix  $\Phi$ ,  $\Phi_{11}$  and  $\Phi_{22}$ , measure the persistence of exogenous productivity and are strictly between 0 and 1, and the off-diagonal elements  $\Phi_{12}$  and  $\Phi_{21}$  measure productivity spillovers. The productivity innovations  $\epsilon_{Zt}$  and  $\epsilon_{Zt}^*$

are normally distributed with zero mean and variance-covariance matrix  $\Sigma_{\epsilon_Z, \epsilon_Z^*}$ .

The representative intermediate firm produces output

$$Y_t^I = Z_t L_t \frac{1}{1 - G(z_t^c)} \int_{z_t^c}^{\infty} z k_t^\alpha(z) g(z) dz, \quad (2)$$

where  $L_t$  is the measure of jobs within the firm,  $k_t(z)$  is the amount of capital allocated to a job with idiosyncratic productivity  $z$ , and the term  $z_t^c$  represents an endogenously determined critical threshold below which jobs that draw  $z_t < z_t^c$  are not profitable. In this case, the value to the firm of continuing the match is less than the value of separation, and the job is destroyed. When terminating a job, each firm incurs a real cost  $F_t$ . Firing costs are not a transfer to workers here and are treated as a pure loss (administrative costs of layoff procedures). Severance transfers from firms to workers would have no allocative effects with wage bargaining as assumed below (see Mortensen and Pissarides, 2002). Finally, the relationship between a firm and a worker can also be severed for exogenous reasons; in which case, however, no firing costs are paid. Denote with  $\lambda$  the fraction of jobs that are exogenously separated from each firm in each period.

Job creation is subject to matching frictions. To hire a new worker, firms have to post a vacancy, incurring a real fixed cost  $\kappa$ . The probability of finding a worker depends on a constant returns to scale matching technology, which converts aggregate unemployed workers  $U_t$  and aggregate vacancies  $V_t$  into aggregate matches  $M_t = \chi U_t^\varepsilon V_t^{1-\varepsilon}$ , where  $0 < \varepsilon < 1$ . Each firm meets unemployed workers at a rate  $q_t \equiv M_t/V_t$ . Searching workers in period  $t$  are equal to the mass of unemployed workers:  $U_t = (1 - L_t)$ .

The timing of events is as follows. At the beginning of each period, a fraction  $\lambda$  of jobs are exogenously separated. Aggregate and idiosyncratic shocks are then realized, after which the representative firm chooses the productivity threshold  $z_t^c$  that determines the measure of jobs endogenously destroyed,  $G(z_t^c)$ . Once the firing round has taken place, firms post vacancies,  $V_t$ , and select their total capital stock,  $K_t = L_t \tilde{k}_t$ , where  $\tilde{k}_t \equiv \int_{z_t^c}^{\infty} k_t(z) g(z) dz / [1 - G(z_t^c)]$ .<sup>8</sup> The assumption that firms select capital after observing aggregate and idiosyncratic shocks follows den Haan, Ramey, and Watson (2000).

The inflow of new workers and the outflow of workers due to separations jointly determine the

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<sup>8</sup>With full capital mobility and price-taker firms in the capital market, it is irrelevant whether producers choose the total stock of capital  $K_t$ , or, instead, determine the optimal capital stock for each existing job,  $k_t(z)$ . See Cacciatore and Fiori (2016) for the proof.

evolution of firm-level employment:

$$L_t = (1 - \lambda) (1 - G(z_t^c)) (L_{t-1} + q_{t-1} V_{t-1}). \quad (3)$$

All separated workers are assumed to immediately reenter the unemployment pool.

As shown in Cacciatore and Fiori (2016), owing to perfectly mobile capital rented in a competitive market, producer's output exhibits constant returns to scale in labor and capital:

$$Y_t^I = Z_t \tilde{z}_t K_t^\alpha L_t^{1-\alpha},$$

where

$$\tilde{z}_t \equiv \left[ \frac{1}{1 - G(z_t^c)} \int_{z_t^c}^{\infty} z^{1/(1-\alpha)} g(z) dz \right]^{1-\alpha}$$

is a weighted average of the idiosyncratic productivity of individual jobs. Intermediate goods producers sell their output to final producers at a real price  $\varphi_t$  in units of consumption. Per-period real profits are given by

$$d_t^I = \varphi_t Z_t \tilde{z}_t K_t^\alpha L_t^{1-\alpha} - \tilde{w}_t L_t - r_t^K K_t - \kappa V_t - G(z_t^c) (1 - \lambda) (L_{t-1} + q_{t-1} V_{t-1}) F_t,$$

where  $r_t^K$  is the rental rate of capital and  $\tilde{w}_t \equiv \int_{z_t^c}^{\infty} w_t(z) g(z) dz / [1 - G(z_t^c)]$  is the average wage paid by the firm, weighted according to the distribution of the idiosyncratic job productivities. Given the constraint in (3), the representative intermediate input producer chooses employment  $L_t$ , capital  $K_t$ , the number of vacancies to be posted  $V_t$ , and the job destruction threshold  $z_t^c$  to maximize the present discounted value of real profits:  $E_t (\sum_{s=t}^{\infty} \beta_{s,t} d_s^I)$ , where  $\beta_{s,t} \equiv \beta^{s-t} u_{CH,s} / u_{CH,t}$  denotes the stochastic discount factor of Home households, who are assumed to own intermediate input firms. The term  $u_{CH,t}$  denotes the marginal utility of consumption:

$$u_{CH,t} \equiv (C_t^H - h_C C_{t-1}^H)^{-\gamma} - h_C \beta E_t \left[ (C_{t+1}^H - h_C C_t^H)^{-\gamma} \right].$$

By combining the first-order conditions for  $L_t$  and  $V_t$ , we obtain the following job creation equation:

$$\frac{\kappa}{q_t} = (1 - \lambda) E_t \left\{ \beta_{t,t+1} \left[ (1 - G(z_{t+1}^c)) \left( (1 - \alpha) \varphi_{t+1} \frac{Y_{t+1}^I}{L_{t+1}} - \tilde{w}_{t+1} + \frac{\kappa}{q_{t+1}} \right) - G(z_{t+1}^c) F_{t+1} \right] \right\}. \quad (4)$$

Equation (4) equalizes the marginal cost and the marginal benefit of posting a vacancy. With

probability  $q_t$  the vacancy is filled; in which case, two events are possible: Either the new recruit will be fired in period  $t + 1$ , and the firm will pay firing costs, or the match will survive job destruction, generating value for the firm. The marginal benefit of a filled vacancy includes expected discounted savings on future vacancy posting, plus the average profits generated by a match. Profits from the match take into account the marginal revenue product from the match and its wage cost. Forward looking iteration of equation (4) implies that, at the optimum, the expected discounted value of the stream of profits generated by a match over its expected lifetime is equal to  $\kappa/q_t$ .

The first-order condition for the job-productivity threshold  $z_t^c$  implies the following job destruction equation:

$$(1 - \alpha) \varphi_t \frac{Y_t^I}{L_t} \left( \frac{z_t^c}{\tilde{z}_t} \right)^{\frac{1}{1-\alpha}} - w(z_t^c) + \frac{\kappa}{q_t} = -F_t. \quad (5)$$

At the optimum, the value to the firm of a job with productivity  $z_t^c$  must be equal to zero, implying that the contribution of the match to current and expected future profits is exactly equal to the firm outside option—firing the worker, paying  $F_t$ . When unprofitable jobs are terminated, the firm loses current and expected profits it would have earned had it kept the laid-off workers. At the same time, however, the firm benefits from job destruction, as unproductive jobs are removed and the distribution of job productivities within the firm is improved.<sup>9</sup>

The optimal capital demand implied by the first-order condition for  $K_t$  equates the marginal revenue product of capital to its marginal cost:  $\alpha \varphi_t Y_t^I / K_t = r_t^K$ .

### *Wage Setting*

As is standard practice in the literature, we assume surplus splitting between an individual worker and the firm. The surplus-splitting rule divides the surplus of each match in shares determined by an exogenous bargaining weight  $\eta \in (0, 1)$ , which identifies the workers' bargaining power.<sup>10</sup> The analytical derivation of the wage equation is presented in an Online Appendix—henceforth referred to simply as the Appendix—along with other technical details and additional material.<sup>11</sup> We show there that the wage payment to each worker is a weighted average between the marginal revenue

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<sup>9</sup> Equation (5) implies that the firm keeps some currently unprofitable jobs occupied. This happens because current job productivity can improve in the future, and the firm has to incur firing and recruitment costs in order to replace a worker.

<sup>10</sup> Following standard practice in the literature, we formulate the problem as though the worker is interested in maximizing expected discounted income. As pointed out by Rogerson, Shimer, and Wright (2005), this is the same as maximizing expected utility if the worker is risk neutral, of course, but also if (s)he is risk averse and markets are complete, since then (s)he can maximize utility by first maximizing income and then smoothing consumption.

<sup>11</sup> The Appendix is available at <http://faculty.washington.edu/ghiro/CacciatoreDuvalFioriGhiroJEDC16Appx.pdf>.

product of the match (plus a firing costs component) and the worker's outside option, denoted with  $\varpi_t$ :

$$w_t(z) = \eta \left[ (1 - \alpha) \varphi_t \frac{Y_t^I}{L_t} \left( \frac{z}{\tilde{z}_t} \right)^{1/(1-\alpha)} + F_t - (1 - \lambda) E_t (\beta_{t,t+1} F_{t+1}) \right] + (1 - \eta) \varpi_t. \quad (6)$$

The worker's outside option  $\varpi_t$  corresponds to the value of unemployment, which includes home production,  $h_p$ , unemployment benefit from the government,  $b_t$ , and the expected discounted value of searching for other jobs:

$$\varpi_t \equiv h_p + b_t + \iota_t (1 - \lambda) E_t \left\{ \beta_{t,t+1} [1 - G(z_{t+1}^c)] \tilde{\Delta}_{t+1}^W \right\}, \quad (7)$$

where  $\iota_t \equiv M_t/U_t$  is the job-finding probability. Unemployment benefits, in units of final consumption, are a transfer from the government financed with lump-sum taxes.<sup>12</sup> The term  $\tilde{\Delta}_{t+1}^W$  denotes the average worker surplus:

$$\tilde{\Delta}_t^W = \tilde{w}_t - \varpi_t + (1 - \lambda) E_t \left\{ \beta_{t,t+1} [1 - G(z_{t+1}^c)] \tilde{\Delta}_{t+1}^W \right\}.$$

Finally, notice that firing costs affect the wage payment in the following way: The firm rewards the worker for the saving in firing costs today (the  $F_t$  term in the square bracket in equation (6)), but it penalizes the worker for the fact that, in the case of firing, it will have to pay firing costs tomorrow.

In equilibrium, the worker's outside option is

$$\varpi_t \equiv h_p + b_t + \left( \frac{\eta}{1 - \eta} \right) [\kappa \vartheta_t + (1 - \lambda) \iota_t E_t (\beta_{t,t+1} F_{t+1})],$$

which implies:

$$w_t(z) = \eta \left[ (1 - \alpha) \varphi_t \frac{Y_t^I}{L_t} \left( \frac{z}{\tilde{z}_t} \right)^{1/(1-\alpha)} + \kappa \vartheta_t + F_t - (1 - \lambda) (1 - \iota_t) E_t \beta_{t,t+1} F_{t+1} \right] + (1 - \eta) (h_p + b_t),$$

where  $\vartheta_t \equiv V_t/U_t$  denotes labor market tightness.

## Non-Tradable Sector

There is a continuum of monopolistically competitive firms, each producing a different non-traded variety  $\omega$ . Following the language convention of most of the macroeconomic literature, we assume

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<sup>12</sup>The distinction between home production and unemployment benefits follows Mortensen and Pissarides (2002).

coincidence between a producer, a product, and a firm. However, as in Bilbiie, Ghironi, and Melitz (2012), each unit in the model is best interpreted as a production line that could be part of a multi-product firm whose boundary is left undetermined. In this interpretation, producer entry and exit capture the product-switching dynamics within firms documented by Bernard, Redding, and Schott (2010).

The number of firms serving the market is endogenous. Prior to entry, firms face a sunk entry cost  $f_{E,t}$ , in units of consumption.<sup>13</sup> Sunk entry costs reflect both a technological constraint ( $f_{T,t}$ ) and administrative costs related to regulation ( $f_{R,t}$ ), i.e.,  $f_{E,t} \equiv f_{T,t} + f_{R,t}$ . In every period  $t$ , there is an unbounded mass of prospective entrants in the final goods sector in each country. All firms that enter the economy produce in every period until they are hit by a “death” shock, which occurs with probability  $\delta \in (0, 1)$  in every period. As noted by Bilbiie, Ghironi, and Melitz (2012), the assumption of exogenous exit is a reasonable starting point for analysis, since, in the data, product destruction and plant exit rates are much less cyclical than product creation and plant entry (see Lee and Mukoyama, 2008 and Broda and Weinstein, 2010).

Denote with  $Y_t^N$  aggregate demand of the consumption basket of non-tradable goods. Aggregate demand includes sources other than household consumption but takes the same translog form as the consumption bundle  $C_t^N$ . This ensures that the non-tradable consumption price index is also the price index for aggregate demand of the non-tradable basket. The producer  $\omega$  faces the following demand for its output:

$$y_t^N(\omega) = \sigma \ln \left( \frac{\bar{p}_t^N}{p_t^N(\omega)} \right) \frac{P_t^N Y_t^N}{p_t^N(\omega)}, \quad (8)$$

where  $\ln \bar{p}_t^N \equiv (1/\sigma N_t) + (1/N_t) \int_{\omega \in \Omega_t} \ln p_t^N(\omega) d\omega$  is the maximum price that a domestic producer can charge while still having a positive market share. To gain some intuition about the firm demand structure, notice that firm revenue,  $p_t^N(\omega) y_t^N(\omega)$ , is a time-varying fraction of the aggregate demand  $P_t^N Y_t^N$ . The firm’s time-varying market share,  $\sigma \ln (\bar{p}_t^N / p_t^N(\omega))$ , depends on the price chosen by the firm relative to the maximum admissible price.

Total real profits are given by

$$d_t^N(\omega) = \left( \frac{p_t^N(\omega)}{P_t} - \varphi_t \right) y_t^N(\omega).$$

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<sup>13</sup>Bilbiie, Ghironi, and Melitz (2012) and Ghironi and Melitz (2005) assume that the same input is used to produce existing varieties and create new ones. In the Appendix, we consider an alternative version of the model in which entry costs are denominated in units of the intermediate input. None of our results is significantly affected by the denomination of sunk entry costs.

All profits are returned to households as dividends. Firms maximize the expected present discounted value of the stream of current and future real profits:  $E_t \left[ \sum_{s=t}^{\infty} \beta_{t,s} (1-\delta)^{s-t} d_s^N(\omega) \right]$ . Future profits are discounted with the Home household's stochastic discount factor, as Home households are assumed to own Home final goods firms. As discussed below, there is a probability  $\delta \in (0, 1)$  that each final good producer is hit by an exogenous, exit-inducing shock at the end of each period. Therefore, discounting is adjusted for the probability of firm survival.

Optimal price setting implies that the real output price is equal to a markup  $\mu_t(\omega)$  over marginal cost  $\varphi_t$ :

$$\frac{p_t^N(\omega)}{P_t} = \mu_t^N(\omega) \varphi_t.$$

The endogenous, time-varying markup  $\mu_t^N(\omega)$  is given by  $\mu_t^N(\omega) \equiv \theta_t^N(\omega) / [\theta_t^N(\omega) - 1]$ , where  $\theta_t^N(\omega) \equiv -\partial \ln y_t^N(\omega) / \partial \ln (p_t^N(\omega) / P_t)$  denotes the price elasticity of total demand for variety  $\omega$ . Translog preferences imply that substitutability across varieties increases with the number of available varieties. As a consequence, the price elasticity of total demand facing producer  $\omega$  increases when the number of Home producers is larger.

**Producer Entry and Exit** Prospective entrants are forward-looking and form rational expectations of their future profits  $d_s$  in any period  $s > t$  subject to the exogenous probability  $\delta$  of incurring an exit-inducing shock at the end of each period. Following BGM and Ghironi and Melitz (2005), we introduce a time-to-build lag in the model and assume that entrants at time  $t$  will start producing only at  $t+1$ . Our assumptions on exit shocks and the timing of entry and production imply that the law of motion for the number of producing Home firms is given by  $N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$ .

Prospective entrants compute their expected post-entry value  $e_t^N$ , given by the expected present discounted value of the stream of per-period profits:  $e_t^N(\omega) = E_t \left[ \sum_{s=t+1}^{\infty} \beta_{t,s} (1-\delta)^{s-t} d_s^N(\omega) \right]$ . Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition  $e_t^N(\omega) = f_{E,t}$ , which in turn implies symmetry across incumbents, i.e.,  $e_t^N(\omega) = e_t^N$  for any  $\omega$ .

Equality of prices across firms implies  $p_t^N(\omega) = p_t^N$ . Denote the real price of each variety, in units of consumption, with  $\rho_{\omega,t}^N \equiv p_t^N / P_t$ , where we maintain the subscript  $\omega$  to avoid confusion with the real price of the non-tradable consumption basket,  $\rho_t^N \equiv P_t^N / P_t$ . Household's preferences imply that the non-tradable price index  $P_t^N$  and the firm-level price  $p_t^N$  are such that

$$\frac{p_t^N}{P_t^N} \equiv \frac{\rho_{\omega,t}^N}{\rho_t^N} = \exp \left\{ -\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t} \right\},$$

where  $\exp(X)$  denotes the exponential of  $X$  to avoid confusion with the notation for firm value. Producer output is  $y_t^N = (\rho_t^N / \rho_{\omega,t}^N) (Y_t^N / N_t)$ , while the elasticity of substitution across non-tradable varieties is  $\theta_t^N = 1 + \sigma N_t$ .

### Tradable Sector

In each country, a unit mass of perfectly competitive, symmetric firms produce a tradable consumption good,  $Y_t^T$ . Production requires both intermediate inputs and non-tradable goods. When serving the export market, producers face per-unit iceberg trade costs,  $\tau_t > 1$ . Thus, in equilibrium,  $Y_t^T = C_{D,t}^T + \tau_t C_{X,t}^T$ , where  $C_{D,t}^T$  and  $C_{X,t}^T$  denote, respectively, the domestic and foreign demand for the Home tradable good, introduced before. The production function is

$$Y_t^T = (Y_{T,t}^I)^\xi (Y_{T,t}^N)^{1-\xi},$$

where  $Y_{T,t}^I$  and  $Y_{T,t}^N$  denote, respectively, the amount of intermediate inputs and non-tradable goods used in the production of the tradable good.

Under perfect competition, Home and Foreign producers take the price of output as given, both in the domestic and export markets. No arbitrage implies that the price of export (in units of Foreign currency) is  $P_{X,t}^T = \tau_t P_{D,t}^T / S_t$ , where  $S_t$  denotes the nominal exchange rate. Let  $d_t^T$  denote per-period profits, defined by  $d_t^T = (P_{D,t}^T / P_t) C_{D,t}^T + (S_t P_{X,t}^T / P_t) C_{X,t}^T - \varphi_t Y_{T,t}^I - (P_t^N / P_t) Y_{T,t}^N$ . Notice that, using the above results,  $d_t^T$  can be expressed as

$$d_t^T = \rho_{D,t}^T (Y_{T,t}^I)^\xi (Y_{T,t}^N)^{1-\xi} - (\varphi_t Y_{T,t}^I + \rho_t^N Y_{T,t}^N), \quad (9)$$

where  $\rho_{D,t}^T \equiv P_{D,t}^T / P_t$  is the real price, in units of Home consumption, of the tradable consumption basket. The representative producer chooses the production inputs in order to maximize the expected present discounted value of the stream of real profits,  $E_t (\sum_{s=t}^{\infty} \beta_{s,t} d_s^T)$ . The first-order, optimal conditions for  $Y_{T,t}^I$  and  $Y_{T,t}^N$  imply, respectively:

$$\xi \rho_{D,t}^T (C_{D,t}^T + \tau_t C_{X,t}^T) = \varphi_t Y_{T,t}^I,$$

$$(1 - \xi) \rho_{D,t}^T (C_{D,t}^T + \tau_t C_{X,t}^T) = \rho_t^N Y_{T,t}^N.$$

Finally, the real export price, in units of Foreign consumption, is  $\rho_{X,t}^T \equiv P_{X,t}^T / P_t^* = \tau_t P_{D,t}^T / Q_t$ ,

where  $Q_t \equiv P_t^* S_t / P_t$  denotes the consumption-based real exchange rate.<sup>14</sup>

### Household Budget Constraint, Intertemporal Choices, and Capital Utilization

The representative household can invest in two types of financial assets: shares in a mutual fund of non-tradable-sector firms and non-contingent, internationally traded bonds denominated in units of domestic and foreign currency that generate risk-free real returns.<sup>15</sup> In addition, the household owns the total stock of capital of the economy.

Investment in the mutual fund of non-tradable-sector firms in the stock market is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. Since there is no entry in the intermediate and tradable sectors (and, therefore, no need to channel resources from households for the financing of such entry), we do not model trade in intermediate- and tradable-sector equities explicitly. We also assume that the profits of intermediate-sector firms are rebated to households in lump-sum fashion.<sup>16</sup> Profits in the tradable sector are zero in equilibrium.

Let  $x_t$  be the share in the mutual fund of Home non-tradable-sector firms held by the representative household entering period  $t$ . The mutual fund pays a total profit in each period (in units of currency) that is equal to the total profit of all firms that produce in that period,  $N_t d_t^N$ . During period  $t$ , the representative household buys  $x_{t+1}$  shares in a mutual fund of  $N_t + N_{E,t}$  firms (those already operating at time  $t$  and the new entrants). Only a fraction  $1 - \delta$  of these firms will produce and pay dividends at time  $t + 1$ . Since the household does not know which firms will be hit by the exogenous exit shock  $\delta$  at the end of period  $t$ , it finances the continuing operation of all pre-existing firms and all new entrants during period  $t$ . The date  $t$  price of a claim to the future profit stream of the mutual fund of  $N_t + N_{E,t}$  firms is equal to the nominal price of claims to future profits of Home firms,  $P_t e_t^N$ .

International asset markets are incomplete, since only risk-free bonds are traded across countries. Home bonds, issued by Home households, are denominated in Home currency. Foreign bonds, issued by Foreign households, are denominated in Foreign currency. We maintain the assumption that nominal returns are indexed to welfare-consistent CPI inflation in each country, so that bonds

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<sup>14</sup>To see this, recall that  $P_{X,t}^T = \tau_t P_{D,t}^T / S_t$ . Thus:  $\rho_{X,t}^T \equiv (P_{X,t}^T / P_t^*) = (\tau_t P_{D,t}^T / P_t) (P_t / S_t P_t^*) = \tau_t \rho_{D,t}^T / Q_t$ .

<sup>15</sup>For simplicity, we assume extreme home bias in equity holdings and rule out international trade in firm shares.

<sup>16</sup>As long as the wage negotiated by workers and firms is inside the bargaining set (and, therefore, smaller than or equal to the firm's outside option), the surplus from a match that goes to the firm is positive, even if intermediate producers are perfectly competitive. Since all workers are identical, the total surplus of the intermediate sector is positive, and so is the profit rebated to households.

issued by each country provide a risk-free real return in units of that country's consumption basket. Home (Foreign) real holdings of Home bonds are denoted with  $a_t$  ( $a_t^*$ ), while Home (Foreign) real holdings of Foreign bonds are denoted by  $a_{*t}$  ( $a_{*t}^*$ ). To induce steady-state determinacy and stationary responses to temporary shocks in the model, we follow Turnovsky (1985), and, more recently, Benigno (2009), and we assume a quadratic cost of adjusting bond holdings. The real cost of adjusting Home bond holdings is  $\psi a_{t+1}^2/2$ , while the cost of adjusting Foreign bond holdings is  $\psi a_{*t+1}^2/2$ . These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion in equilibrium.

The household accumulates the physical capital and rents it to intermediate input producers in a competitive capital market. Investment in the physical capital stock,  $I_{K,t}$ , requires the use of the same composite of all available varieties as the basket  $C_t$ . As standard practice in the literature, we introduce convex adjustment costs in physical investment and variable capital utilization in order to account for the smooth behavior of aggregate investment and the pronounced cyclical variability in capacity utilization observed in the data.<sup>17</sup> We assume that the utilization rate of capital is set by the household.<sup>18</sup> Thus, effective capital rented to firms,  $K_t$ , is the product of physical capital,  $\tilde{K}_t$ , and the utilization rate,  $u_{K,t}$ :  $K_t = u_{K,t}\tilde{K}_t$ . Increases in the utilization rate are costly because higher utilization rates imply faster depreciation rates. Following Greenwood, Hercowitz, and Huffman (1988) and Burnside and Eichenbaum (1996), we assume the following convex depreciation function:  $\delta_{K,t} \equiv \varkappa u_{K,t}^{1+\varsigma} / (1 + \varsigma)$ . Physical capital,  $\tilde{K}_t$ , obeys a standard law of motion:

$$\tilde{K}_{t+1} = (1 - \delta_{K,t}) \tilde{K}_t + I_{K,t} \left[ 1 - \frac{\nu_K}{2} \left( \frac{I_{K,t}}{I_{K,t-1}} - 1 \right)^2 \right], \quad (10)$$

where  $\nu_K > 0$  is a scale parameter.

The per-period household's budget constraint is:

$$\begin{aligned} a_{t+1} + Q_t a_{*t+1} + \frac{\psi}{2} a_{t+1}^2 + \frac{\psi}{2} Q_t \frac{\psi}{2} a_{*t+1}^2 + C_t + e_t^N (N_t + N_{E,t}) x_{t+1} + I_{K,t} = \\ = (1 + r_t) a_t + (1 + r_t^*) a_{*t} Q_t + (d_t^N + e_t^N) N_t x_t + \tilde{w}_t L_t + r_t^K K_t + b_t (1 - L_t) + d_t^I + T_t^g + T_t^a, \end{aligned} \quad (11)$$

where  $r_t$  and  $r_t^*$  denote, respectively, real returns on Home and Foreign bond holdings between  $t-1$

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<sup>17</sup>For simplicity, we do not provide a microfoundation of capital market frictions. Baxter and Crucini (1993) first introduced adjustment costs in the international real business cycle model, explicitly calibrating them to match investment volatility in the one-sector two-country framework.

<sup>18</sup>Our assumption that households make the capital accumulation and utilization decisions is standard in the literature. At the cost of more complicated notation, we could work with an alternative decentralization scheme in which firms make these decisions (leaving the model unaffected).

and  $t$ ,  $T_t^g$  is a lump-sum transfer (or tax) from the government, and  $T_t^a$  is a lump-sum rebate of the cost of adjusting bond holdings from the intermediaries to which it is paid.

The household maximizes its expected intertemporal utility subject to (10) and (11). This yields standard Euler equations for share holdings, capital accumulation, investment, and bond holdings, as well as the optimality condition for capital utilization, which we relegate to the Appendix.

### Some Equilibrium Relations

In equilibrium,  $x_t = x_{t+1} = 1$ ,  $T_t^g = -b_t(1 - L_t)$ , and  $T_t^a = (\psi/2)(a_{t+1}^2 + Q_t a_{*t+1}^2)$ . Aggregate demand of the final consumption basket must be equal to the sum of market consumption, investment in physical capital, and the costs associated to product creation, job creation, and job destruction:

$$Y_t^C = C_t + I_{K,t} + N_{E,t} f_{E,t} + \kappa V_t + \frac{G(z_t^c) L_t}{1 - G(z_t^c)} F_t.$$

Labor market clearing requires:

$$Z_t \tilde{z}_t K_t^\alpha L_t^{1-\alpha} = \exp \left\{ \frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t} \right\} Y_t^N + Y_{T,t}^I.$$

Total aggregate demand for the non-tradable good is  $Y_t^N = (C_t^N + Y_{T,t}^N)$ , while market clearing in the tradable sector requires  $C_{D,t}^T + \tau_t C_{X,t}^T = (Y_{T,t}^I)^{\xi} (Y_{T,t}^N)^{1-\xi}$ . The equilibrium price indexes imply:

$$1 = (1 - \alpha_N) (\rho_t^T)^{1-\phi_N} + \alpha_N (\rho_t^N)^{1-\phi_N},$$

$$\rho_t^T = (1 - \alpha_X) (\rho_{D,t}^T)^{1-\phi_T} + \alpha_X (\rho_{X,t}^{T*})^{1-\phi_T}.$$

Finally, bonds are in zero net supply, which implies the equilibrium conditions  $a_{t+1} + a_{t+1}^* = 0$  and  $a_{*t+1} + a_{*t+1}^* = 0$  in all periods. Net foreign assets are determined by:

$$a_{t+1} + Q_t a_{*t+1} = (1 + r_t) a_t + Q_t (1 + r_t^*) a_{*t} + TB_t,$$

where  $TB_t \equiv Q_t \rho_{X,t}^T C_{X,t}^T - \rho_{X,t}^{T*} C_{X,t}^{T*}$  denotes the trade balance.

The Appendix summarizes the model's endogenous and exogenous variables and the equations that determine the endogenous variables in equilibrium.

### 3 Calibration

Given the nonlinear nature of the equilibrium conditions, the decision rules that determine present and future values of all the variables cannot be solved for analytically. Thus, we must assign specific values to the model parameters and solve for the decision rules numerically.

We assume a symmetric calibration across countries.<sup>19</sup> We interpret periods as quarters and choose parameter values from the literature and to match features of euro area macroeconomic data from 1995:Q1 to 2013:Q1. Unless otherwise noted, data are taken from the Eurostat database.<sup>20</sup> We use the NIPA definition of GDP as total income:  $Y_t^g \equiv \tilde{w}_t L_t + r_t^K K_t + N_t d_t^N + d_t^I$ , which equals the sum of consumption, investment in physical capital, product creation expenses, and the trade balance:  $Y_t^g = C_t + I_{K,t} + N_{E,t} (f_{R,t} + f_T) + TB_t$ .<sup>21</sup> Below, variables without a time subscript denote steady-state values.

We use standard values for all the parameters that are conventional in the business cycle literature. We set the discount factor  $\beta$  equal to 0.99, the risk aversion  $\gamma$  equal to 1, the “share” parameter on capital in the Cobb-Douglas production function  $\alpha$  equal to 0.33, the capital depreciation rate  $\delta_K$  equal to 0.025, and the elasticity of marginal depreciation with respect to the utilization rate  $\varsigma$  equal to 0.41.<sup>22</sup> We set consumption habit,  $h_C$ , equal to 0.6, as estimated by Smets and Wouters (2004) for the euro area. We calibrate the elasticity of substitution between tradable and non-tradable goods,  $\phi_N$ , equal to 0.5, consistent with the estimates for industrialized countries in Mendoza (1991). We set the elasticity of substitution between tradable goods produced in Home and Foreign,  $\phi_T$ , equal to 6, consistent with recent estimates provided by Imbs and Mejean (2015).<sup>23</sup> For the bivariate productivity process, we set persistence and spillover parameters consistent with Baxter and Farr (2005), implying zero spillovers across countries and persistence equal

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<sup>19</sup>Our choice is motivated by the fact that the level of market regulation in the euro-area is rather homogenous across countries; see the Appendix for details. For robustness, we have repeated our exercises by considering an asymmetric calibration in which Home and Foreign feature characteristics of the periphery and core of the euro area, respectively. None of our results is significantly affected by this alternative parameterization. Details are available upon request.

<sup>20</sup>Data are available at <http://epp.eurostat.ec.europa.eu>

<sup>21</sup>The inclusion of product creation expenses in  $Y_t^g$  is consistent with the fact that intangible capital and non-residential structures (the technological components of the entry cost) are accounted for by statistical agencies when constructing GDP; see the documentation available at <http://ec.europa.eu/eurostat/statistics-explained>. Moreover, the cost of complying with legal requirements of market entry involves the purchase of goods and services, over and beyond licence fees; see Djankov, Porta, Lopez-De-Silanes, and Shleifer (2002).

<sup>22</sup>Although the term  $1 - \alpha$  does not necessarily correspond to the labor share (since the labor share in general depends on the outcome of the bargaining process), our conventional choice for  $\alpha$  implies that  $\tilde{w}L/Y = 0.61$ , in line with the data. For the period 1995-2013, the average labor share in the euro area is 0.62.

<sup>23</sup>None of our main results is significantly affected if we use  $\phi_T = 1.5$ , the standard value in the international business cycle literature.

to 0.999. Finally, we set the elasticity of matches to unemployment,  $\varepsilon$ , equal to 0.6, the midpoint of estimates reported by Petrongolo and Pissarides (2006). To maintain comparability with much of the existing literature, we choose the worker's bargaining power parameter,  $\eta$ , such that the so-called Hosios condition is satisfied, i.e.,  $\eta = \varepsilon$ .<sup>24</sup>

We calibrate the remaining parameters to match statistics from simulated data to empirical targets. Concerning the parameters that are specific to the product market, we set the firm exit rate,  $\delta$ , such that gross steady-state job destruction accounted for by firm exit is 25 percent, the midpoint of estimates in Haltiwanger, Scarpetta, and Schweiger (2006). (Their estimates for France, Germany, and Italy range between 20 and 30 percent.) In order to calibrate the entry costs related to regulation,  $f_R$ , we update the procedure in Ebelt and Haefke (2009) and convert into months of lost output the OECD indicator for administrative burdens on start-ups (OECD, Product Market Regulation Database, 2013). See the Appendix for details. Following this procedure, the aggregate cost of product market regulation is 2 percent of GDP.<sup>25</sup> We choose  $f_T$  such that aggregate R&D expenditures are 1.97 percent of GDP (OECD, Science and Technology Database).<sup>26</sup> We set the price-elasticity of the spending share on individual goods,  $\sigma$ , such that the steady-state markup,  $\mu$ , is 25 percent, a weighted-average for the euro area of the estimates provided by Thum-Thysen and Canton (2015). We calibrate the degree of home bias,  $\alpha_N$ , and the size of the tradable sector,  $\alpha_T$ , to match a steady-state import share of 15 percent (corresponding to the average within-eurozone import share) and a steady-state output share of 38 percent in manufacturing (from the EU-KLEMS database). Finally, we set the share of non-tradable goods in the production of tradables,  $\xi$ , such that the share of manufacturing value added from services averages forty percent, as documented by Boeri, Castanheira, Faini, and Galasso (2006). This implies setting  $\xi = 0.6$ .

We now turn to the parameters that are specific to the conventional search and matching framework. We set unemployment benefits such that the average benefit replacement rate,  $b/\tilde{w}$ , is 32 percent (OECD, Benefits and Wages Database, 2013).<sup>27</sup> We choose the cost of posting a vacancy,  $\kappa$ , such that the steady-state hiring cost is 13 percent of the average wage, as estimated

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<sup>24</sup>Absent other distortions, the Hosios condition requires the equality of the worker share of the surplus,  $\eta$ , and the worker's contribution to matching,  $\varepsilon$ . This implies that congestion and trading externalities that characterize the search and matching process exactly cancel out, leading to efficient job creation and destruction. In the presence of other distortions, the basic Hosios condition  $\eta = \varepsilon$  must be adjusted to include an appropriate additional term in order to deliver efficiency. For simplicity of exposition and consistency with much literature (for instance, Arseneau and Chugh, 2012), we simply refer to the condition  $\eta = \varepsilon$  as the Hosios condition.

<sup>25</sup>The implied entry cost at the producer level is a loss of 1.3 months of steady-state firm's output.

<sup>26</sup>The implied cost of non-regulatory entry barriers at the producer level is 65 percent of output per worker, a midpoint of the values used by Barseghyan and DiCecio (2011) for the U.S. economy.

<sup>27</sup>As before, we consider a weighted average of the unemployment benefits across euro area member countries.

by

Abowd and Kramarz (2003) for France. Following the argument in den Haan, Ramey, and Watson (2000), we assume that firms experiencing exogenous separations attempt to refill the positions by posting vacancies in the ensuing matching phase. Accordingly, we choose the exogenous separation rate,  $\lambda^x$ , so that the percentage of jobs counted as destroyed in a given year that fail to reappear in the following year is 71 percent, as reported by Gomez-Salvador, Messina, and Vallanti (2004) for the euro area as a whole. We set home production,  $h_p$ , the matching function constant,  $\chi$ , and firing costs,  $F$ , to match the total separation rate,  $\lambda^{tot}$ , the unemployment rate,  $U$ , and the probability of filling a vacancy,  $q$ . We set  $U = 0.09$ , the average unemployment rate in our sample period,  $q = 0.6$ , as reported by Weber (2000), and  $\lambda^{tot} = 0.036$ , in line with the estimates in Hobijn and Sahin (2009). With this calibration targets, firing costs and home production amount, respectively, to 11 and 23 percent of the average wage.<sup>28</sup>

Three parameters are left to calibration: the lognormal scale and shape parameters,  $\mu_{z_i}$  and  $\sigma_{z_i}$ , and the investment adjustment costs,  $\nu$ . As standard practice we choose  $\nu$  such that the model reproduces the variability of investment in physical capital,  $I_{K,t}$ . Following den Haan, Ramey, and Watson (2000) and Krause and Lubik (2007), we normalize  $\mu_{z_i}$  to zero and set  $\sigma_{z_i}$  to match the variability of unemployment relative to output. The model calibration is summarized in Table 1.

## Model Properties

Our parameterization implies a quarterly job-finding probability equal to 0.34, not too distant from the euro area quarterly average of 0.25 (see Hobijn and Sahin, 2009). Furthermore, the steady-state decile ratio of gross earnings between ninth-to-first deciles in the artificial economy is equal to 9.9 (where ninth and first deciles are upper-earnings decile limits). The corresponding (median) figure for yearly gross earnings in the euro area is 9.2 (see Eurostat, 2010, Table 2 on page 21). This result provides additional support to our choice for  $\sigma_{z_i}$ .

In Table 2, we further investigate the model properties by comparing the model-implied second moments for key macroeconomic variables (normal fonts) to their empirical counterparts (bold fonts). Actual and model-generated data are HP-filtered, with a smoothing parameter set to 1600. We solve for the dynamics in response to exogenous productivity shocks using a second-order approximation of the model equilibrium conditions around the deterministic steady state.

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<sup>28</sup>The implied value of  $F$  is lower than the average value estimated for European countries, which is typically around 25 percent of yearly wages; see Doing Business Database, World Bank (2008). The reason for this discrepancy is that empirical estimates include severance payments, while, as explained before, the model does not.

An issue of special importance when comparing our model to properties of the data concerns the treatment of variety effects. As argued by Ghironi and Melitz (2005), as the economy experiences entry of Home and Foreign firms, the welfare-consistent non-tradable price index  $P_t^N$  can fluctuate even if product prices remain constant.<sup>29</sup> In the data, however, aggregate price indexes do not take these variety effects into account.<sup>30</sup> To resolve this issue, we follow Ghironi and Melitz (2005) and introduce the data-consistent price index,  $\tilde{P}_t$ . In turn, given any variable  $X_t$  in units of consumption, we then construct its data-consistent counterpart as  $X_{Rt} \equiv X_t \tilde{\rho}_t$ , where  $\tilde{\rho}_t \equiv P_t / \tilde{P}_t$ . (Additional details, including the analytical expression for  $\tilde{\rho}_t$ , are presented in the Appendix.)

While the volatility of output, unemployment, and investment is matched by virtue of our calibration strategy, the model reproduces rather well the volatility of market consumption, and vacancies.<sup>31</sup> The model also generates a negative Beveridge curve (given by the contemporaneous correlation between vacancies and unemployment), and it reproduces well the contemporaneous correlation between output and all the other macroeconomic variables. Moreover, consistent with the evidence in Elsby, Hobijn, and Sahin (2013), the job finding rate is procyclical, while the separation rate is countercyclical. Finally, as in Bilbiie, Ghironi, and Melitz (2012), our model can jointly reproduce important stylized facts about product creation and the dynamics of profits and markups: procyclical entry and profits with countercyclical markups.

#### 4 Market Reforms in Normal Times

We begin to investigate the consequences of structural reforms by studying the dynamic adjustment to market deregulation assuming that the economy is at the non-stochastic steady state. We consider a permanent reduction of policy parameters in a perfect foresight environment: the policy shock comes as an initial surprise to agents, who then have perfect foresight from that moment on.<sup>32</sup> Given the large size of the shocks, transition dynamics from the initial equilibrium to the

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<sup>29</sup>The term  $(1/2\sigma) (1/N_t - 1/\tilde{N})$  in equation (1) implies that even if prices are the same for all goods, the expenditure needed to reach a certain level of consumption declines with  $N_t$ . Thus, provided that  $\sigma > 0$ , the utility function from the translog expenditure function exhibits love of variety.

<sup>30</sup>There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010). Furthermore, the adjustment for variety neither happens at the frequency represented by periods in the model, nor using the specific functional form for preferences that the model assumes.

<sup>31</sup>Following ECB (2002) and Christoffel, Kuester, and Linzert (2009), our empirical measure of vacancies is a population-weighted euro area vacancy measure.

<sup>32</sup>Market reforms are usually the outcome of legislative processes such that implementation is anticipated by agents when it happens. This notwithstanding, treating reforms as unanticipated shocks remains a useful benchmark for analysis. We address the issue of anticipated reforms by considering the case of credible reform commitment below.

final equilibrium are found by solving the model as a nonlinear, forward-looking, deterministic system using a Newton-Raphson method, as described in Laffargue (1990). This method solves simultaneously all equations for each period, without relying on low-order, local approximations.

We assume that policy parameters in the Home economy are lowered to their corresponding U.S. levels.<sup>33</sup> To recalibrate entry costs related to regulation,  $f_R$ , we follow the same procedure described in Section 4, which implies a loss of steady-state firm's output equal to 1 month. We assume that unemployment benefits corresponds to 28 percent of the average wage (OECD, Benefits and Wages Database, 2013), and set firing costs to zero as in Veracierto (2008). Since in the model unemployment benefits are financed with lump-sum taxes, the aggregate resource constraint is not directly affected by a cut in unemployment benefits. That is, in the model a cut in unemployment benefits only affects the worker's outside option at the bargaining stage, without directly changing household's income. In order to address this issue, we consider an alternative labor market reform which reduces the value of home production. We assume the same percentage reduction implied by the cut in unemployment benefits.<sup>34</sup>

Macroeconomic dynamics in the deregulating economy are similar to what described in Cacciatore and Fiori (2016). Figure 1 (continuous lines) shows the effects of a permanent decrease in barriers to entry ( $f_R$ ). In the aftermath of the reform, output and employment are essentially unaffected. On one hand, producer entry increases aggregate demand, since in order to pay for sunk entry costs producers need to purchase final output. On the other hand, consumption (and thus aggregate demand) fall relative to their initial pre-reform equilibrium, since households increase saving to finance product creation. With an open capital account, increased entry can also be financed by borrowing from abroad. As a result, the deregulating economy runs a current account deficit during the first part of the transition. Importantly, the terms of trade,  $TOT_t \equiv Q_t \rho_{X,t} / \rho_{X,t}^*$ , appreciate on impact in response to the reform, and remain above the initial steady state for approximately 5 years. Increased entry in the non-traded sector puts upward pressure on the price of Home intermediate goods relative to Foreign (as shown in Figure 1, the marginal cost of production in Home's non-traded sector,  $\varphi_t$ , rises relative to Foreign). In turn, higher intermediate good prices and higher non-traded good prices (relative to Foreign) imply higher production costs in Home's

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<sup>33</sup>We take the United States as the benchmark for market flexibility, but we make no presumption that U.S. market regulation levels should be optimal for other countries—or, for that matter, that they are optimal for the U.S. We leave optimal market regulation and reform in a dynamic stochastic macroeconomic framework as a topic for future study.

<sup>34</sup>Alternatively, we could change the baseline model assuming that both home production and unemployment benefits are exogenous endowments that contribute to household's income. The adjustment to a reduction in unemployment benefits in this case would be isomorphic to a reduction in home production

traded sector and an appreciation of the terms of trade that is reversed only gradually.<sup>35</sup>

Over time, as new firms enter the market, fiercer competition in the non-tradable sector erodes the market share of incumbents, who downsize. This effect leads to a reduction in the demand for the intermediate input, and, as a consequence, higher job destruction. Labor market frictions further propagate the adjustment to deregulation, since job creation induced by new entrants is a gradual process, the slow reallocation of workers across producers increases unemployment and lowers aggregate output. Unemployment peaks at 0.3 percent, while GDP falls by 0.3 percent at the trough.

The Foreign economy is negatively affected by the initial reduction in Home entry barriers, with both GDP and employment that temporarily fall relatively to the initial steady state. The reason is twofold. First, the temporary decline in Home aggregate demand reduces the demand for Foreign tradables goods. Moreover, since Foreign households invest in the Home economy, there are fewer resources available for domestic production.

Both Home and Foreign recover over time. Once the number of producing firms in the deregulating economy has increased, the reduction in red-tape implies that more resources can be devoted to consumption and investment in physical capital. In addition, as jobs are reallocated to new entrants, unemployment falls, further boosting aggregate demand at Home and abroad. The larger number of available goods results in higher goods substitutability and lower markups. In the long run, Home GDP increases by 2.21 percent. There are positive, yet small, spillover effects on Foreign GDP, which increases by 0.18 percent.

Figure 2 (continuous lines) plots the dynamic adjustment to a permanent reduction in firing costs. Deregulation, in this case, presents a different intertemporal trade-off. Lower firing costs reduce the profitability of low productive matches, increasing job destruction. At the same time, however, lower firing costs reduce the expected cost of terminating a match, boosting job creation. Since destroying existing jobs is an instantaneous process, while matching firms and workers takes time, employment, output, and consumption decrease in the aftermath of the reform but recover over time. It takes about one year for unemployment to fall below its pre-deregulation level. This happens because the expected present discounted value of job creation increases slowly over time, reflecting the production lag for new matches and the initial reduction in aggregate demand induced by firing. In the long run, GDP increases by 0.33 percent.

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<sup>35</sup>From a policy perspective, this result suggests that policymakers should not expect deregulation of upstream service sectors to boost downstream external competitiveness quickly.

The deregulating economy initially runs a current account surplus in the aftermath of the reform, which then turns into a deficit. The initial surplus reflects the initial contractionary effects implied by the removal of firing costs, since Foreign households find it more profitable to invest domestically. Current account dynamics counteract the reduction of export demand for Foreign goods. As a consequence, the Foreign economy is not significantly affected by Home deregulation along the transition. As for product market deregulation, there are positive but small international spillovers from asymmetric deregulation.

In contrast to a reduction in entry barriers or firing costs, a reform that lowers unemployment benefits does not have short-run contractionary effects. The reason is that lower unemployment benefits reduce the workers' outside option and boost job creation without increasing job destruction. Thus, as shown in Figure 3 (continuous lines), unemployment gradually falls over time, with beneficial effects for aggregate consumption, output, and investment. In the long run, GDP increases by 1.57 percent.

The reduction in unemployment benefits leads to an initial current account surplus, followed by a prolonged reversal.<sup>36</sup> In contrast to the removal of firing costs, the initial current account surplus reflects the depreciation of Home's terms of trade and the corresponding surplus in the trade balance. In particular, the reduction in unemployment benefits leads to wage moderation, reducing the marginal cost of non-tradable production at Home relatively to Foreign. In turn, expenditure switching toward Home tradables goods increases Home net exports.

The short-run adjustment to a reduction in home production mirrors the dynamics following deregulation of unemployment benefits (see the Appendix for details). This result suggests that, in a highly regulated economy, the beneficial effects on job creation and destruction implied by a reduction of the worker's outside option dominate the potential costs associated to lower household's consumption.

Table 3 computes the welfare effects of Home product market deregulation. We compute the percentage increase of steady-state consumption  $\Delta$  that would make the household indifferent between not implementing a given reform (consuming  $C$ , constant, in each period) and deregulating (consuming  $C_t$ , time varying until the economy reaches the new steady state); see the Appendix for the analytical details. All the reforms we consider have beneficial long-term effects, although the

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<sup>36</sup>In an estimated, three-country, dynamic stochastic general equilibrium model, Kollmann, Ratto, Roeger, in't Veld, and Vogel (2015) find that shocks to leisure, interpreted as changes in unemployment benefit legislation, contributed to the current account surplus experienced by Germany in the aftermath of the labor market reforms initiated by then Chancellor Gerhard Schröder in 2003.

effect is quantitatively stronger for a reduction in barriers to entry and unemployment benefits (the gains is 0.59 percent of pre-deregulation, steady state consumption in both cases). By contrast, the removal of firing costs induces a smaller gain, equal to 0.11 percent of the pre-deregulation steady-state consumption. As discussed in Cacciatore and Fiori (2016), the reason is that positive firing costs counterbalance the distortionary effect of high barriers to entry and unemployment benefits on the job destruction rate. Thus, while removing firing costs increases efficiency along the job creation margin, there are efficiency losses stemming from more inefficiently high job destruction. In turn, the severity of this trade-off explains why the welfare gains induced by lowering firing costs are smaller relative to the other dimensions of deregulation.

## 5 Market Reforms in Times of Imbalance

We now study how business cycle conditions at the time of reform implementation affect the adjustment to market deregulation. We consider the following experiment. We assume that at quarter 0 both Home and Foreign are hit by a symmetric, negative productivity shock. We calibrate the size of the shock so that we can reproduce the peak-to-trough decline of euro-area output of about 4 percent following the collapse of Lehman Brothers in September 2008. We set the persistence of the shock such that it takes about 4 years for Home and Foreign to return to the initial steady state in the absence of market reform. Next, we assume that at quarter 1 there is a permanent change in regulation. As before, we consider a permanent reduction in barriers to entry, firing costs, and unemployment benefits, and we treat this policy shock as unanticipated.<sup>37</sup>

Figure 4 presents the impulse responses following the symmetric, negative productivity shock in the absence of market deregulation. Lower aggregate productivity reduces the present discounted value of product and job creation. Over time, more jobs become unprofitable, leading intermediate input producers to increase job destruction. As a result, GDP and the number of producers fall, and unemployment rises. Product market dynamics result in temporarily higher markups. Notice that due to the symmetric reduction in aggregate productivity in both countries, there are no movements in the current account, terms of trade, and the real exchange rate.

We now turn to the consequences of market deregulation. We construct the net effect of deregulating markets in a recession as the difference between the impulse responses following deregulation and the impulse responses following the negative productivity shock in the absence of market re-

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<sup>37</sup>This amounts to considering an unanticipated regulation shock assuming that all the state variables of the model take the value implied by the impact response to the productivity shock.

form. Figure 1 (dashed lines) shows the net effect of lowering entry barriers when the economy is in a recession.

The effect is rather similar to that obtained when product market deregulation is implemented in normal times, although short-run costs are marginally higher in a recession. The intuition is straightforward and hinges on the fact that recession has offsetting effects on the present discounted value of product creation. On one side, lower aggregate demand reduces the expected stream of profits, with a negative effect on the incentive to enter. On the other side, markups are higher when productivity is below trend, which encourages product creation. This two opposite effects largely cancel out, and this implies a small difference between product market reform in normal times or during recession.

Consistent with this intuition, the welfare gains from product market deregulation are only slightly smaller in a recession relative to normal times (see Table 3). (Details about the welfare calculations are relegated to the Appendix.) Importantly for the ongoing policy debate, these results suggest that deregulating product markets, if used as a response to cyclical conditions, does little to boost the recovery from a recession. To substantiate this, in the Appendix, we compare the response of the economy to the negative productivity shock with and without the policy response of a product market deregulation. Not surprisingly, dynamics are remarkably similar.<sup>38,39</sup>

Figure 2 (dashed lines) shows the net effect of removing firing costs when the economy is in a recession. This reform entails larger and more persistent adverse short-run effects on employment and output when implemented in a recession. Correspondingly, the small beneficial welfare effects of removing firing costs in normal times become even smaller (see Table 3).

Once again, the intuition is straightforward: For a given level of aggregate productivity, positive firing costs imply that relatively unprofitable jobs survive job destruction. When aggregate productivity is below trend, the share of unprofitable matches that survive job destruction because of firing costs is greater compared to the steady state. As a consequence, the removal of firing costs leads to larger job destruction, which further depresses aggregate demand and output in the short run. The increase in unemployment is twice as large relative to normal times (0.8 percent

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<sup>38</sup>It is important to clarify that while we find that product market reform is of limited use as a policy *response* to recession, this is not saying that recessions display virtually identical dynamics in the pre- and post-reform environment (i.e., around the pre- and post-deregulation steady states). For instance, see Cacciatore and Fiori (2016) for the benefits of market reforms in terms of business cycle dynamics in a more flexible economy.

<sup>39</sup>Notice also that if we assume a more persistent recession (output below trend for 7 years, in line, for instance, with the experience of Italy) the reduction in aggregate demand becomes sufficiently strong that it more than offsets the entry incentive from higher markups. In this case, product market reform becomes a more effective instrument to boost recovery, and the trough for GDP is approximately 0.3 percent lower compared to what observed in normal times.

versus 0.4), and the beneficial effects of the reform materialize only after 2 and a half years, when output finally increases above its pre-deregulation level.

Figure 3 (dashed lines) shows the net effect of reducing unemployment benefits when the economy is in a recession. Output and employment increase more strongly in a recession relative to normal times. As in these times, the reduction in unemployment benefits (or home production) reduces the worker's outside option, boosting job creation. In a recession, unemployment is higher relative to the steady state, implying that a larger pool of workers is searching for jobs. As a result, the probability of filling a vacancy is higher, and thus the expected cost of job creation is lower. Furthermore, for a given level of unemployment benefits, real wages are below steady state during a recession, a second factor that contributes to the larger increase in job creation. The welfare gain from reducing unemployment benefits is thus higher in a recession (see Table 3). As we show in the Appendix, the same results apply when considering a reduction in home production. This suggests that, at the aggregate level, the loss of household consumption associated to a reduction in unemployment benefits is more than offset by the beneficial effects of increased job creation even during a recession.

## 6 Credible Commitment to Future Deregulation

We now conduct a second experiment, studying the effects of credible announcements to implement structural reforms at some future date. This scenario captures the existence of legislative delays that often drive a time-wedge between the executive decision of the government in office, the final ratification of market reforms by the legislative authorities, and the implementation of reforms. In this scenario, market deregulation acts as a news shock.

To address this issue, we assume that the government credibly announces that market deregulation will be implemented within a year, i.e., after 3 quarters. The reform is then effectively implemented. When the economy is in a recession, the announcement takes place at quarter 1, and it is unexpected in the prior quarter, i.e., when the negative productivity shocks in Home and Foreign are realized.

The general message of our analysis is twofold. First, regardless of whether reforms are implemented in normal times or during an economic downturn, the announcement of future reforms induces short-run dynamics, which can be either expansionary or contractionary depending on the reform considered.<sup>40</sup> Second, concerning the relative merits of deregulating in normal versus crisis

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<sup>40</sup>The response of the economy when deregulation is actually implemented remains (at least qualitatively) similar

times, credible commitment to future deregulation significantly reduces the adverse short-run effects of an unanticipated removal of firing costs in a recession. By contrast, the consequences of deregulating barriers to entry and unemployment benefits are less affected.

Figure 5 presents the adjustment following the announcement (and the subsequent implementation) of product market deregulation. Regardless of whether the reform is implemented in normal versus crisis times, the Home economy reacts to the announcement by reducing investment in product creation, since agents anticipate that it will be cheaper to create new products in the near future. The reduction in investment causes an immediate drop in GDP, and an increase in unemployment. However, in contrast to an unanticipated reform, consumption does not fall on impact, and welfare rises (see Table 4).

Since agents expect the reform to increase permanent income, the Home economy borrows from abroad immediately in order to smooth consumption over time. When the reform is implemented, the adjustment is similar to that previously described.<sup>41</sup> Credible commitment to future deregulation does not change the conclusion about the alternative merits of deregulating product markets in normal versus crisis times, as the dynamics remain very similar in the two scenarios. This result is not surprising, as the commitment to future deregulation affects symmetrically the expected present discounted value of profits and the behavior of markups.

Figure 6 presents the adjustment following the announcement (and the subsequent implementation) of the removal of firing restrictions. In this case, the commitment to future deregulation of firing changes the short-run adjustment more significantly relative to unanticipated reforms. The contractionary effects of the reform are much smaller, since committing to a future reduction in firing costs boosts current job creation (by increasing the present discounted value of product creation) without triggering a large and immediate increase in job destruction. In turn, aggregate demand is higher. In contrast to product market deregulation, the effect of commitment to future cuts in firing costs are larger in a recession, since a larger share of workers survive job destruction relative to the steady state. As a consequence, the discrepancy between lifting firing restrictions in normal and crisis times is significantly mitigated relative to the case of unanticipated reforms.

Figure 7 presents the adjustment following the announcement (and the subsequent implementation) of a future reduction in unemployment benefits. The main difference relative to the unanticipated scenario is that commitment to future benefit reduction triggers product creation at the

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to that observed with unanticipated reforms.

<sup>41</sup>The presence of habits smooths the adjustment of consumption, which initially is virtually unchanged and then falls smoothly over time when investment in new products needs to be financed.

time of the announcement (regardless of business cycle conditions). The intuition is as follows: On one side, agents expect lower wages in the future, which boosts the present discounted value of product creation; On the other, agents anticipate that at the time of the reform incumbent firms will immediately benefit from the cut in unemployment benefits, thus having the same competitive advantage relative to new entrants discussed above.

GDP increases by more relative to an unanticipated reform, as increased product creation stimulates aggregate demand and wages.<sup>42</sup> However, the increase in entry is temporary, as once unemployment benefits are effectively reduced, and aggregate demand and employment increase toward their higher long-run values, the demand for physical capital increases. As a result, the composition of Home investment shifts from product creation to capital accumulation.

Similarly to product market deregulation, credible commitment to future reduction of unemployment benefits does not change the conclusion about the merits of deregulating in normal versus crisis times. The relative difference remains similar to that under unanticipated reforms—and as in that case, results are unchanged when considering a reduction in home production (see the Appendix).

## 7 Constraints on External Borrowing

To complete our analysis of the importance of the conditions under which reforms are implemented, we study whether the existence of constraints on external borrowing during a recession affect the adjustment to market reforms. We capture the existence of binding borrowing constraints in a simple fashion by assuming financial autarky, i.e., assuming that non-contingent bonds are traded only domestically. This implies that bond market equilibrium conditions become  $a_{t+1} = a_{t+1}^* = 0$  and  $a_{*t+1}^* = a_{*t+1} = 0$ , and trade must be balanced in each period:  $TB_t \equiv Q_t \rho_{Xt}^T C_{X,t}^T - \rho_{Xt}^{T*} C_{X,t}^{T*} = 0$ .

Figure 8 shows that the short-run contractionary effects induced by a reduction in barriers to producer entry in the service sector are larger when Home cannot borrow from abroad. Home households must reduce consumption by more to finance increased entry in production of services, and this reduces aggregate demand. Notice, however, that output and employment fall by less in Foreign, as less resources are shifted across the border to the deregulated trade partner.

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<sup>42</sup>Notice that investment increases by 4 percent on impact, not too far from the outcome with an unanticipated product market reform. The key difference relative to this scenario is that consumption does not fall as much, leading to an immediate increase in GDP. This happens because the permanent income effect following the expected reduction in unemployment benefits is stronger relative to the permanent income effect of an immediate reduction in barriers to entry—long-run benefits materialize more slowly with product market deregulation, since producer entry is a gradual process.

By contrast, lack of access to international financial markets does not significantly affect the adjustment of the Home economy following labor market deregulation (hence, we relegate the corresponding figures to the Appendix). The reason is that current account movements play a smaller role for the short-run adjustment to labor market reforms to begin with.<sup>43</sup>

## 8 Conclusions

This paper studied the consequences of implementing or credibly announcing market reforms under different economic conditions. We showed that the situation of the cycle and the ability of a country to access international lending matter for the dynamics triggered by changes in product and labor market regulation. Reducing firing costs during recessions exacerbates the short-run adjustment costs to this reform, while reduction in unemployment benefits is more beneficial during recession than in normal times. Lack of access to international financial markets makes product market reform more costly in terms of short-run consumption and output, as more domestic resources must be directed to producer entry in the deregulated sector.

Our results suggest that policymakers should be cautious in trying to use reforms as instruments to address crisis situations, as costs and benefits can vary significantly across reforms. Even when reforms generate long-run benefits and more favorable business cycle dynamics in the post-reform environment, implementing the “wrong” reform at the “wrong” time could derail the political support necessary to push through implementation and eventually reap important benefits.<sup>44</sup>

Finally, we considered only exogenous changes in regulation policy parameters. Thus, we did not study the optimal level of market regulation, optimal reforms, or their optimal sequencing, neither in the long run nor over the business cycle. We view these topics as important avenues for future research.<sup>45</sup>

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<sup>43</sup>The Appendix also presents an analysis of the quantitative relevance of sectoral spillovers for the propagation of product market reforms through input-output linkages. This is accomplished by studying how the effects of reforms vary with the share of non-tradables in production of tradables,  $1 - \xi$ .

<sup>44</sup>The argument could be made that recessions make reforms costly but also create pressure to reform. The evidence in Bonfiglioli and Gancia (2015) suggests that uncertainty has a positive effects on reform adoption, but recessions are generally associated with smaller reforms.

<sup>45</sup>In a complementary study, Asturias, Hur, Kehoe, and Ruhl (2016) study the optimal sequencing of market reforms, focusing on changes in entry barriers, trade costs, and contract enforcement.

## References

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TABLE 1: CALIBRATION

Variety elasticity	$\sigma = 0.34$	Unemployment benefit	$b = 0.33$
Risk aversion	$\gamma = 1$	Firing costs	$F = 0.06$
Discount factor	$\beta = 0.99$	Matching function elasticity	$\varepsilon = 0.6$
EOS, home and foreign goods	$\phi_T = 6$	Home bias	$1 - \alpha_T = 0.6$
EOS, tradables and non-tradables	$\phi_N = 0.5$	Share of non-tradables consumption	$\alpha_N = 0.80$
Share of non-tradables in manufacturing	$\xi = 0.6$	Bond adjustment cost	$\psi = 0.0025$
Technological entry cost	$f_T = 0.73$	Workers' bargaining power	$\eta = 0.6$
Regulation entry cost	$f_R = 1.09$	Home production	$h_P = 0.6$
Plant exit	$\delta = 0.004$	Matching efficiency	$\chi = 0.45$
Investment adjustment costs	$\nu_K = 0.16$	Vacancy cost	$k = 0.11$
Capital depreciation rate	$\delta_K = 0.025$	Exogenous separation rate	$\lambda = 0.036$
Capital share	$\alpha = 0.33$	Lognormal shape	$\sigma_{z_i} = 0.14$
Capital utilization, scale	$\varkappa = 0.035$	Lognormal scale	$\mu_{z_i} = 0$
Consumption habits	$h_C = 0.6$	Capital utilization, convexity	$\varsigma = 0.41$
TFP, standard deviation	$\sigma_Z = 0.007$	TFP, covariance	$\sigma_{ZZ^*} = 0.253$
TFP, persistence	$\phi_{11} = 0.999$	TFP, spillover	$\phi_{12} = 0$

TABLE 2: MODEL PROPERTIES

Variable $X$	$\sigma_X$		$Corr(Y_{R,t}, X_t)$		$Corr(X_t, X_{t-1})$	
	Data	Model	Data	Model	Data	Model
GDP ( $Y_R$ )	<b>1.45</b>	1.45	<b>1</b>	1	<b>0.76</b>	0.83
Consumption ( $C_R^M$ )	<b>0.63</b>	0.80	<b>0.63</b>	0.92	<b>0.78</b>	0.92
Investment ( $I_{KR}$ )	<b>3.02</b>	3.02	<b>0.92</b>	0.89	<b>0.90</b>	0.94
Unemployment ( $U$ )	<b>5.55</b>	5.55	<b>-0.87</b>	-0.82	<b>0.93</b>	0.92
Vacancies ( $V$ )	<b>9.01</b>	11.00	<b>0.80</b>	0.78	<b>0.93</b>	0.55
$corr(U_t, V_t)$	<b>-0.66</b>	-0.26				

Note: Data moments are computed for the period 1995:Q1 to 2013:Q1.

Actual and model-generated data are HP-filtered with smoothing parameter equal to 1600.

$\sigma_X \equiv$  standard deviation of variable  $X$  (in percentage terms).

TABLE 3: WELFARE EFFECTS OF UNANTICIPATED REFORMS

	Reform in Steady State	Reform in a Recession Home Welfare Change**	Reform in a Boom*
Entry Barriers	0.59%	0.58%	0.59%
Firing Costs	0.11%	0.08%	0.12%
Unemployment Benefit	0.59%	0.62%	0.58%
Home Production	0.55%	0.59%	0.52%
Joint Reform***	0.68%	0.69%	0.68%
		Foreign Welfare Change**	
Entry Barriers	0.03%	0.03%	0.03%
Firing Costs	0.01%	0.01%	0.01%
Unemployment Benefit	0.06%	0.06%	0.05%
Home Production	0.08%	0.09%	0.08%
Joint Reform***	0.04%	0.03%	0.04%

Notes: \* Included for completeness of comparison. Expansion is assumed symmetric to recession.

\*\* Welfare change  $\Delta$  expressed as percentage of pre-deregulation steady-state consumption.

\*\*\* Reduction in barriers to entry, firing costs, and unemployment benefits.

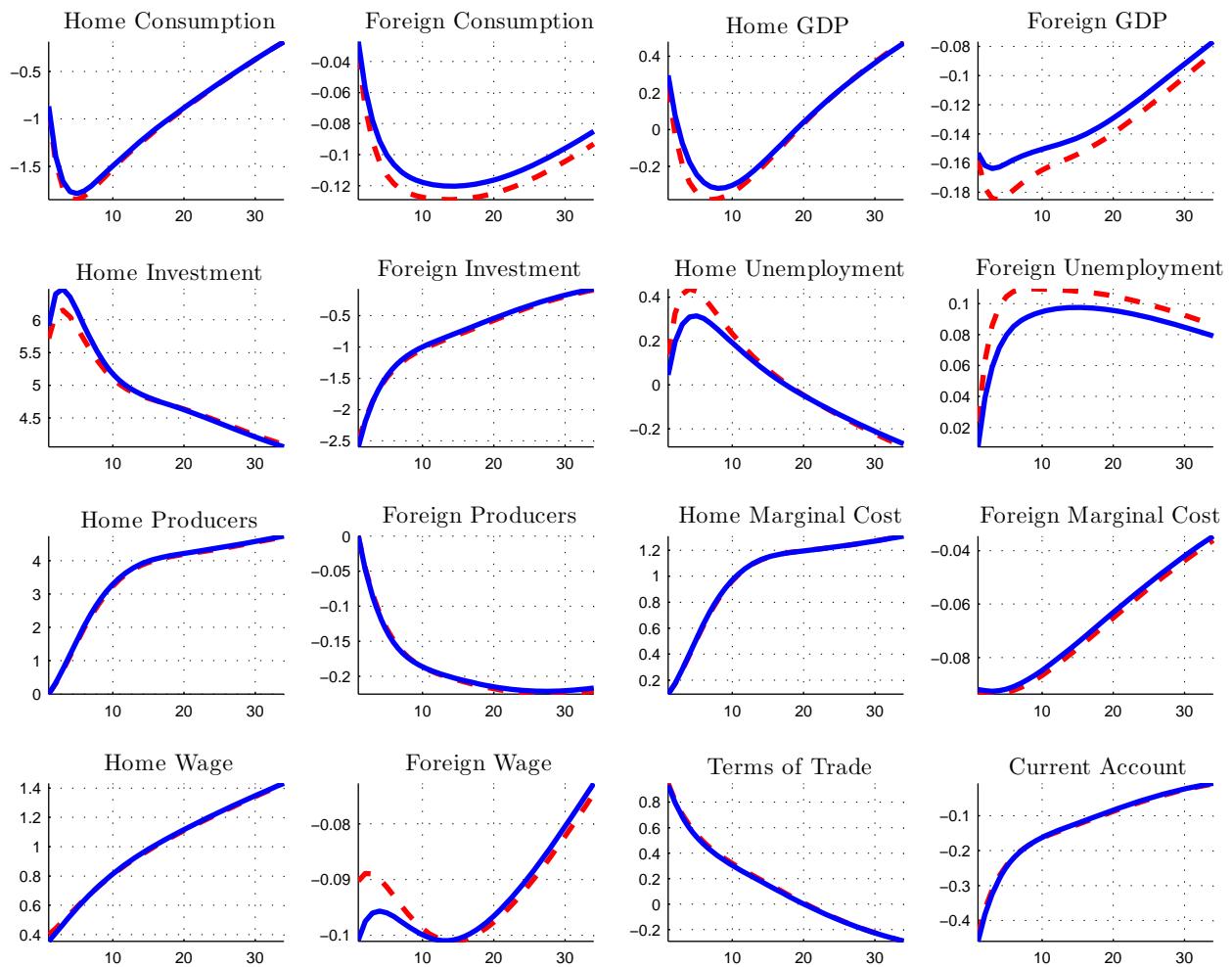
TABLE 4: WELFARE EFFECTS OF ANTICIPATED REFORMS

	Reform in Steady State	Reform in a Recession Home Welfare Change**	Reform in a Boom*
Entry Barriers	0.59%	0.59%	0.59%
Firing Costs	0.11%	0.10%	0.12%
Unemployment Benefit	0.59%	0.61%	0.58%
Home Production	0.55%	0.59%	0.52%
Joint Reform***	0.68%	0.69%	0.68%
		Foreign Welfare Change**	
Entry Barriers	0.03%	0.03%	0.03%
Firing Costs	0.01%	0.01%	0.01%
Unemployment Benefit	0.06%	0.06%	0.05%
Home Production	0.08%	0.09%	0.08%
Joint Reform***	0.04%	0.03%	0.04%

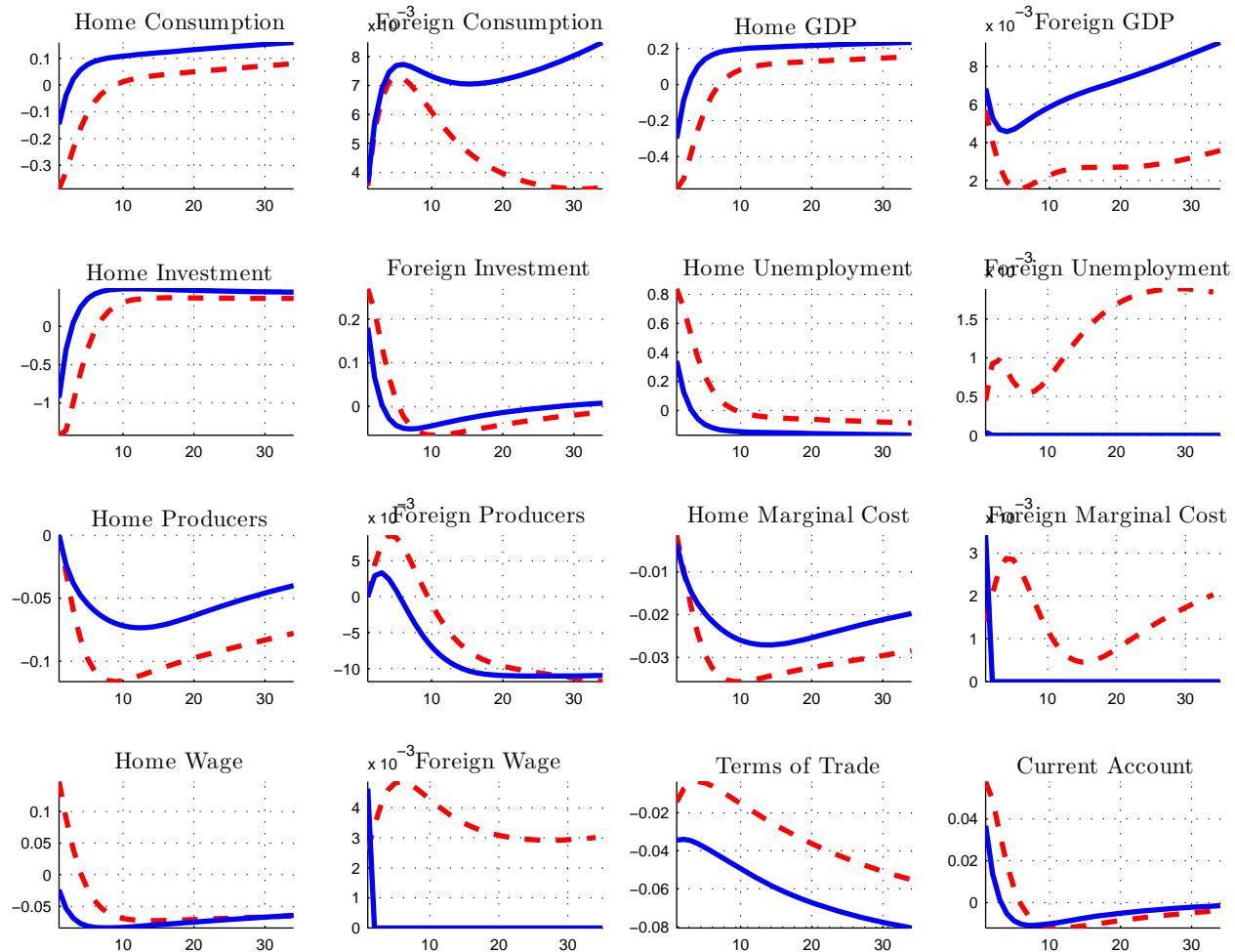
Notes: \* Included for completeness of comparison. Expansion is assumed symmetric to recession.

\*\* Welfare change  $\Delta$  expressed as percentage of pre-deregulation steady-state consumption.

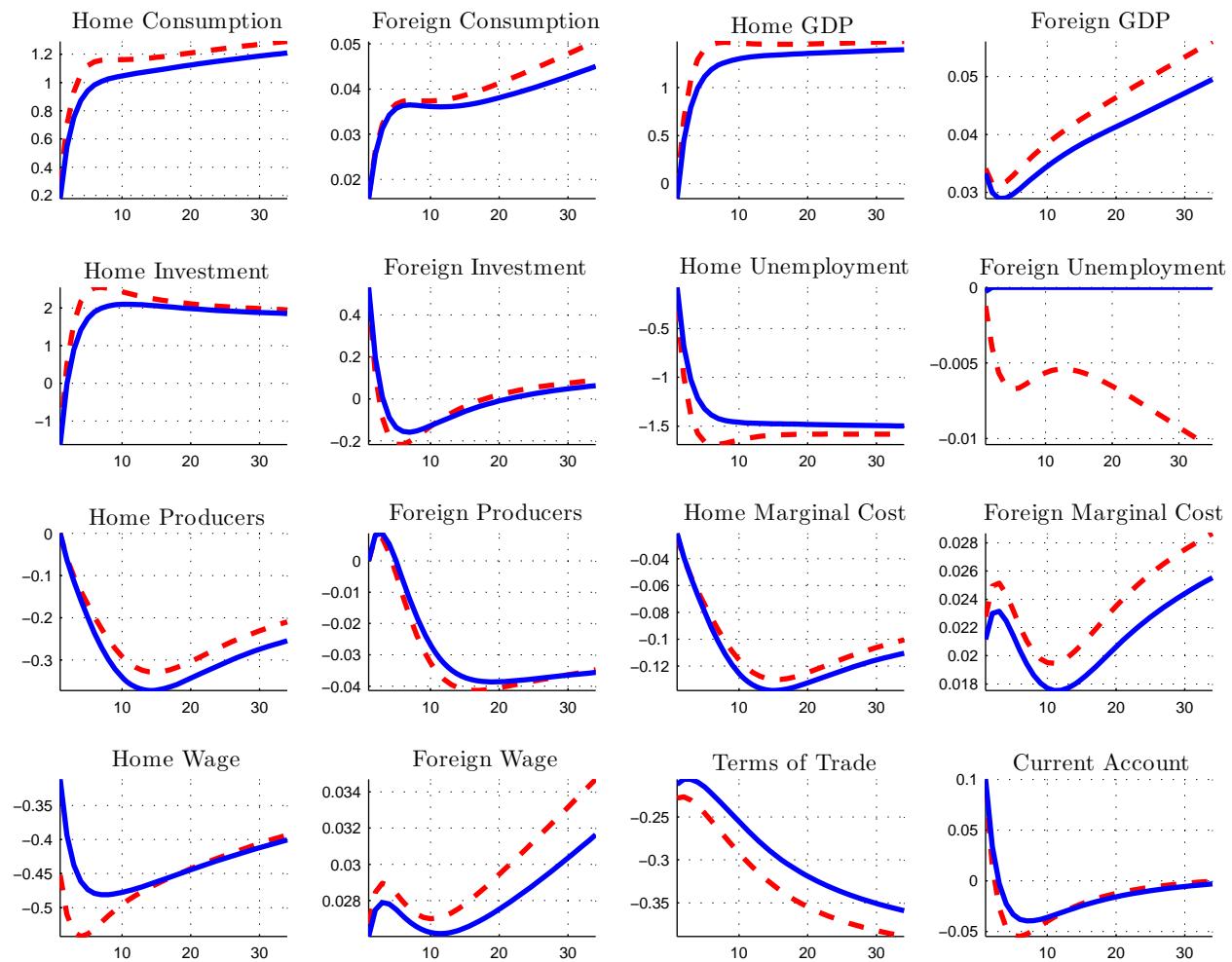
\*\*\* Reduction in barriers to entry, firing costs, and unemployment benefits.



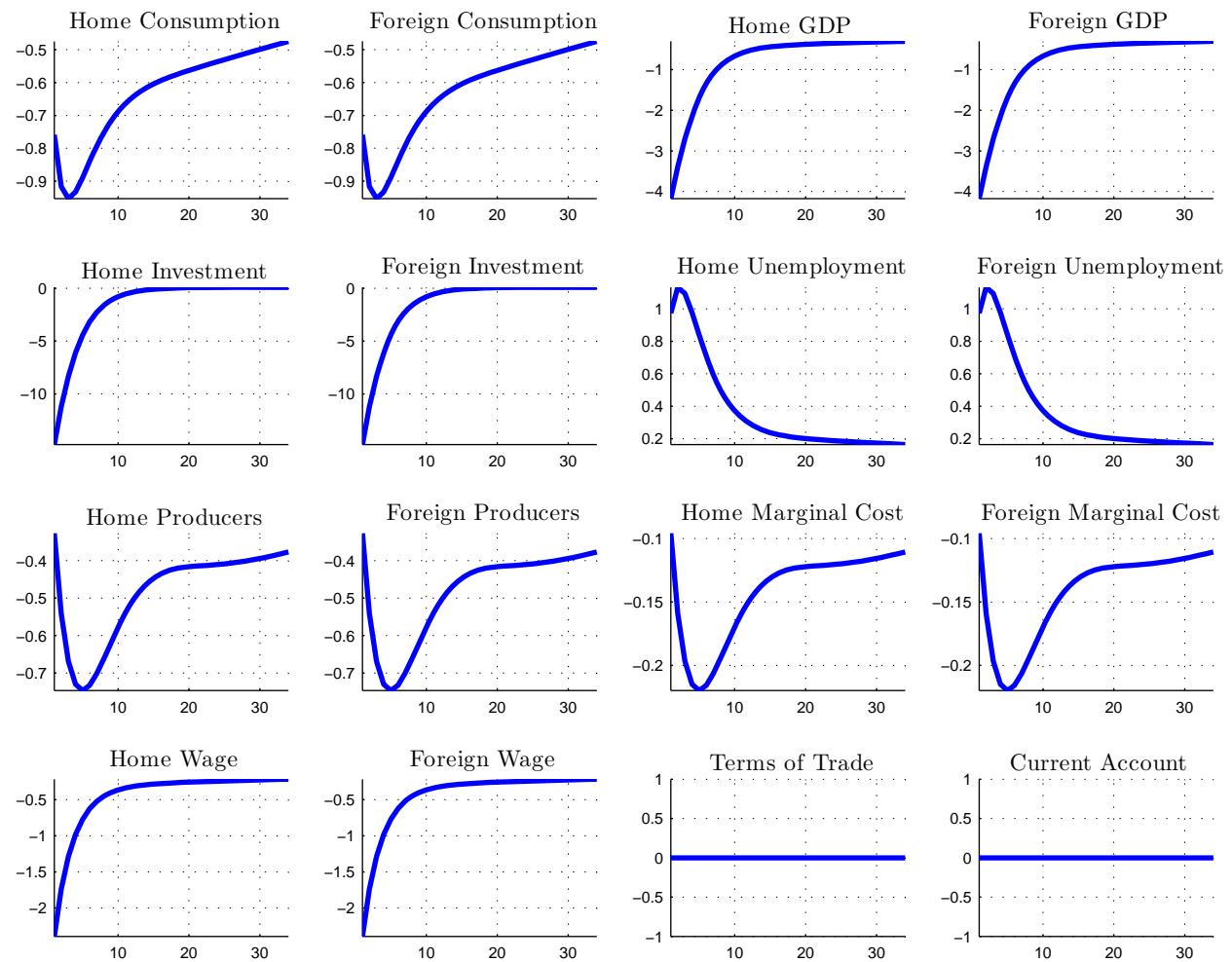
**Figure 1.** Home product market reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



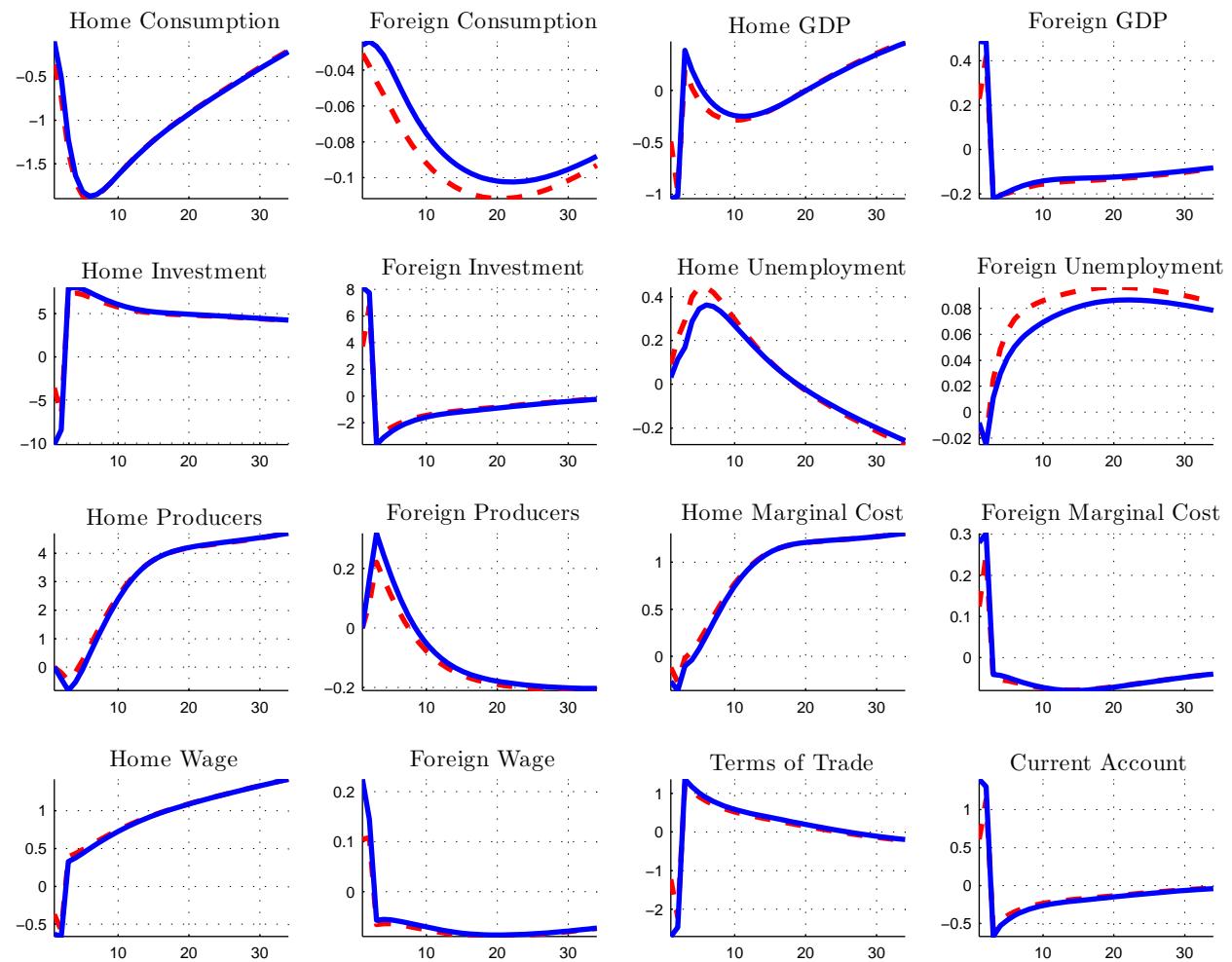
**Figure 2.** Home firing costs reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



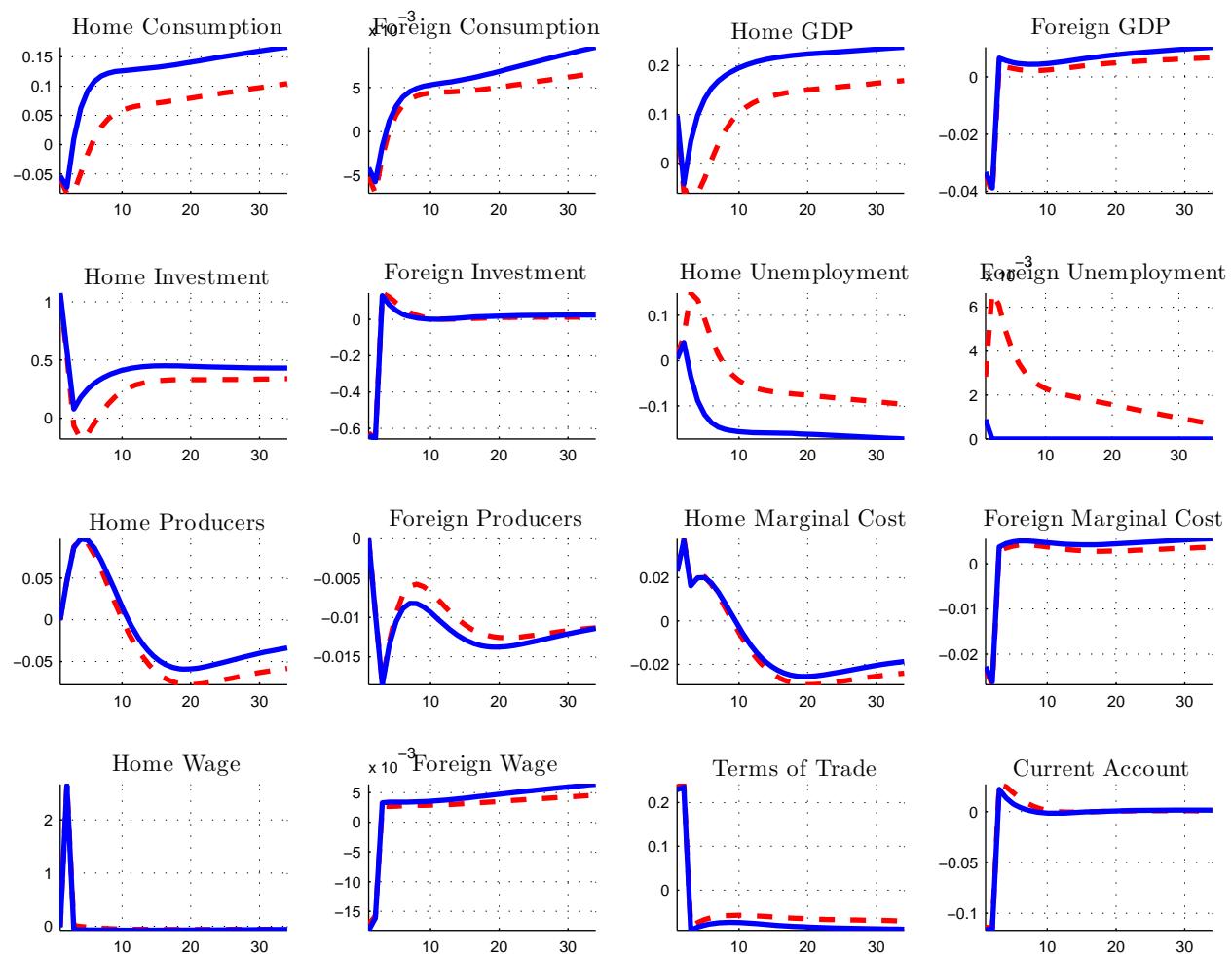
**Figure 3.** Home unemployment benefits reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



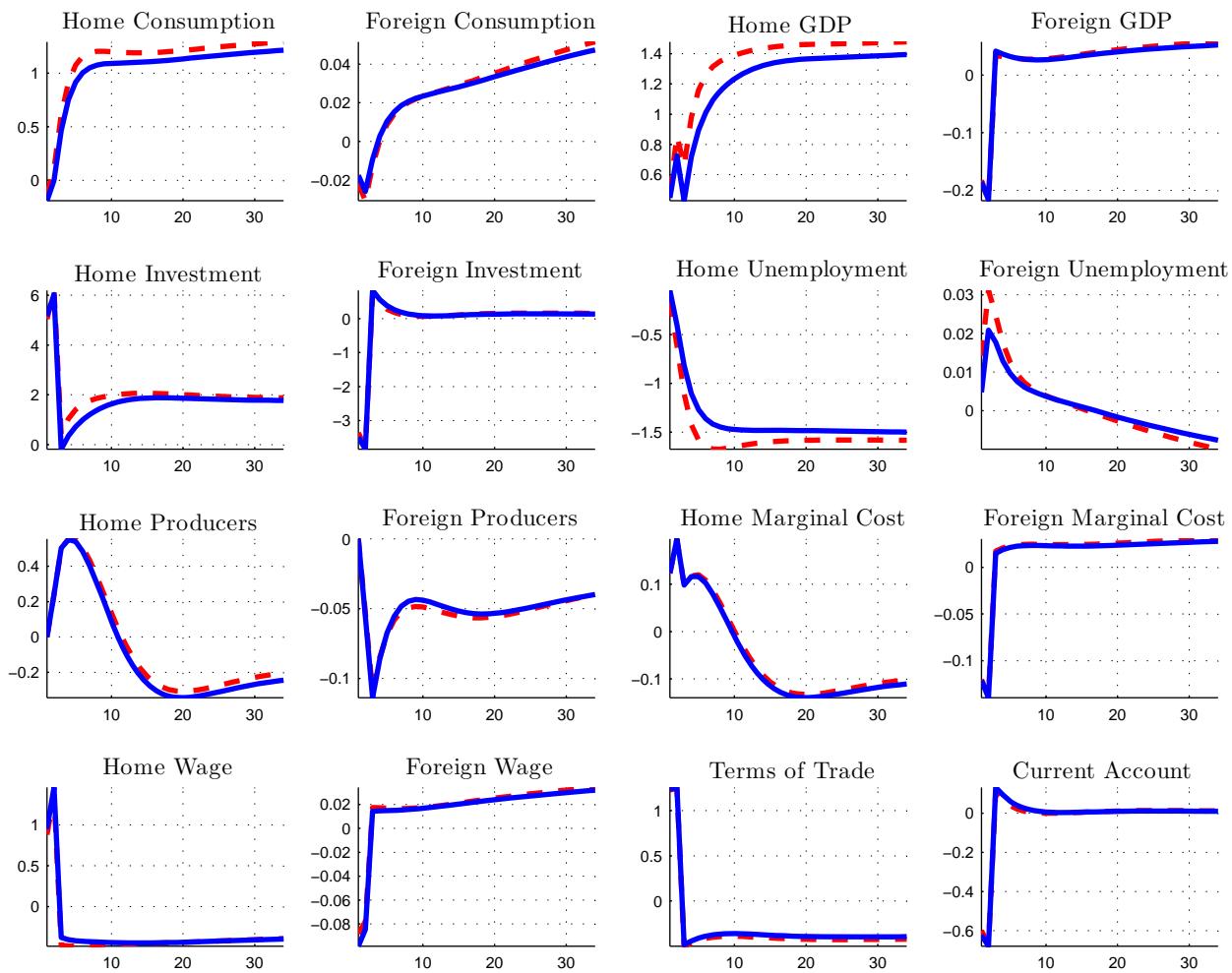
**Figure 4.** Home and Foreign negative productivity shock with high regulation. Responses show percentage deviations from the steady state. Unemployment is in deviations from the steady state.



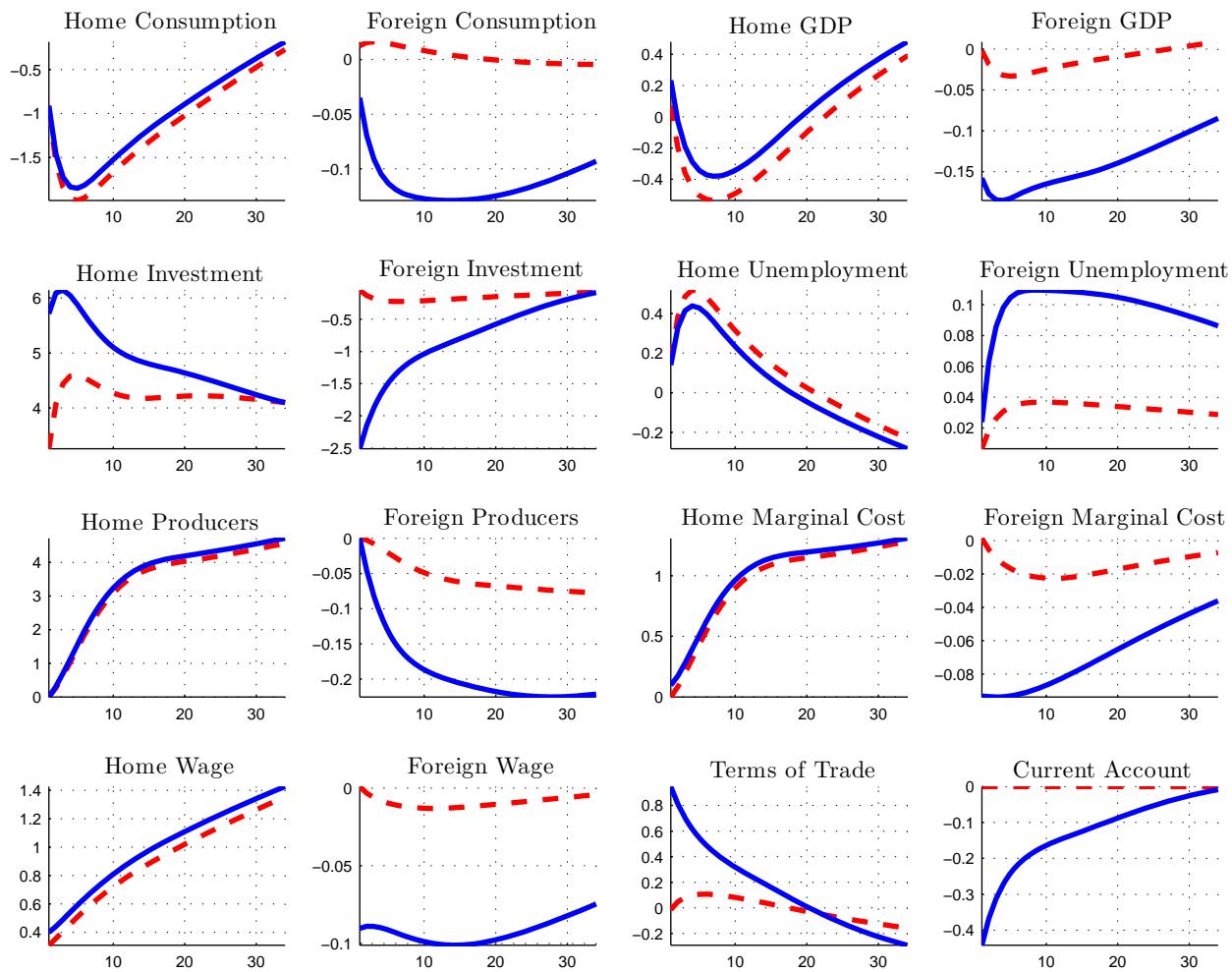
**Figure 5.** Anticipated Home product market reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



**Figure 6.** Anticipated Home firing costs reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



**Figure 7.** Anticipated Home unemployment benefits reform, normal times (continuous lines) versus recession (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.



**Figure 8.** Home product market reform in a recession, open capital account (continuous lines) versus financial autarky (dashed lines). Responses show percentage deviations from the initial steady state. Unemployment is in deviations from the initial steady state.