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# The macroeconomic effects of goods and labor markets deregulation ☆

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ABSTRACT

We study the macroeconomic effects of deregulating the goods and labor markets. To this end, we introduce endogenous product creation and labor market frictions in an otherwise-standard real business cycle model. Regulation affects producer entry costs, firing restrictions, and unemployment benefits. We find that reforms can have short-run recessionary effects, despite being expansionary in the long run. Estimates from a panel VAR for OECD countries provide empirical support for this result. Moreover, market deregulation has sizable effects on the efficiency of business cycle fluctuations. Increased flexibility in both goods and labor markets lowers the level and volatility of the inefficiency wedges that distort agents' equilibrium decisions, leading to a substantial reduction in the welfare cost of business cycles. Nevertheless, individual reforms produce contrasting effects.



## 1. Introduction

Since the early 1980s, the stringency of product and labor market regulation has been considered a key contributing factor to the poor record of job creation and high unemployment in many European countries. Calls for removal, or at least a reduction, of market regulation have predominantly focused on regulatory barriers to market entry, firing restrictions, and the generosity of unemployment benefits (OECD, 2005). The recent financial crisis that hit European countries reheated the debate. At a time when the conventional tools of demand-side macroeconomic policy are constrained, policies aimed at deregulating product and labor markets have been the cornerstone of international agencies' advice to the euro area periphery (see, for instance, IMF, 2010 and OECD, 2012).

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In the academic literature, a large body of research supports the view that lower product and labor market regulation improves long-run economic performance.[3] However, less is known about the short-run consequences of reducing regulation. Do product and labor market reforms entail significant adjustment costs? Does market flexibility change the characteristics of business cycles? Understanding these dynamic effects is important, for at least two reasons. It helps clarify how market reforms affect economic activity and welfare beyond steady-state outcomes; and, it may contribute to explaining the historical aversion of governments to implement reforms.

Thus far, relatively few studies have addressed how reforms affect macroeconomic dynamics, and focus solely on the business cycle implications of labor market regulation. Our contribution adds to the existing literature along three dimensions. First, we develop a novel theoretical framework that allows us to capture key empirical features of product and labor market regulation and reform. Second, we investigate how the adoption of reforms—both individually and jointly—affects short-run macroeconomic dynamics and business cycle fluctuations. Third, we address the consequences of such dynamic effects for welfare and efficiency.

To this end, we embed endogenous product creation and labor market frictions in an otherwise-standard Real Business Cycle (RBC) model. We integrate two leading frameworks developed to study product and labor market dynamics. The endogenous variation of monopolistically competitive firms builds on Bilbiie et al. (2012). Labor markets are characterized by search-and-matching frictions, with endogenous job creation and destruction as in Mortensen and Pissarides (1994) and den Haan et al. (2000).[4] Since variations in the number of producers induce changes in the competitive environment, we allow markups to endogenously vary because of demand-side pricing complementarities. The dimensions of deregulation that we consider are: (1) a reduction in barriers to entry (by cutting sunk entry costs) in the product market; (2) lower firing costs; (3) a reduction in unemployment benefits.

We calibrate the model in order to match euro area macroeconomic data, and show that the model successfully reproduces several features of euro area business cycles. We then study the effect of lowering entry barriers, unemployment benefits, and firing costs to their U.S. counterparts, in order to mimic the transition to a more deregulated economy. Consistent with previous work, we find that market deregulation increases employment and output in the long-run.

In addition, we find that market deregulation entails important dynamic effects. Two main results emerge. First, product and labor market reforms may have recessionary effects in the short run. Importantly, different types of reforms lead to adjustment along different margins. Product market deregulation features a slow reallocation of resources from incumbents to new entrants. Labor market deregulation in the form of lower firing costs leads instead to temporary layoffs of less productive workers, without triggering large firm dynamics. In both these cases, unemployment increases and output falls in the short run. We provide econometric evidence in support of these results by estimating a panel VAR for OECD countries over the period 1982–2005.

Second, market deregulation affects the volatility of business cycles, with important consequences for the efficiency of aggregate fluctuations. Increased flexibility in both goods and labor markets lowers the level and volatility of the inefficiency wedges that distort agents' equilibrium decisions, reducing the welfare cost of business cycles by 1.38 percent of pre-deregulation steady-state consumption. Yet, when only firing costs are removed, the cost of fluctuations increases by more than 2.03 percent. The intuition for this result is that the distortions induced by high barriers to entry and unemployment benefits create an endogenous connection between macroeconomic volatility and the average level of consumption around which the economy fluctuates. When these two dimensions of regulation are lifted, wages absorb more of the productivity fluctuations and markups become less volatile, leading to lower firm-level and aggregate volatility. Since product and job creation are sensitive to uncertainty about and anticipation of future profits, lower volatility increases the average value of producer entry, employment, and investment toward their socially efficient levels, raising consumption and welfare. By contrast, the removal of firing costs alone increases the measure of jobs that are sensitive to destruction, making job flows, unemployment, and output more volatile. This effect is large when real wages are acyclical and markups volatile but small in the opposite scenario. Accordingly, when both barriers to entry and unemployment benefits are high, the removal of firing costs results in business cycles that are more inefficiently volatile, increasing (instead of lowering) dynamic distortions. This result suggests that policies' interdependence is a key factor to consider when implementing market deregulation.

Before discussing how our paper relates to the literature, we note some caveats in interpreting our results. First, we assume full commitment to permanent deregulation. Second, for tractability reasons, we assume that agents engage in perfect risk sharing within their households. Thus, this paper does not address the distributional consequences of reforms. While these are important topics for future research, we believe that the channels through which market reforms affect aggregate macroeconomic dynamics in the present study are likely to be robust to future analysis.[5]

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[3] Various empirical studies document that high unemployment benefits and more rigid employment laws increase aggregate unemployment; see, among others, Bernal-Verdugo et al. (2012), Botero et al. (2004), Elmeskov et al. (1998), and Nickell (1997). Bertrand and Kramarz (2002) show that barriers to entry hinder job creation and employment growth, while Fiori et al. (2012) find that product market deregulation is more effective at the margin when labor market regulation is high.

[4] den Haan et al. (2000) embed the Mortensen and Pissarides' (1994) model into a full general equilibrium RBC model. We augment their framework by introducing endogenous product creation and modeling labor market frictions within the context of a large firm setup. In so doing, we allow product and labor market regulation to affect both the size and the number of producing firms.

[5] For instance, Krusell et al. (2010) introduce Bewley–Huggett–Aiyagari incomplete markets in the one-firm-one-worker search and matching model. They show that raising unemployment benefits reduces long-run welfare, since aggregate labor-market inefficiencies significantly outweigh the benefits

Our paper contributes to a large and varied literature on the macroeconomic consequences of product and labor market regulation and reform. One 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 or the implications of deregulation for business cycle fluctuations. Our closest antecedent in this vein of work is the seminal article by Blanchard and Giavazzi (2003), who study the consequences of deregulation in product and labor markets, with an emphasis on the political economy aspects of reforms.[6]

Another strand of the literature investigates how labor market institutions affect business cycle fluctuations and the transmission of monetary policy, without addressing their implications for efficiency and welfare.[7] A notable exception is Veracierto (2008), who analyzes the role of firing costs in a RBC model with establishment level dynamics. He finds that lowering firing costs increases macroeconomic volatility without affecting the welfare cost of business cycles. A key message of our paper is that the level of regulation, both in product and labor markets, has first-order consequences for the efficiency of aggregate fluctuations and their welfare cost. Concerning the role of firing costs, the difference between our findings and those in Veracierto (2008) is explained by two factors. First, for tractability reasons, the computational method used by Veracierto relies on a linear approximation around the deterministic steady state, implying that macroeconomic volatility affects consumption variability but not average consumption, akin to the welfare costs initially studied by Lucas (1987).[8] Second, following the removal of firing costs, aggregate fluctuations are Pareto efficient in Veracierto (2008), whereas dynamic distortions increase in our model. Put differently, it is only when barriers to entry and unemployment benefits are reduced that the removal of firing costs opens the door to sizable welfare gains.

None of the aforementioned studies consider transition dynamics following deregulation, and all abstract from endogenous producer entry. In contrast, by incorporating micro-level product dynamics and search and matching frictions into a standard RBC setting, we also contribute to a recent and growing literature that studies the importance of product creation and turnover for welfare and macroeconomic dynamics. Notable recent contributions that focus on the role of endogenous producer entry subject to irreversible investment costs include Bilbiie et al. (2012), Ghironi and Melitz (2005), and Jaimovich and Floetotto (2008). Petrosky-Nadeau and Wasmer (2011) focus instead on the consequences of matching frictions in the goods, labor and credit markets.[9]

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 and the business cycle implications of market reforms. Section 5 discusses how regulation affects efficiency and welfare. Section 6 evaluates the robustness of the results to alternative parameterizations. Section 7 concludes. Technical details of the derivations and proofs are provided in a Web-based technical appendix (henceforth, the Appendix).

## 2. The model

All contracts and prices are written in nominal terms, and prices are flexible. Thus, we only solve for the real variables in the model. Currency only serves as a unit of account in our model, and we work in a cashless environment as in Woodford (2003).

### 2.1. Household preferences

The 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. 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.

The representative household maximizes the expected intertemporal utility function

$$E_0\left[\sum_{t=0}^{\infty}\beta^t C_t^{1-\gamma}/(1-\gamma)\right], \tag{1}$$

from insurance beyond self-insurance. In a similar model, Nakajima (2012) shows that the cyclical properties of unemployment and vacancies are affected little by strengthening or shutting down the uninsured individual unemployment risk.

[6] Other contributions include Ebell and Haefke (2009), Fang and Rogerson (2011), and Felbermayr and Prat (2011), who study the long-run consequences of product market reforms; Alessandria and Delacroix (2008), Alvarez and Veracierto (1999), Bentolila and Bertola (1990), and Hopenhayn and Rogerson (1993) focus on labor market regulation. Koeniger and Prat (2007) study the effects of firing costs and sunk entry costs on firm and job turnover.

[7] Christoffel et al. (2009) show that the efficiency of the matching process affects the transmission of monetary policy. Thomas and Zanetti (2009) and Zanetti (2011) focus on firing costs and unemployment benefits, extending the partial-equilibrium analysis in Yashiv (2004).

[8] Up to the first order, volatility does not affect the variables' mean values, since the expected value of each variable coincides with its nonstochastic steady. For this reason, we resort to a second-order accurate solution to the model.

[9] Cacciatore (2014) studies how labor market frictions affect short-run dynamics following trade integration in a two-country version of the present model that also features firm heterogeneity. See Bilbiie et al. (2012) for a more complete list of references.

where $\beta \in (0, 1)$ is the discount factor, and $C_t$ represents consumption of market and home-produced goods. Consumption of market goods, denoted with $C_t^M$, consists of a basket of goods defined over a continuum $\Omega$. At any given point in time, only a subset of goods $\Omega_t \in \Omega$ is available. We assume that the aggregator $C_t^M$ takes a translog form following Feenstra (2003b). As a result, the elasticity of substitution across varieties within the basket $C_t^M$ 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 et al. (2007).[10] Translog preferences are characterized by defining the unit expenditure function (i.e., the price index) associated with the preference aggregator. Let $p_{\omega t}$ be the nominal price for the good $\omega \in \Omega_t$. The unit expenditure function on the basket of goods $C_t^M$ is given by:

$$\ln P_t = \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}}\right) + \frac{1}{N_t}\int\limits_{\omega\in\Omega_t} \ln p_{\omega t} d\omega + \frac{\sigma}{2N_t}\int\limits_{\omega\in\Omega_t}\int\limits_{\omega'\in\Omega_t} \ln p_{\omega t}(\ln p_{\omega t} - \ln p_{\omega' t}) d\omega d\omega', \tag{2}$$

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 $\Omega$.

Following Mortensen and Pissarides (1994) and much of the literature, we assume that each unemployed worker produces $h_p$ nontradable units of consumption, capturing the value of leisure time and domestic activities.[11] Total consumption is then $C_t = C_t^M + (1 - L_t) h_p$, where $L_t$ denotes the number of employed workers.

### 2.2. Production

There is a continuum of monopolistically competitive firms, each producing a different variety $\omega$. Following the language convention of most of the macroeconomic literature, we assume coincidence between a producer, a product, and a firm. However, as in Bilbiie et al. (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 et al. (2010).

The number of firms serving the market is endogenous. Prior to entry, firms face a sunk entry cost $f_{E,t}$, to be specified later on. 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 et al. (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).

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 et al. (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 $i$ at firm $\omega$ produces $Z_t z_{it} k_{i\omega t}^{\alpha}$ units of output, where $Z_t$ denotes aggregate productivity, $z_{it}$ represents a random disturbance that is specific to match $i$, and $k_{i\omega t}$ is the stock of capital allocated to the job. Within each firm, jobs with identical productivity $z_{it}$ 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 $g(z)$.[12] 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 $Z_t$ follows an $AR(1)$ process in logs, $\log Z_t = \phi_Z \log Z_{t-1} + \epsilon_t$, where $\epsilon_t$ represents $i.i.d.$ draws from a normal distribution with zero mean and standard deviation $\sigma_Z$.

Total output for producer $\omega$, denoted with $y_{\omega t}$, is given by

$$y_{\omega t} = Z_t l_{\omega t}\left[1 - G(z_{\omega t}^c)\right]^{-1}\int\limits_{z_{\omega t}^c}^{\infty} k_{\omega t}^{\alpha}(z)\, z g(z) dz, \tag{3}$$

where $l_{\omega t}$ is the measure of jobs within the firm, and the term $z_{\omega t}^c$ represents an endogenously determined critical threshold below which jobs that draw $z_t < z_{\omega t}^c$ are not profitable. In this case, the value to the firm of continuing the match is less

[10] A demand-, preference-based explanation for time-varying, flexible-price markups is empirically appealing because the data show that most entering and exiting firms are small, and much of the change in the product space is due to product switching within existing firms, pointing to a limited role for supply-driven competitive pressures in markup dynamics. Bilbiie et al. (2012) find that translog preferences result in markup dynamics that are remarkably close to U.S. data. Bergin and Feenstra (2000) show that a translog expenditure function generate plausible endogenous persistence in macro models. For a review of the applications of translog preferences in the trade literature, see Feenstra (2003a).

[11] It follows that $h_p$ takes the same translog form as the bundle of market consumption. Home production in standard RBC settings has been considered by Benhabib et al. (1991) and Greenwood and Hercowitz (1991). In contrast to these papers, our results do not rely on stochastic variability of the home-production technology.

[12] As is common in the literature, the $i.i.d$ assumption is for analytical tractability, as it eliminates the need to consider match-specific state variables for continuing relationships. den Haan et al. (2000) show that the addition of a persistent component to the process of idiosyncratic shocks does not significantly affect aggregate dynamics.

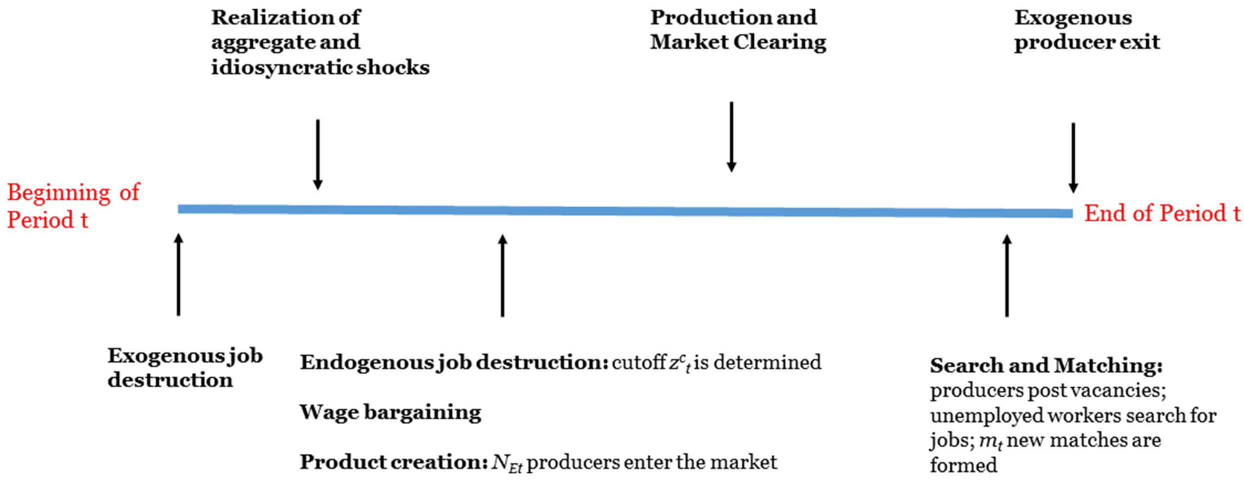


**Fig. 1.** Timing of events.

than the value of separation, and the job is destroyed. When terminating a job, each firm incurs a real cost $F$. 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 $\lambda^x$ 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 $q_t \equiv M_t/V_t$.

The timing of events, summarized in Fig. 1, proceeds as follows: At the beginning of each period, a fraction $\lambda^x$ of jobs are exogenously separated in each firm. Aggregate and idiosyncratic shocks are then realized, after which firms choose the productivity threshold $z^c_{\omega t}$ that determines the measure of jobs endogenously destroyed, $G\left(z^c_{\omega t}\right)$. Once the firing round has taken place, firms post vacancies, $v_{\omega t}$, and select their total capital stock, $k_{\omega t} = l_{\omega t}\tilde{k}_{\omega t}$, where $\tilde{k}_{\omega t} \equiv \int_{z^c_{\omega t}}^{\infty} k_{\omega t}(z)\, g(z)dz/\left[1 - G\left(z^c_{\omega t}\right)\right]$.[13] The assumption that firms select capital after observing aggregate and idiosyncratic shocks follows den Haan et al. (2000).

The inflow of new workers and the outflow of workers due to separations jointly determine the evolution of firm-level employment:

$$l_{\omega t} = (1 - \lambda_{\omega t})\,(l_{\omega t-1} + q_{t-1} v_{\omega t-1})\,, \tag{4}$$

where $\lambda_{\omega t} \equiv \lambda^x + (1 - \lambda^x)G\left(z^c_{\omega t}\right)$ represents the total fraction of jobs destroyed within the firm. When a firm exits the market, its entire stock of workers becomes unemployed. All separated workers are assumed to immediately reenter the unemployment pool.

*2.2.1. Profit maximization*

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

$$y_{\omega t} = \sigma \ln\left(\bar{p}_t/p_{\omega t}\right) P_t Y_t/p_{\omega t}, \tag{5}$$

where $\ln \bar{p}_t \equiv (1/\sigma N_t) + (1/N_t)\int_{\omega\in\Omega_t} \ln p_{\omega t} d\omega$ 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, $p_{\omega t} y_{\omega t}$, is a time-varying fraction of the aggregate demand $P_t Y_t$. The firm's time-varying market share, $\sigma \ln\left(\bar{p}_t/p_{\omega t}\right)$, depends on the price chosen by the firm relative to the maximum admissible price.

As shown in the Appendix, owing to perfectly mobile capital rented in a competitive market, producer's output exhibits constant returns to scale in labor and capital:

[13] With full capital mobility and price-taker firms in the capital market, it is irrelevant whether producers choose $k_{\omega t}$, or, instead, determine the optimal capital stock for each individual job, $k_{\omega t}(z)$. See the Appendix for the proof.

$$y_{\omega t}=Z_t\tilde{z}_{\omega t}k_{\omega t}^{\alpha}l_{\omega t}^{1-\alpha}, \tag{6}$$

where

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

is a weighted average of the idiosyncratic productivity of individual jobs.

Let $\rho_{\omega t}\equiv p_{\omega t}/P_t$ be the variety $\omega$'s price in units of consumption. The firm per-period real profit is given by

$$d_{\omega t}=\rho_{\omega t}y_{\omega t}-\tilde{w}_{\omega t}l_{\omega t}-r_tk_{\omega t}-\kappa v_{\omega t}-G(z_{\omega t}^{c})\left(1-\lambda^{x}\right)(l_{\omega t-1}+q_{t-1}v_{\omega t-1})F, \tag{7}$$

where $r_t$ is the rental rate of capital and $\tilde{w}_{\omega t}\equiv\int_{z_{\omega t}^{c}}^{\infty}w_{\omega t}(z)g(z)dz/\left[1-G\left(z_{\omega t}^{c}\right)\right]$ is the average wage paid by the firm, weighted according to the distribution of the idiosyncratic job productivities.

Given the constraints in (4), (5), and (6), the firm's optimization problem is to choose the price of its product $\rho_{\omega t}$, employment $l_{\omega t}$, capital $k_{\omega t}$, the number of vacancies to be posted $v_{\omega t}$, and the job destruction threshold $z_{\omega t}^{c}$ to maximize the present discounted value of real profits: $E_t\left[\sum_{s=t}^{\infty}\beta_{s,t}(1-\delta)^{s-t}d_{\omega s}\right]$, where $\beta_{s,t}\equiv\beta\left(C_{t+s}/C_t\right)^{-\gamma}$. We assume that firms take wages as given when choosing employment and capital. Strictly speaking, however, producers face a downward sloping demand, and the scale of each firm changes nonlinearly with its labor and capital input. Thus, large firms' inputs adjustment should take into account that the choice of $k_{\omega t}$ and $l_{\omega t}$ potentially affects wages if they depend on the marginal product of labor (Cahuc et al., 2008). We abstract from the feedback effect of firms' employment and capital decisions on wages for computational convenience, since there is no closed-form solution to the intra-firm bargaining problem under translog preferences.[14]

Let $\varphi_{\omega t}$ be the Lagrange multiplier associated with the constraint (6), corresponding to the firm's real marginal cost of production. By combining the first-order conditions for $l_{\omega t}$ and $v_{\omega t}$, we obtain the following job creation equation for producer $\omega$:

$$\frac{\kappa}{q_t}=(1-\delta)\left(1-\lambda^{x}\right)E_t\left\{\beta_{t,t+1}\left[\left(1-G\left(z_{\omega t+1}^{c}\right)\right)\left(\tilde{\pi}_{\omega t+1}-\tilde{w}_{\omega t+1}+\frac{\kappa}{q_{t+1}}\right)-G\left(z_{\omega t+1}^{c}\right)F\right]\right\}, \tag{8}$$

where $\tilde{\pi}_{\omega t}\equiv(1-\alpha)\varphi_{\omega t}y_{\omega t}/l_{\omega t}$ represents the average marginal revenue product of labor. Equation (8) 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 $F$, 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 (8) 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 $z_{\omega t}^{c}$ implies the following job destruction equation:

$$\pi\left(z_{\omega t}^{c}\right)-w\left(z_{\omega t}^{c}\right)+\frac{\kappa}{q_t}=-F, \tag{9}$$

where $\pi\left(z_{\omega t}^{c}\right)\equiv\tilde{\pi}_{\omega t}\left(z_{\omega t}^{c}/\tilde{z}_{\omega t}\right)^{1/(1-\alpha)}$ denotes the marginal revenue product of the match. At the optimum, the value to the firm of a job with productivity $z_{\omega t}^{c}$ 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 $F$. 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.[15]

The first-order condition for $k_{\omega t}$ equates the marginal revenue product of capital to its marginal cost: $\alpha\varphi_{\omega t}y_{\omega t}/k_{\omega t}=r_t$. Finally, let $\theta_{\omega t}\equiv-\partial\ln y_{\omega t}/\partial\ln\rho_{\omega t}$ denote the price elasticity of total demand for variety $\omega$. The first-order condition with respect to $p_{\omega t}$ implies that the (real) output price $\rho_{\omega t}$ is equal to an endogenous, time-varying markup over marginal cost: $\rho_{\omega t}=\mu_{\omega t}\varphi_{\omega t}$, where $\mu_{\omega t}\equiv\theta_{\omega t}/(\theta_{\omega t}-1)=1+\ln\left(\bar{p}_t/p_{\omega t}\right)$. Notice that incumbents charge the same price (and thus face the same demand) provided they have the same real marginal cost. To see this, use the Lambert function, $W(\cdot)$, to solve for $1+\ln\left(\bar{p}_t/p_{\omega t}\right)$ as a function of $\varphi_{\omega t}$ and aggregate variables, thus obtaining a closed-form solution for $\rho_{\omega t}$:

[14] Our results are robust to an alternative version of the model featuring CES preferences and intra-firm bargaining. Dynamic models featuring monopolistic competition and search and matching frictions typically abstract from within-firm strategic bargaining, and assume surplus splitting between an individual worker and the firm; see, among others, Krause and Lubik (2007), Krause et al. (2008), and Faia (2009).

[15] Equation (9) 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.

$$\rho_{\omega t} = W\left(\exp(1)\,\frac{\bar{p}_t}{P_t\varphi_{\omega t}}\right)\varphi_{\omega t}, \tag{10}$$

where $\exp(X)$ denotes the exponential of $X$.[16] The above result ensures that the model features a symmetric equilibrium provided that $\varphi_{\omega t} = \varphi_t$. As shown below, the latter condition is met in every period.

### 2.2.2. Wage setting

Following Cooley and Quadrini (1999) and Krause and Lubik (2007), 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.[17] The analytical derivation of the wage equation is presented in the Appendix. We show there that the wage payment to each worker is a weighted average between the marginal revenue product of the match (plus a firing costs component) and the worker's outside option, denoted with $\varpi_t$:

$$w_{\omega t}(z) = \eta\left\{\pi_{\omega t}(z) + \left[1-(1-\delta)\left(1-\lambda^x\right)E_t\beta_{t,t+1}\right]F\right\} + (1-\eta)\,\varpi_t. \tag{11}$$

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

$$\varpi_t \equiv h_p + b + \int_{\omega\subset\Omega_t}^{\infty} \frac{s_t v_{\omega t}}{V_t}(1-\delta)\left(1-\lambda^x\right)E_t\left\{\beta_{t,t+1}\left[1-G\left(z^c_{\omega t+1}\right)\right]\tilde{\Delta}^W_{\omega t+1}\right\}d\omega, \tag{12}$$

where $s_t \equiv M_t/U_t$ is the job-finding probability. Unemployment benefits, in units of the consumption basket $C_t$, are a transfer from the government financed with lump-sum taxes.[18] The term $s_t v_{\omega t}/V_t$ in (12) represents the probability of a match with a producer $\omega$ when searching for jobs at time $t$; $\tilde{\Delta}^W_{\omega t}$ is the corresponding average worker surplus:

$$\tilde{\Delta}^W_{\omega t} = \tilde{w}_{\omega t} - \varpi_t + (1-\delta)\left(1-\lambda^x\right)E_t\left\{\beta_{t,t+1}\left[1-G\left(z^c_{\omega t+1}\right)\right]\tilde{\Delta}^W_{\omega t+1}\right\}.$$

Finally, notice that firing costs affect wage payments in the following way: The firm rewards the worker for the saving in firing costs today (the first term in the square bracket in equation (11)), but it penalizes the worker for the fact that, in the case of firing, it will have to pay firing costs tomorrow.

## 2.3. Firm entry and symmetry among producers

In every period, there is a mass $N_t$ of firms producing in the economy and an unbounded mass of prospective entrants. These entrants are forward looking and form rational expectations of their expected future profits $d_{\omega s}$ in every period $s > t$. As in Bilbiie et al. (2012), entrants at time $t$ only start producing at time $t+1$, which introduces a one-period time-to-build lag in the model. Prospective entrants in period $t$ compute their expected post-entry value $e_t$, which corresponds to the present discounted value of their expected stream of profits: $e_{\omega t} \equiv E_t\left[\sum_{s=t+1}^{\infty}\beta_{s,t}(1-\delta)^{s-t}d_{\omega s}\right]$. The timing of entry and production we have assumed implies that the number of producing firms during period $t$ is given by $N_t = (1-\delta)(N_{t-1} + N_{Et-1})$, where $N_{Et-1}$ denotes the mass of new entrants at time $t-1$.

Prior to entry, firms face a sunk entry cost $f_{E,\omega t} \equiv f_R + f_T + \kappa v^e_{\omega t}$. The first two terms represent, respectively, the costs in terms of goods and services imposed by regulatory and administrative barriers to market entry ($f_R$) and technological requirements for business creation ($f_T$) such as research and development (R&D), nonresidential structures, etc. To pay for these costs, each firm has to purchase a basket of materials that has the same composition as the basket $Y_t$. The term $\kappa v^e_{\omega t}$, instead, corresponds to the real cost of posting vacancies to recruit workers (firms have zero workers when they enter the market).

The choice of the initial amount of labor is an important aspect of the model. If new entrants found it optimal to choose an initial number of workers that is different from that of existing incumbents, there would be ex-post heterogeneity across cohorts of producers that entered the market at different points in time. However, as shown in the Appendix, model tractability is preserved, since, upon entry, producers optimally hire the same mass of workers employed by existing incumbents, implying that the model features a symmetric equilibrium. To understand this result, notice that identically and independently distributed idiosyncratic shocks, together with linear hiring and firing costs, imply that the outside option of each firm (not being matched to a particular worker) only depends on aggregate conditions. As a result, in equilibrium all the producers choose the same job-productivity threshold $z^c_{\omega t} = z^c_t$, regardless of how long they have been on the market.

[16] The Lambert function has the following property: if $x = y\exp(y)$, then $y = W(x)$. To obtain equation (10), notice that $\left[1+\ln\left(\bar{p}_t/p_{\omega t}\right)\right]\times \exp\left(1+\ln\left(\bar{p}_t/p_{\omega t}\right)\right) = \exp(1)\,\bar{p}_t/(P_t\varphi_{\omega t})$, since $1+\ln\left(\bar{p}_t/p_{\omega t}\right) = p_{\omega t}/(P_t\varphi_{\omega t})$.

[17] As is common in the literature, we formulate the problem as though the worker is interested in maximizing expected discounted income. As pointed out by Rogerson et al. (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.

[18] The distinction between home production and unemployment benefits follows Mortensen and Pissarides (2002).

In turn, identical total factor productivity, $Z_t\tilde{z}_t$, implies that all firms face the same marginal cost, $\varphi_{\omega t} = \varphi_t$. Thus, equilibrium prices, quantities, and firm values are identical across firms. The representative new entrant posts $v_t^e = (l_t + q_t v_t)/q_t$ vacancies. Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition $e_t = f_{E,t}$.

### 2.4. Household budget constraint and first-stage budgeting

Households hold shares in a mutual fund of firms and own the total stock of capital of the economy, $K_t$. Following Bilbiie et al. (2012), investment in the mutual fund of firms in the stock market is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. Let $x_t$ be the share in the mutual fund held by the representative household at the beginning of period $t$. The mutual fund pays a total profit in each period (in units of consumption) equal to the total profit of all firms that produce in that period, $N_t d_t$. During period $t$, the representative household buys $x_{t+1}$ shares in a mutual fund of $N_t + N_{Et}$ firms (those already operating at time $t$ and the new entrants). The date-$t$ real price of a claim to the future profit stream of the mutual fund of $N_t + N_{Et}$ firms is equal to real price of claims to future firm profits, $e_t$.

Households accumulate the physical capital and rent it to firms producing at time $t$ in a competitive capital market. Investment in the physical capital stock, $I_{Kt}$, requires the use of the same composite of all available varieties as the basket $Y_t$. As standard practice in the literature, we introduce convex adjustment costs in physical investment in order to account for the smooth behavior of aggregate investment observed in the data.[19] Physical capital, $K_t$, obeys a standard law of motion:

$$K_{t+1} = (1-\delta_K) K_t + I_{Kt}\left[1-(\nu/2)(I_{Kt}/I_{Kt-1}-1)^2\right], \tag{13}$$

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

The per-period household's budget constraint is:

$$C_t + e_t(N_t + N_{Et})x_{t+1} + I_{Kt} = (d_t + e_t)N_t x_t + \tilde{w}_t L_t + r_t K_t + \left(h_p + b\right)(1-L_t) + T_t, \tag{14}$$

where $T_t$ are lump-sum taxes. The household maximizes its expected intertemporal utility subject to (13) and (14). The Euler equation for share holdings is: $e_t = (1-\delta) E_t\left[\beta_{t,t+1}(d_{t+1} + e_{t+1})\right]$; the Euler equation for capital accumulation requires: $\zeta_{Kt} = E_t\left\{\beta_{t,t+1}\left[r_{t+1} + (1-\delta_K)\zeta_{Kt+1}\right]\right\}$, where $\zeta_{Kt}$ denotes the shadow value of capital (in units of consumption), defined by the first-order condition for investment $I_{Kt}$:

$$1 = \zeta_{Kt}\left[1 - \frac{\nu}{2}\left(\frac{I_{Kt}}{I_{Kt-1}}-1\right)^2 - \nu\left(\frac{I_{Kt}}{I_{Kt-1}}-1\right)\left(\frac{I_{Kt}}{I_{Kt-1}}\right)\right] + \nu\beta_{t,t+1}E_t\left[\zeta_{Kt+1}\left(\frac{I_{Kt+1}}{I_{Kt}}-1\right)\left(\frac{I_{Kt+1}}{I_{Kt}}\right)^2\right].$$

### 2.5. Equilibrium

In the symmetric equilibrium, the elasticity of substitution across varieties is $\theta_t = 1 + \sigma N_t$, while the endogenous, time-varying markup is $\mu_t = 1 + (1/\sigma N_t)$. Translog preferences imply that as $N_t$ increases, goods become closer substitutes, reducing markups. The equilibrium price index in (2) implies that $p_t/P_t \equiv \rho_t = \exp\left[-\left(\tilde{N} - N_t\right)/\left(2\sigma\tilde{N}N_t\right)\right]$.

Aggregate employment is given by $L_t = N_t l_t$, while aggregate vacancies are the sum of vacancies posted by producing firms and new entrants: $V_t = (N_t + N_{Et})v_t + N_{Et}l_t/q_t$. By combining these two equilibrium conditions with the law of motion for employment at the firm level, we obtain the following law of motion of aggregate employment: $L_t = (1-\lambda_t^{tot})(L_{t-1} + q_{t-1}V_{t-1})$, where $\lambda_t^{tot} \equiv 1-(1-\lambda_t)(1-\delta)$. Searching workers in period $t$ are equal to the mass of unemployed workers: $U_t = (1-L_t)$. Since the total labor force is constant and equal to one, $U_t$ also measures the unemployment rate of the economy.

Market clearing for physical capital requires that $K_t = N_t k_t$. Total output is $Y_t = \rho_t Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha}$. Furthermore, since $x_t = x_{t+1} = 1$ and $T_t = -b(1-L_t)$, the household's budget constraint (14) yields the following aggregate resource constraint:

$$Y_t = C_t^M + I_{Kt} + N_{Et}(f_R + f_E) + \kappa V_t + F_t, \tag{15}$$

where $F_t \equiv F L_t G\left(z_t^c\right)/\left[1-G\left(z_t^c\right)\right]$ denotes aggregate firing costs. Intuitively, total output produced by firms 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.

Table 1 summarizes the equilibrium conditions of the model. The table contains 10 equations that determine 10 endogenous variables: $C_t$, $\rho_t$, $N_{t+1}$, $L_t$, $V_t$, $M_t$, $z_t^c$, $K_{t+1}$, $I_{Kt}$, $\zeta_{Kt}$. (The variables $s_t$, $q_t$, $\tilde{z}_t$, and $\mu_t$ that appear in the table depend on the above ten variables as previously described.) Additionally, the model features one exogenous variable: the aggregate productivity $Z_t$. Since we model market deregulation as a one-time, permanent decrease in the size of administrative and regulatory barriers to entry, $f_R$, unemployment benefits, $b$, and firing costs, $F$, we do not denote the latter with a time subscript to economize on notation.

[19] For simplicity, we do not provide a microfoundation of capital market frictions. Reduced-form investment adjustment costs feature prominently in the literature on dynamic stochastic general equilibrium models; see Fiori (2012) and references therein.

**Table 1**
Model equations.

| | |
|---|---|
| (1) | $L_t = (1-\lambda_t)(1-\delta)(L_{t-1}+M_{t-1})$ |
| (2) | $K_{t+1} = (1-\delta_K)K_t + I_{Kt}\left[1-\frac{\nu}{2}\left(\frac{I_{Kt}}{I_{Kt-1}}-1\right)^2\right]$ |
| (3) | $1 = \zeta_{Kt}\left[1-\frac{\nu}{2}\left(\frac{I_{Kt}}{I_{Kt-1}}-1\right)^2 - \nu\left(\frac{I_{Kt}}{I_{Kt-1}}-1\right)\left(\frac{I_{Kt}}{I_{Kt-1}}\right)\right] + \nu\beta_{t,t+1}E_t\left[\zeta_{Kt+1}\left(\frac{I_{Kt+1}}{I_{Kt}}-1\right)\left(\frac{I_{Kt+1}}{I_{Kt}}\right)^2\right]$ |
| (4) | $\rho_t = \exp\left\{-\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right\}$ |
| (5) | $M_t = \chi U_t^{\varepsilon}V_t^{1-\varepsilon}$ |
| (6) | $1 = (1-\delta)E_t\left\{\beta_{t,t+1}\left[1+(f_T+f_R)^{-1}\left(1-\frac{1}{\mu_{t+1}}\right)\frac{Y_{t+1}}{N_{t+1}}\right]\right\}$ |
| (7) | $1 = \frac{q_t}{\kappa}E_t\tilde{\beta}_{t,t+1}\left\{(1-\eta)(1-\alpha)\left[1-G\left(z_{t+1}^c\right)\right]\frac{\rho_{t+1}}{\mu_{t+1}}Z_{t+1}\tilde{z}_{t+1}\left(\frac{K_{t+1}}{L_{t+1}}\right)^{\alpha}\left[1-\left(\frac{z_{t+1}^c}{\tilde{z}_{t+1}}\right)^{\frac{1}{1-\alpha}}\right]-F\right\}$ |
| (8) | $1 = \frac{q_t}{\kappa(q_t\eta\vartheta_t-1)}\left\{(1-\eta)\left[(1-\alpha)\frac{\rho_t}{\mu_t}Z_t\tilde{z}_t\left(\frac{K_t}{L_t}\right)^{\alpha}\left(\frac{z_t^c}{\tilde{z}_t}\right)^{\frac{1}{1-\alpha}}-(h_p+b)\right]+\left[1-\eta\left(1-E_t\tilde{\beta}_{t,t+1}(1-s_t)\right)\right]F\right\}$ |
| (9) | $1 = E_t\left\{\beta_{t,t+1}\left[\alpha\frac{\rho_{t+1}}{\mu_{t+1}}Z_{t+1}\tilde{z}_{t+1}\left(\frac{K_{t+1}}{L_{t+1}}\right)^{\alpha-1}\frac{1}{\zeta_{Kt}}+(1-\delta_K)\frac{\zeta_{Kt+1}}{\zeta_{Kt}}\right]\right\}$ |
| (10) | $\rho Z_t\tilde{z}_tK_t^{\alpha}L_t^{1-\alpha}+h_p(1-L_t) = C_t + I_{Kt} + \kappa V_t + \left(\frac{N_{t+1}}{1-\delta}-N_t\right)(f_R+f_T)+\frac{G(z_t^c)}{1-G(z_t^c)}L_tF$ |

Note: $\beta_{t,t+1} \equiv \beta(C_{t+1}/C_t)^{-\gamma}$; $\tilde{\beta}_{t,t+1} \equiv (1-\delta)\left(1-\lambda^x\right)\beta_{t,t+1}$, and $\vartheta_t \equiv V_t/U_t$.

## 3. Calibration and model properties

### 3.1. 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 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 noticed, data are taken from the Eurostat database.[20] We use the NIPA definition of GDP as total income: $Y_t^g \equiv \tilde{w}_tL_t + r_tK_t + N_td_t$, which equals the sum of consumption, investment in physical capital, and product creation expenses: $Y_t^g = C_t^M + I_{Kt} + N_{Et}(f_R + f_T)$.[21] 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: the discount factor $\beta$, the risk aversion $\gamma$, the "share" parameter on capital in the Cobb–Douglas production function $\alpha$, and the capital depreciation rate $\delta_K$. We set $\beta = 0.99$, $\gamma = 1$, $\alpha = 0.33$, and $\delta_K = 0.025$. 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.[22] Moreover, 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., $\eta = \varepsilon$.[23]

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 et al. (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 follow Ebell and Haefke (2009) and convert into months of lost output the index for entry delay compiled by Pissarides (2003).[24] Following this procedure, the aggregate cost of product market regulation is 1.98 percent of GDP. We choose $f_T$

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[20] Data are available at http://epp.eurostat.ec.europa.eu.

[21] The inclusion of product creation expenses in $Y_t^g$ is consistent with the fact that intangible capital and nonresidential structures 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 et al. (2002).

[22] For the period 1995–2013, the average labor share in the euro area is 0.62.

[23] The Hosios condition requires the equality of the worker share of the surplus, $\eta$, and the worker's contribution to matching, $\varepsilon$. Absent other distortions, this condition implies that congestion and trading externalities that characterize the search and matching process exactly cancel out, leading to efficient job creation and destruction. See Section 6 for further details.

[24] The index compiles the number of business days required to fulfill entry requirements. We consider a weighted average of the index values across euro area member countries, with weights equal to the contributions of individual countries' GDPs to euro area total GDP. The implied entry cost at the producer level is a loss of 2.07 months of steady-state firm's output.

**Table 2**
Inefficiency wedges.

| | |
|---|---|
| (1) | $\Sigma_{PC,t} \equiv \frac{(1-\delta)}{f_T} E_t \left\{ \beta_{t,t+1} \frac{Y_{t+1}}{N_{t+1}} \left[ \Upsilon_{N,t+1} - \frac{\Upsilon_R}{(f_T+\Upsilon_R)(1+\sigma N)} \right] \right\}$ |
| (2) | $\Sigma_{JC,t} \equiv E_t \frac{q_t}{\kappa} \beta_{t,t+1} \left(1-\lambda^{tot}_{t+1}\right) \left\{ (1-\varepsilon)(1-\alpha) \frac{Y_{t+1}}{L_{t+1}} \left[ 1 - \left( \frac{z^c_{t+1}}{\tilde{z}_{t+1}} \right)^{\frac{1}{(1-\alpha)}} \right] \Upsilon_{\mu,t+1} + \frac{\Upsilon_F}{\left[1-G\left(z^c_{t+1}\right)\right]} \right\}$ |
| (3) | $\Sigma_{JD,t} \equiv \frac{q_t}{\kappa(q_t \varepsilon \vartheta_t - 1)} \left\{ (1-\varepsilon)(1-\alpha) \frac{Y_t}{L_t} \left( \frac{z^c_t}{\tilde{z}_t} \right)^{\frac{1}{(1-\alpha)}} \Upsilon_{\mu,t} + (1-\varepsilon)\Upsilon_b - \left[ 1 - \eta \left( 1 - E_t \tilde{\beta}_{t,t+1}(1-s_t) \right) \right] \Upsilon_F \right\}$ |
| (4) | $\Sigma_{K,t} \equiv \alpha E_t \beta_{t,t+1} \frac{Y_{t+1}}{\zeta_{Kt} K_{t+1}} \Upsilon_{\mu,t+1}$ |
| (5) | $\Sigma_{Y,t} \equiv \frac{L_t G(z^c_t)}{1-G(z^c_t)} \Upsilon_F + \Upsilon_R N_{Et}$ |

Note: $\beta_{t,t+1} \equiv \beta \left(C_{t+1}/C_t\right)^{-\gamma}$; $\tilde{\beta}_{t,t+1} \equiv (1-\delta)\left(1-\lambda^x\right)\beta_{t,t+1}$.
$\Upsilon_{N,t} \equiv (1-(1/\mu_t)) - 1/(2\sigma N_t)$; $\Upsilon_{\mu,t} \equiv 1 - 1/\mu_t$; $\Upsilon_R \equiv f_R$; $\Upsilon_F \equiv F$; $\Upsilon_b \equiv b$.

**Table 3**
Calibration.

| | | | |
|---|---|---|---|
| Variety elasticity | $\sigma = 3.12$ | Unemployment benefit | $b = 1.06$ |
| Risk aversion | $\gamma = 1$ | Firing costs | $F = 0.11$ |
| Discount factor | $\beta = 0.99$ | Matching function elasticity | $\varepsilon = 0.6$ |
| Technological entry cost | $f_T = 1.67$ | Workers' bargaining power | $\eta = 0.6$ |
| Regulation entry cost | $f_R = 1.77$ | Home production | $h_P = 0.38$ |
| Plant exit | $\delta = 0.009$ | Matching efficiency | $\chi = 0.43$ |
| Investment adjustment costs | $\nu = 1.5$ | Vacancy cost | $k = 0.12$ |
| Capital depreciation rate | $\delta_K = 0.025$ | Lognormal shape | $\sigma_{z_i} = 0.147$ |
| Capital share | $\alpha = 0.33$ | TFP, persistence | $\phi_Z = 0.983$ |
| Exogenous separation rate | $\lambda^x = 0.025$ | TFP, standard deviation | $\sigma_Z = 0.009$ |

such that aggregate R&D expenditures are 1.87 percent of GDP (OECD, Science and Technology Database).[25] Finally, we set the price-elasticity of the spending share on individual goods, $\sigma$, such that the steady-state markup, $\mu$, is 10 percent, a benchmark value in the literature.

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 62 percent (OECD, Benefits and Wages Database).[26] 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 by Abowd and Kramarz (2003) for France. Following the argument in den Haan et al. (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 et al. (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, firing costs and home production amount, respectively, to 7 and 23 percent of the average wage.[27]

Five parameters are left to calibration: the autoregressive parameter and the standard deviation of the technology shock, $\phi_Z$ and $\sigma_Z$, the lognormal scale and shape parameters, $\mu_{z_i}$ and $\sigma_{z_i}$, and the investment adjustment costs, $\nu$. As is standard practice in the literature, we set $\phi_Z$ and $\sigma_Z$ to match the first-order autocorrelation and the absolute standard deviation of GDP in the data, and choose $\nu$ such that the model reproduces the variability of investment in physical capital, $I_{K,t}$. Following den Haan et al. (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 GDP. We find $\phi_Z = 0.98$, $\sigma_Z = 0.009$, $\sigma_{z_i} = 0.14$, and $\nu = 1.5$.[28] The model calibration is summarized in Table 3. In Section 7, we investigate the robustness of the results to several alternative parameterizations, including, among others, the initial calibration of the regulation parameters $f_R$, $b$, and $F$, and scenarios in which the Hosios condition does not hold.

[25] 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. For robustness, in Section 7, we consider broader measures for $f_T$.

[26] As before, we consider a weighted average of the unemployment benefits across euro area member countries.

[27] 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.

[28] The implied value for the investment adjustment cost parameter, $\nu$, is in the range of estimates obtained by Eberly et al. (2012) for the U.S. economy.

**Table 4**
Second moments – benchmark economy.

| Variable $X$ | $\sigma_X$ | | $Corr(Y_{R,t}, X_t)$ | | $Corr(X_t, X_{t-1})$ | |
|---|---|---|---|---|---|---|
| | *Data* | Model | *Data* | Model | *Data* | Model |
| GDP ($Y_R$) | *1.45* | 1.45 | *1* | 1 | *0.76* | 0.76 |
| Consumption ($C_R^M$) | *0.63* | 0.88 | *0.63* | 0.98 | *0.78* | 0.73 |
| Investment ($I_{KR}$) | *3.02* | 3.02 | *0.92* | 0.77 | *0.90* | 0.94 |
| Unemployment ($U$) | *5.55* | 5.55 | *−0.87* | −0.57 | *0.93* | 0.89 |
| Vacancies ($V$) | *9.01* | 11.13 | *0.80* | 0.77 | *0.93* | 0.57 |
| Job finding rate ($s$) | *6.61* | 5.31 | *0.83* | 0.90 | *0.28* | 0.68 |
| Job separation rate ($\lambda^{tot}$) | *7.22* | 5.21 | *−0.92* | −0.28 | *0.24* | 0.66 |
| $corr(U_t, V_t)$ | *−0.66* | −0.14 | | | | |

Note: Data moments are computed for the period 1995:Q1 to 2013:Q1.
Model-implied moments are computed by averaging out 500 simulations of sample size 200.
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).

### *3.2. 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 10.1 (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 4, we further investigate the model properties by comparing the model-implied second moments for key macroeconomic variables (normal fonts) to their empirical counterparts (italic 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.

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), empirically relevant variables—as opposed to welfare-consistent concepts—net out the effect of changes in the range of available products.[29] It follows that CPI data are closer to the firm-level price $p_t$ than the consumption-based price $P_t$. For this reason, we focus on real variables deflated by a data-consistent price index. For any variable $X_t$ in units of the consumption basket, its data-consistent counterpart is obtained as $X_{R,t} \equiv P_t X_t / p_t = X_t / \rho_t$.

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, vacancies, and the job finding and separation rates observed in the data.[30] 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, including the job finding and separation rates. Finally, as in Bilbiie et al. (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 and macroeconomic dynamics

### *4.1. Transitional adjustment*

We begin to investigate the consequences of structural reforms by studying the dynamic adjustment to market deregulation. In the Appendix, we derive analytical results that illustrate how market regulation affects the unemployment rate and the number of producers in the long run.

We consider a perfect foresight, permanent reduction of policy parameters. Given the large size of the shocks, transition dynamics from the initial equilibrium to the 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 local approximations.

[29] The construction of CPI data by statistical agencies does not adjust for availability of new products as in the welfare-consistent price index. 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.

[30] Following ECB (2002) and Christoffel et al. (2009), our empirical measure of vacancies is a population-weighted euro area vacancy measure. For the job finding and separation rates, we construct population-weighted averages using the flow hazard rates provided by Elsby et al. (2013) for OECD countries. They obtain monthly estimates from annual data assuming that flow hazards are constant within years. Thus, given a monthly/year flow hazard $x_t^m$, we construct its quarterly counterpart as $1-\left(1-x_t^m\right)^3$.

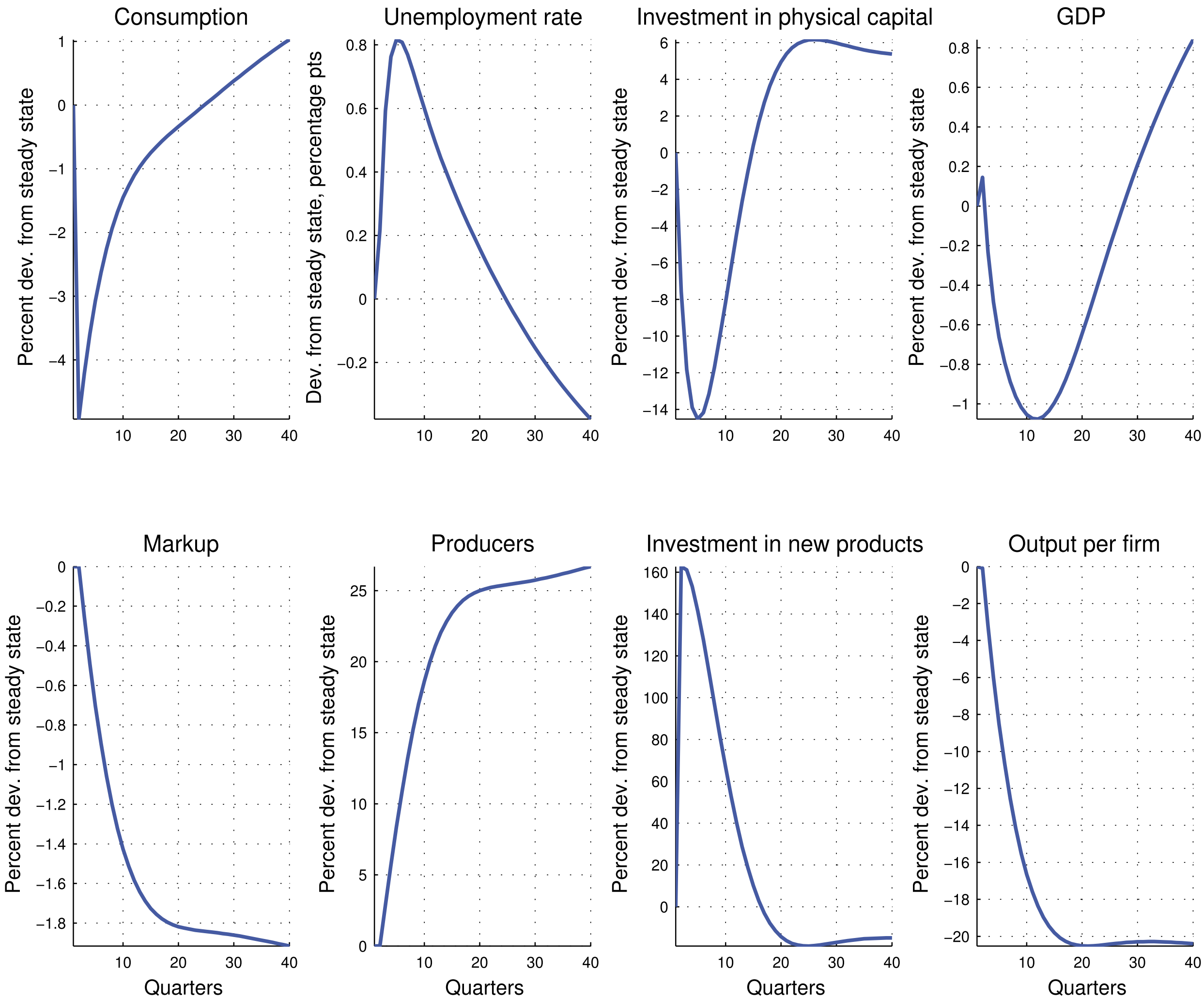


**Fig. 2.** Impulse responses, reduction in sunk costs of market entry ($f_R$).

We assume that policy parameters are lowered to their corresponding U.S. levels. To recalibrate entry costs related to regulation, $f_R$, we follow the same procedure described in Section 4. Pissarides (2003) reports that in the United States it takes (on average) 9 days to fulfill entry requirements, implying a loss of steady-state firm's output equal to 0.54 months. We assume that unemployment benefits correspond to 57 percent of the average wage (OECD, Benefits and Wages Database), and set firing costs to zero as in Veracierto (2008).

Fig. 2 shows the effects of a permanent decrease in barriers to entry ($f_R$). In the aftermath of the reform, output, employment and consumption fall relative to their initial pre-reform equilibrium. This result reflects the combination of investment and labor market dynamics. On the one hand, households need to reduce consumption and investment in physical capital in order to finance entry of new producers, leading to a temporary reduction in aggregate demand.[31] On the other hand, as new firms enter the market, fiercer competition erodes the market share of incumbents, who downsize by destroying unproductive matches. Since job creation from new entrants is a gradual process, the slow reallocation of workers across producers increases unemployment and lowers aggregate output. The unemployment rate increases by 0.8 percentage points at the peak, while GDP falls by 1 percent at the trough. The economy recovers over time. Once the number of producing firms 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. The larger number of available goods results in higher goods substitutability and lower markups.[32] In the long run, GDP increases by 2.7 percent.

[31] In the aftermath of the reform, total expenses in product creation, $N_{Et}(f_R + f_T)$, more than double relative to the initial steady state.

[32] Notice that the reduction in market shares at the producer level more than offsets the output expansion induced by lower markups. As a result, output per firm falls following product market deregulation.

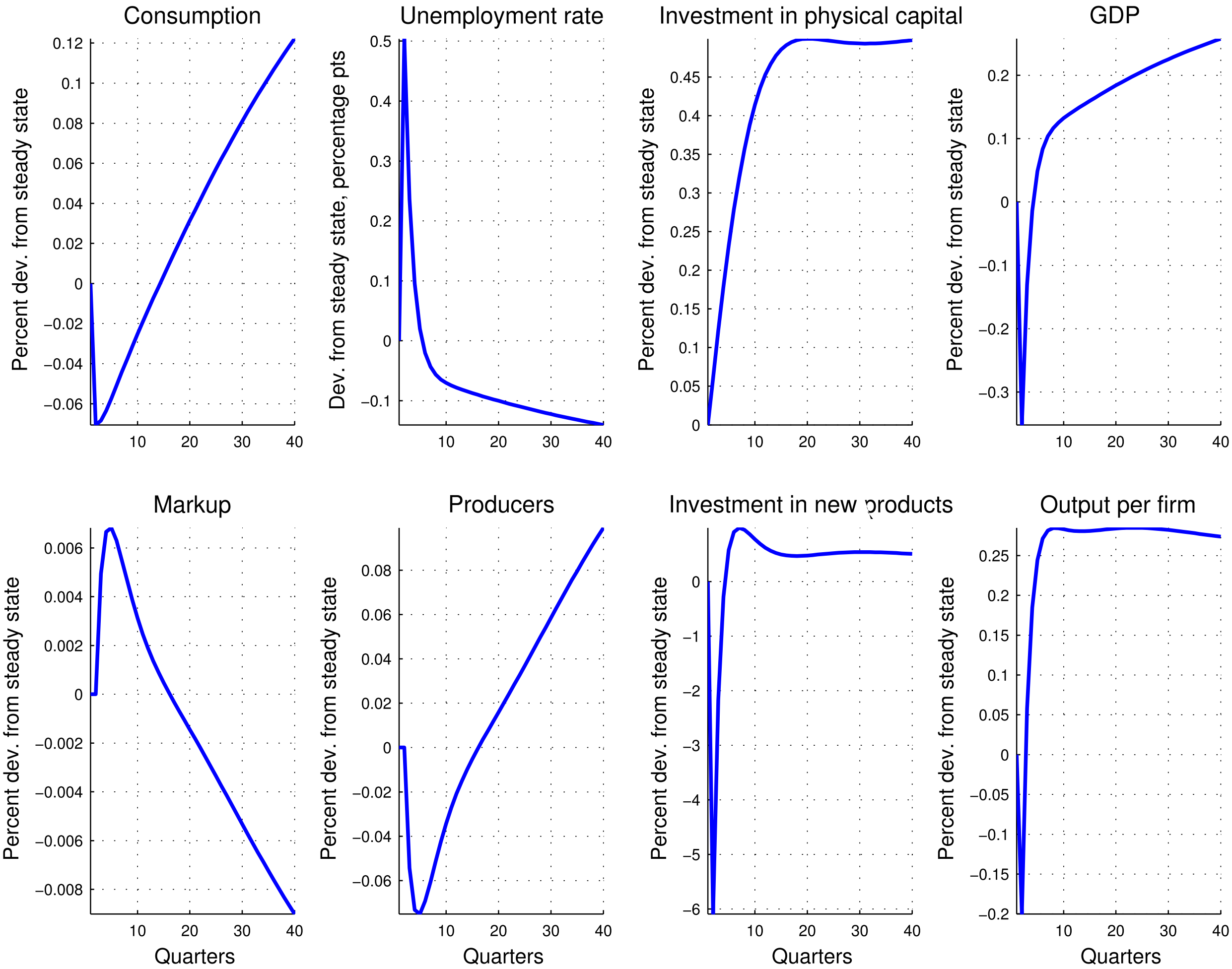


**Fig. 3.** Impulse responses, reduction in firing costs ($F$).

Fig. 3 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 times, employment, output, and consumption decrease in the aftermath of the reform but recover over time. It takes about one year for the unemployment rate 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 0.4 percent.

In contrast to a reduction in entry barriers or firing costs, a reform that lowers unemployment benefits does not have short-run recessionary 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 Fig. 4, the unemployment rate gradually falls over time, with beneficial effects for aggregate consumption, output, and investment. Long-run GDP increases by 1.9 percent. Importantly, the implied semi-elasticity of unemployment with respect to the replacement rate is 3.39 percent, in the range of estimates provided by Costain and Reiter (2008); see Table 3 on page 1136 of their article.[33]

Notice that in contrast to product market deregulation, labor market reforms do not trigger large firm dynamics. For instance, while the long-run employment gains induced by lowering unemployment benefits are similar to those implied by the reduction in barriers to entry, the number of producers is barely affected in the case of labor market deregulation. This happens because a flexible labor market boosts incumbents' incentives to expand production by increasing their stock of labor. In turn, a tighter labor market raises the entry cost, since new entrants must post a larger number of vacancies to

[33] Notice, however, that the model-implied semi-elasticity does not vary linearly with changes in the replacement rate. Thus the success of the model along this dimension is specific to the change in the benefit replacement rate we consider. See Rogerson et al. (2009) for a detailed analysis of the consequences of "large" versus "small" changes in unemployment insurance in the canonical search and matching model.

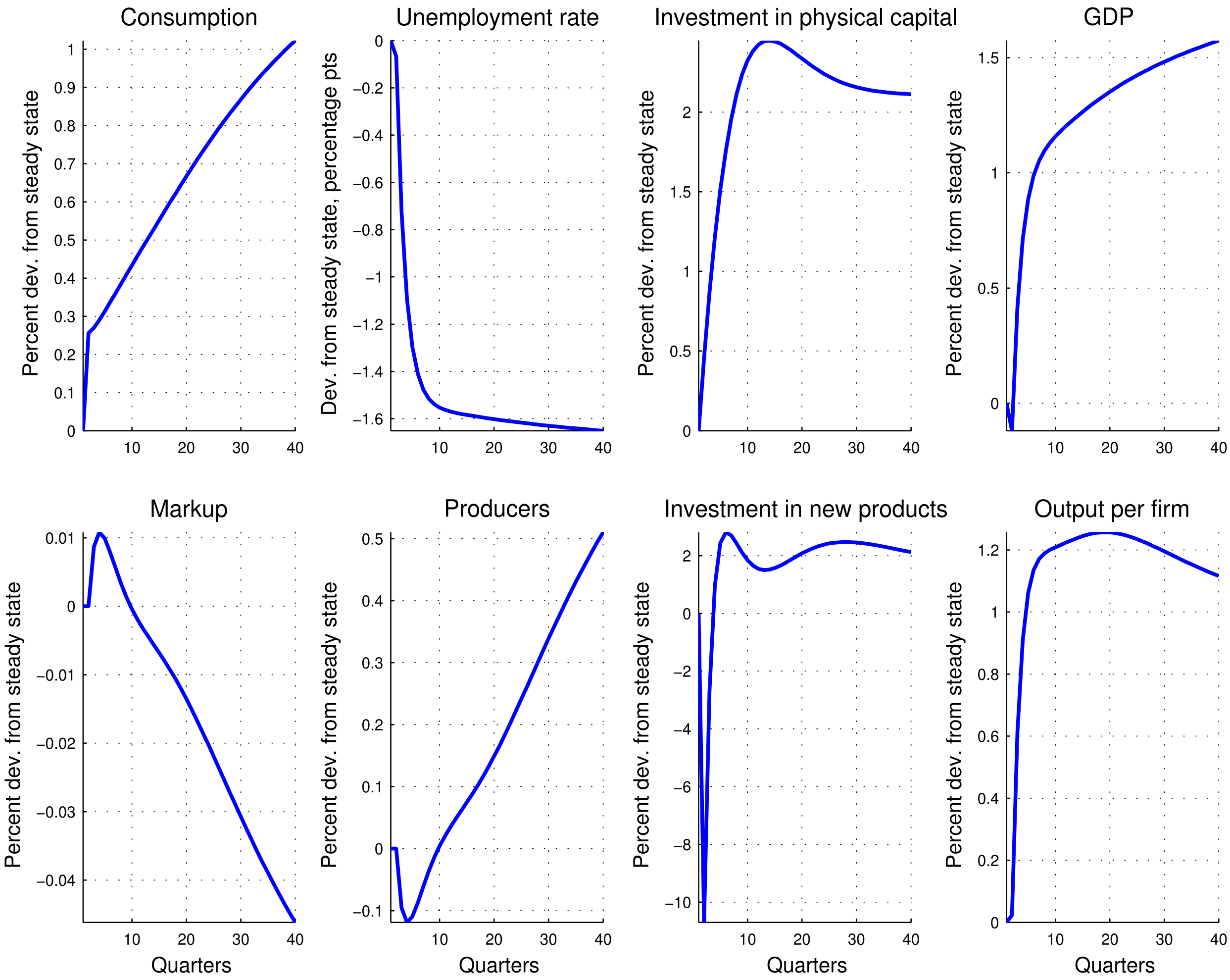


**Fig. 4.** Impulse responses, reduction in the unemployment-benefit replacement rate ($b/\tilde{w}$).

recruit workers. This effect counterbalances the increase in expected profits due to higher aggregate demand, implying that incumbents have a competitive advantage with respect to potential entrants: The former do not have to incur sunk entry costs in order to benefit from the labor market reform.

To conclude, we consider the dynamic adjustment following simultaneous joint deregulation in goods and labor markets. As shown in Fig. 5, a flexible labor market favors the reallocation of workers between incumbents and new entrants, mitigating the recessionary effects induced by the lowering of barriers to entry. At the same time, larger incentives to create firms and jobs reduce the firing of less productive workers. Thus, transition dynamics are shorter lived relative to individual reforms. Long-run gains materialize faster and are larger, since GDP increases by 4.9 percent relative to the pre-deregulation steady state.

### 4.2. Business cycle dynamics

Once deregulation is completed, the economy may face a different adjustment to aggregate shocks. From a theoretical point of view, product and labor market reforms affect cyclical fluctuations through different channels. When barriers to entry $f_R$ are relaxed, the economy fluctuates around a steady state with a larger number of producers, smaller markups and smaller profits at the producer level. As a result, the present discounted value of entry varies less in response to aggregate disturbances, reducing the variability of markups and profits. In turn, reduced firm-level volatility results in smaller volatility at the aggregate level. As shown in Table 5, setting product market regulation to the U.S. level reduces the volatility of the unemployment rate by 30 percent. Output volatility falls by 7 percent.

A reduction in unemployment benefits $b$ generates similar effects, even though for a different reason. Specifically, lower unemployment benefits reduce the returns to nonmarket activities by worsening the workers' outside option. For this reason, real wages co-move more strongly with aggregate productivity, dampening the sensitivity of job creation and destruction to

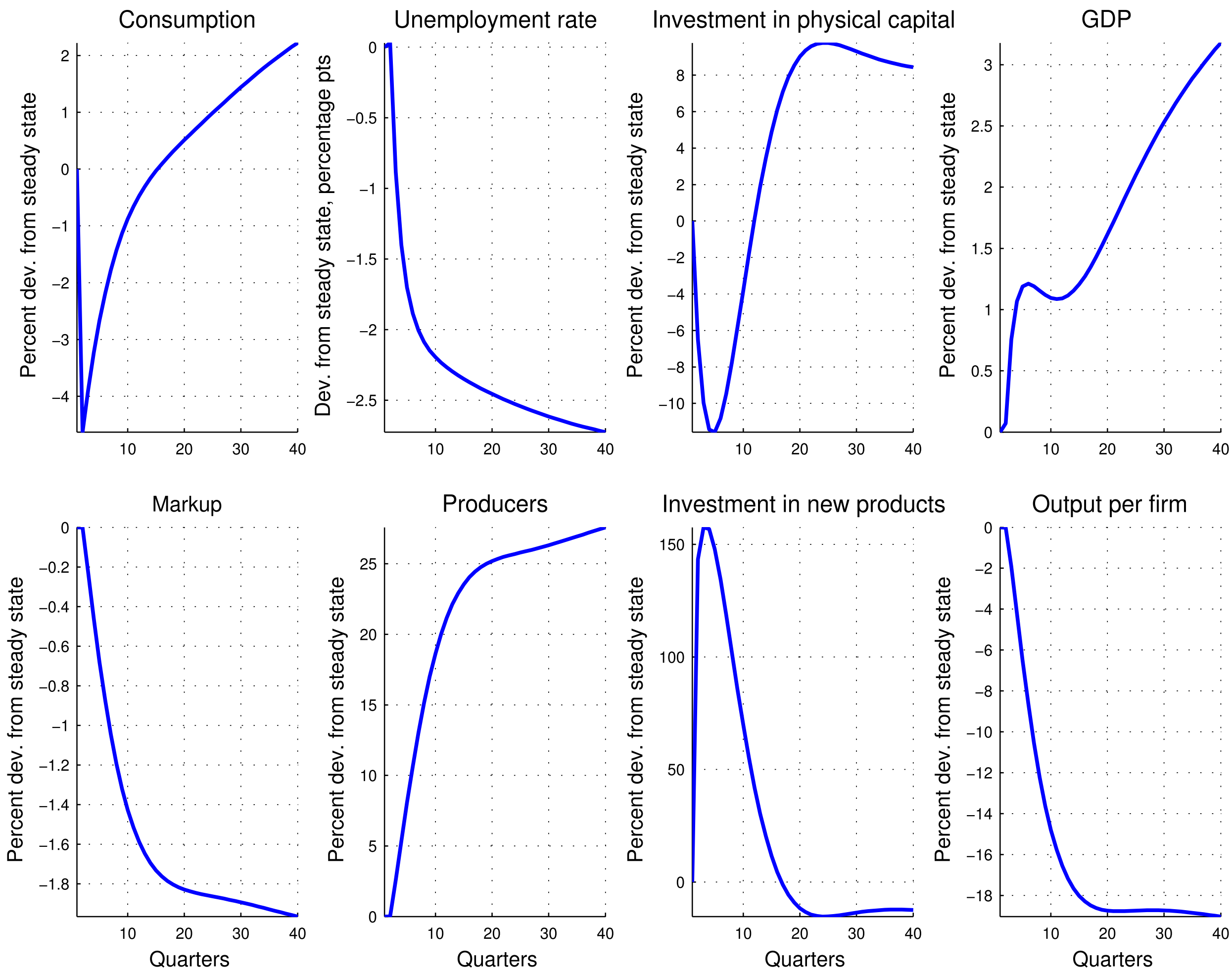


**Fig. 5.** Impulse responses, joint reform in product and labor markets.

**Table 5**
Business cycle implications of reforms.

| | Baseline | Entry cost ($f_R$) | Firing cost ($F$) | Benefit ($b$) | Joint ($f_R, F, b$) |
|---|---|---|---|---|---|
| $\sigma_{Y_R}$ | 1.45 | 1.36 | 1.75 | 1.31 | 1.30 |
| $\sigma_{C_R^M}$ | 0.88 | 0.83 | 1.15 | 0.76 | 0.76 |
| $\sigma_U$ | 5.55 | 3.84 | 10.85 | 2.57 | 2.23 |
| $\sigma_{\tilde{w}_R}$ | 1.10 | 1.13 | 1.07 | 1.16 | 1.18 |
| $Corr(Y_{R,t}, Y_{R,t-1})$ | 0.76 | 0.75 | 0.77 | 0.73 | 0.72 |
| $Corr(U_t, U_{t-1})$ | 0.89 | 0.88 | 0.87 | 0.88 | 0.86 |
| $Corr(w_{R,t}, Y_{R,t})$ | 0.89 | 0.96 | 0.56 | 0.99 | 0.99 |
| $Corr(y_t, Y_{R,t})$ | 0.98 | 0.97 | 0.98 | 0.98 | 0.97 |

Model-implied moments are computed by averaging out 500 simulations of sample size 200.
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).

aggregate productivity shocks. When the benefit replacement rate is set to the U.S. level, the volatility of the unemployment rate approximately halves, while output volatility falls by 10 percent.

The removal of firing costs, $F$, has an opposite effect on volatility. Intuitively, lowering $F$ increases the measure of jobs sensitive to destruction, which results in stronger incentives for firms to hire and fire workers over the business cycle. Accordingly, the volatility of job flows, unemployment and output increases. In our calibrated exercise, the removal of firing restrictions makes the unemployment rate twice as volatile, while the volatility of output increases by 22 percent.

Table 5 shows that the effects of reforms are significantly nonlinear. When the three dimensions of regulation are jointly lowered to the corresponding U.S. level, the volatility of output is 11 percent lower relative to the pre-deregulation scenario. By contrast, the algebraic sum of the individual effects of each reform would imply an increase in output volatility approxi-

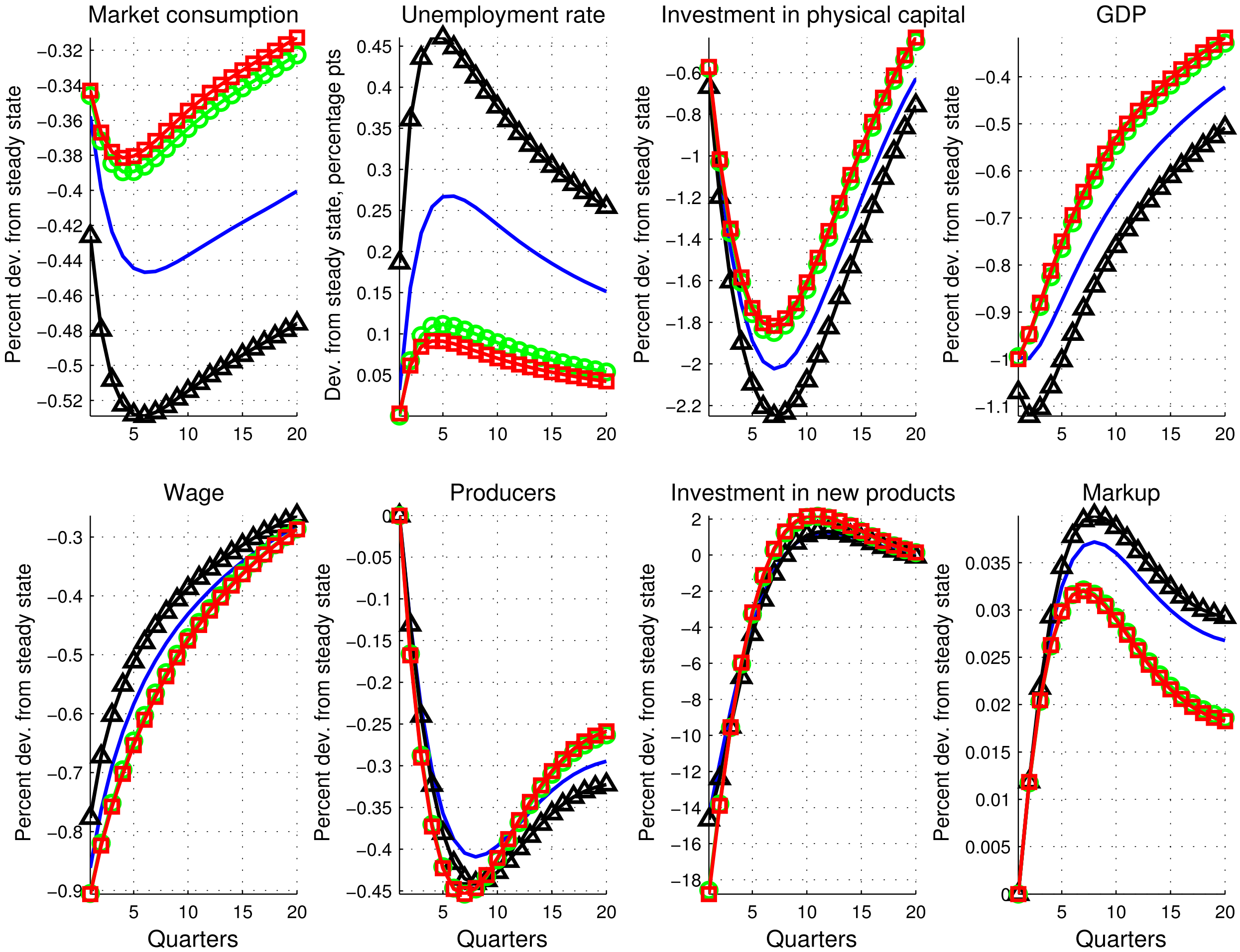


**Fig. 6.** Impulse responses to a negative productivity shock for different levels of regulation. *Solid line*: euro area regulation; *Triangle-point line*: barriers to entry and unemployment benefits at the euro area levels, firing costs at U.S. level; *Squared-point line*: barriers to entry and unemployment benefits at U.S. level, firing costs at the euro area level; *Circled-point line*: U.S. regulation.

mately equal to 5 percent. These differences are even larger when considering the behavior of unemployment volatility (see Table 5). Behind this result is the fact that the extent to which lowering firing costs increase aggregate volatility depends on the level of the other dimensions of regulation: barriers to entry and unemployment benefits. With low regulation, real wages absorb more of the productivity fluctuations and markups are less volatile, implying that hiring and firing decisions are less sensitive to aggregate shocks. Accordingly, the effect on volatility of a reduction in firing costs is muted. To substantiate this point, Fig. 6 contrasts the response of two different economies following a temporary negative productivity shock. In both economies, unemployment benefits and barriers to entry are set at the euro area level, but firing costs differ. In the first economy (solid line), $F$ is also set at the euro area level; in the second economy (triangle-point line), $F$ is equal to zero. Fig. 6 shows that the drop in output and employment is much larger in the economy without firing costs. We then repeat the exercise but assuming that in both economies $f_R$ and $b$ are low (at their corresponding U.S. level). In contrast to the previous case, the adjustment is now virtually identical in the two economies (squared- and circled-point line, respectively), confirming that when the other dimensions of regulation are flexible, the level of $F$ does not have a significant impact on aggregate dynamics. As discussed above and illustrated in Fig. 6, the different behavior of wages and markups across the various economies we consider explains this result. Importantly, as shown in Section 7, this result is not specific to the particular calibration we consider, but it generalizes to several alternative parameterizations of the model (including different initial levels of regulation and reforms of different size).

### 4.3. Empirical evidence

Our results on the business cycle implications of market regulation are consistent with Blanchard and Wolfers (2000) and Balakrishnan and Michelacci (2001). Blanchard and Wolfers document that the interaction between negative aggregate shocks and rigid market institutions is an important determinant of European unemployment dynamics; Balakrishnan and Michelacci find that European labor markets adjust more slowly to aggregate shocks than the United States, suggesting that

European economies might be dynamically "sclerotic."[34] In our context, these findings can be explained by the fact that rigid regulation increases the persistence of macroeconomic dynamics in response to aggregate shocks.

In contrast, existing evidence on the short-run adjustment to market reforms is scant. For this reason, we estimate a panel VAR using harmonized annual data for a sample of nineteen OECD countries over the period 1982–2005. We consider three macroeconomic variables—the unemployment rate, real GDP, and real investment—and three measures of regulation: (i) the OECD indicator of regulatory impediments, which reflects legal barriers restricting access to markets[35]; (ii) the OECD indicator of employment protection, which captures essential components of firing restrictions that are part of the model (including procedural inconveniences to dismiss a worker and prevailing standards of and penalties for unfair dismissals); (iii) gross replacement rates, measuring the fraction of income replaced by unemployment benefits. All the variables are described in detail in the Appendix.

In the baseline specification, we include the three macroeconomic variables (linearly detrended) and one of the three measures of regulation.[36] We also include country-fixed effects, accounting for unobserved, time-invariant cross-country heterogeneity, and year fixed effects, accounting for the presence of common shocks across countries. Due to the limited dimension of the data set, we restrict each equation coefficient to be the same across countries. Finally, motivated by legislative delays in approving modifications to the level of regulation, we assume that regulation responds with at least a one-period delay to macroeconomic shocks. This is tantamount to imposing a recursive ordering of the structural shocks.[37]

Fig. 7 presents impulse responses following a one-standard deviation reduction in each regulation variable.[38] Continuous lines represent median responses, while dashed lines represent 68 percent confidence bands. (We use bias-corrected bootstrap intervals as in Kilian, 1998, performed with 1000 replications.) Consistent with the model predictions, a reduction in barriers to entry and employment protection legislation leads to a sizable and statistically significant decline in output and increase in unemployment in the short run. By contrast, a reduction of the benefit replacement rate implies a positive short-run response of economic activity.

For robustness, we consider alternative VAR specifications. First, we include all the three regulation indexes in the VAR simultaneously. Second, we consider a VAR with the first difference of all variables. Moreover, we consider an alternative identification scheme based on sign restrictions upon the impulse responses. Our results are robust across all these alternative specifications. See the Appendix for details.

## 5. Efficiency, welfare and normative implications

Thus far, our analysis has left two important questions aside: (i) How do market reforms affect efficiency and welfare? (ii) How should market reforms be implemented in a normative perspective? We turn to these issues next.

### *5.1. Efficiency*

Characterizing efficient allocations is a necessary first step for understanding the welfare implications of market reforms, both in the long run and over the business cycle. Toward this end, in the Appendix we derive the equilibrium conditions implied by the solution to a first-best, optimal planning problem. As is standard in search-based models, efficient allocations are understood to be restricted by the matching technology and the distribution of workers' productivity, $G(z)$.[39] Moreover, the only entry costs that are relevant to the social planner are the technological component of the overall entry cost, $f_T$, and the costs of recruiting workers for new entrants. Thus, in the planner's environment $b = F = f_R = 0$.

Comparing the equilibrium conditions of the planner economy to those characterizing the market economy, allows us to identify the distortions at work in our model and define inefficiency wedges relative to the efficient, "zero-wedge" allocation. As summarized by Table 2, our model features five sources of distortion that affect the resource constraint for consumption output and four margins of adjustment: product creation, job creation, job destruction, and capital accumulation. Following Arsenau and Chugh (2012) and Chari et al. (2007), we focus on the overall wedges because what matters in determining welfare is the overall wedges, not each distortion separately.

Inefficiency along the market economy's product creation margin reflects deviations of the return to product creation from its socially efficient level. This wedge, denoted by $\Sigma_{PC,t}$, is the result of two separate distortions. First, new entrants

[34] The empirical evidence in Blanchard and Wolfers (2000) refers to unemployment insurance and employment protection legislation. Duval et al. (2007) find an analogous effect for product market regulation.

[35] As shown by Ebell and Haefke (2009), this index is highly correlated with the index for entry delay constructed by Pissarides (2003) for OECD countries in the year 1998 (the only year for which the index is available), which forms the basis for the calibration of administrative costs in the model.

[36] The panel-unit-root tests proposed by Breitung and Das (2005) and Levin et al. (2002) reject at the one percent confidence level the presence of unit roots in the three macroeconomic variables (against the alternative that each panel is trend-stationary) as well as in the regulation variables (against the alternative that each panel is stationary). Since in the model we study permanent shocks to regulation, in the Appendix we also consider a first-difference VAR, allowing for the presence of stochastic trends in all the variables of interest.

[37] Since we are not interested in identifying shocks to macroeconomic variables, their ordering is irrelevant for the purpose of our analysis. The VAR includes two lags, the minimum value for which we obtained white-noise residuals.

[38] This is roughly equivalent to lower each dimension of regulation from the average level in the euro area to its U.S. counterpart.

[39] Our approach follows Arsenau and Chugh (2012), who develop welfare-relevant labor wedges that take into account primitive matching frictions in the Diamond–Mortensen–Pissarides model.

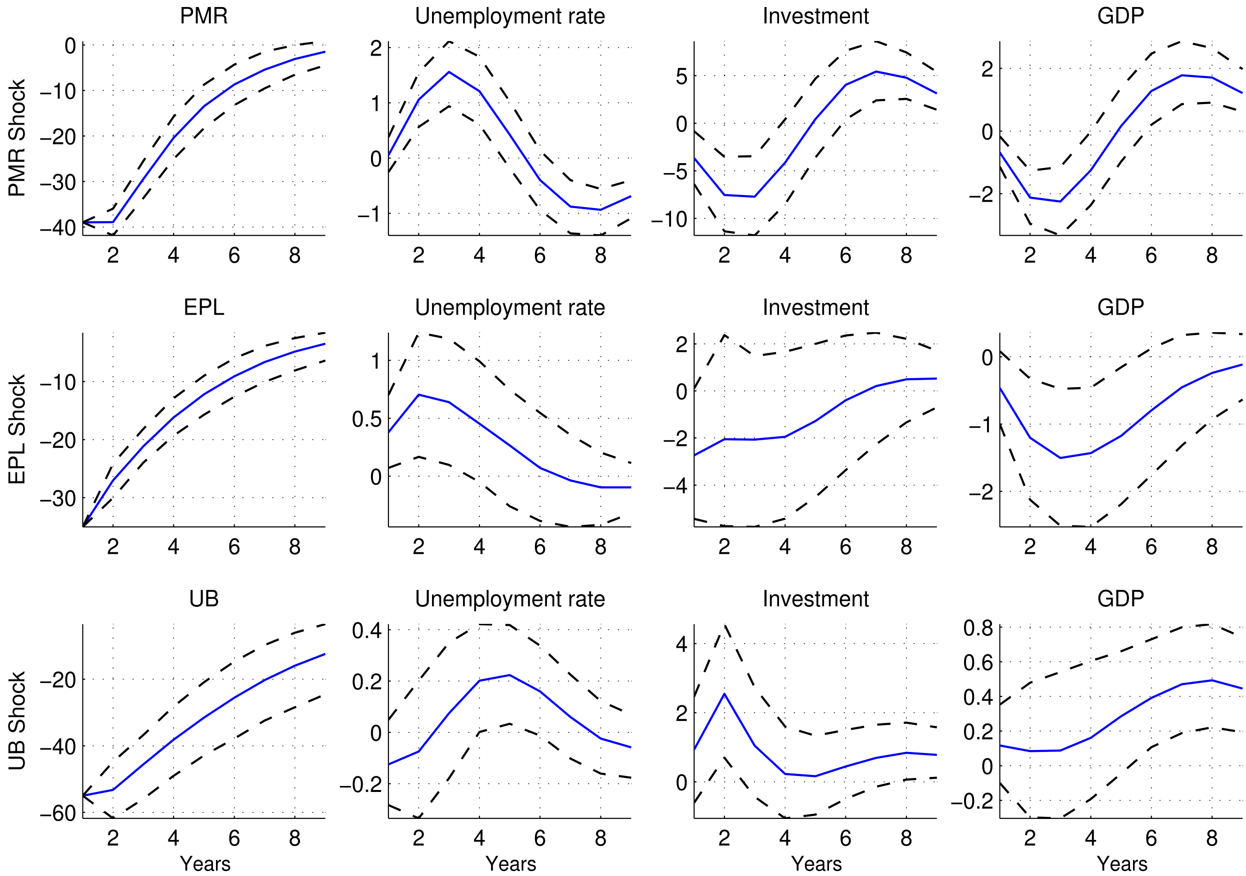


**Fig. 7.** Panel VAR, impulse responses to regulation shocks. GDP and Investment are in percent from baseline; Unemployment rate is in deviations from baseline. *PMR*: index of product market regulation; *EPL*: index of employment protection legislation; *UB*: benefit replacement rate.

do not internalize the positive effect of a new variety on consumer surplus and the negative effect on other firms' profits. As discussed by Bilbiie et al. (2008), with translog preferences these two effects do not cancel out, since the profit rate $(1-1/\mu_t)$ differs from the benefit of variety to consumers $1/(2\sigma N_t)$.[40] Second, for a given profit rate, regulatory barriers increase the entry cost above the efficient level, resulting in a suboptimal return on product creation. When $(1-1/\mu_t)=1/(2\sigma N_t)$ and $f_R=0$, the product creation margin is efficient: $\Sigma_{PC,t}=0$.

Inefficiency along the job creation and destruction margins results in the wedges $\Sigma_{JC,t}$ and $\Sigma_{JD,t}$, respectively. First, firm's monopoly power induces a suboptimal marginal revenue product of a match for any given level of job productivity. Second, unemployment benefits, $b$, increase the workers' outside option above its efficient level. Third, firing costs distort the present discounted value of new and existing jobs by making job destruction inefficiently costly. When $(1-1/\mu_t)=b=F=0$, the labor market wedges are zero. This condition holds true as long as the worker's bargaining share is equal to the unemployment elasticity of the matching function, a condition that is met in our benchmark calibration. Failure of the Hosios condition introduces an additional source of distortion in job creation and destruction by leading, other things equal, to inefficient surplus-splitting between the firm and the worker.[41]

Firm's monopoly power also distorts the marginal revenue product of physical capital, resulting in suboptimal investment. Inefficiency along this margin is measured by the wedges $\Sigma_{K,t}$. When $(1-1/\mu_t)=0$, $\Sigma_{K,t}=0$. Finally, product market regulation and firing costs distort the resource constraint for consumption output by inducing a diversion of resources from consumption and creation of new product lines and vacancies. This wedge is measured by $\Sigma_{Y,t}$.

The market allocation is efficient only if all the distortions are eliminated and the associated wedges are closed at all points in time. If the government had access to an appropriate set of distortionary and lump-sum fiscal instruments that could remove the distortions induced by firm monopoly power and translog preferences, the optimal level of regulation would be zero. However, since we abstract from optimal fiscal policy, it follows that the efficient allocation cannot be

[40] As shown by Bilbiie et al. (2008), the benefit of additional product variety is $\rho(N_t)=\exp\left\{-\left(\tilde{N}-N_t\right)/\left(2\sigma\tilde{N}N_t\right)\right\}$, or, in elasticity form, $\upsilon(N_t)\equiv\rho'(N_t)/\rho(N_t)N_t=1/(2\sigma N_t)$.

[41] Other things equal, the share of surplus accruing to the worker is inefficiently high when $\eta>\varepsilon$.

**Table 6**
Welfare effects of reforms.

| | Entry Cost ($f_R$) | Firing Cost ($F$) | Benefit ($b$) | Joint ($f_R, F, b$, simultaneous[*]) | Joint ($f_R, F, b, f_R$ first[*]) | Joint ($f_R, F, b, F, b$ first[*]) |
|---|---|---|---|---|---|---|
| $\Delta_{SR}$ | −3.15% | −0.04% | 0.38% | −2.49% | −3.15% | 0.56% |
| $\Delta_{LR}$ | 4.94% | 0.20% | 0.73% | 5.78% | 4.93% | 1.11% |
| $\Delta_{SR} + \Delta_{LR}$ | 1.79% | 0.16% | 1.11% | 3.29% | 1.80% | 1.67% |
| $\Delta_{BC}$ | 0.82% | −2.03% | 1.29% | 1.38% | 1.38% | 1.38% |
| $\Delta_{SR} + \Delta_{LR} + \Delta_{BC}$ | 2.61% | −1.87% | 2.40% | 4.67% | 3.18% | 3.05% |

Note: $\Delta_{SR} \equiv$ short-run welfare change; no aggregate uncertainty.
$\Delta_{LR} \equiv$ medium-to-long-run welfare change; no aggregate uncertainty.
$\Delta_{BC} \equiv$ change in the welfare cost of business cycles ($\Delta_{BC} > 0$ implies a reduction in the welfare cost of business cycles).
$\Delta_{SR}$, $\Delta_{LR}$, and $\Delta_{BC}$ expressed as percentage of steady-state consumption in the rigid economy.
[*] Timing of implementation of joint reforms.

achieved. Moreover, since the level of regulation affects all existing market distortions, deregulation can induce efficiency trade-offs by reducing some wedges but increasing others.

### 5.2. Welfare

#### 5.2.1. Transition dynamics and steady state

To begin, we abstract from the presence of aggregate uncertainty. 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): $[C(1+\Delta/100)]^{(1-\gamma)} = (1-\beta) W_0$, where $W_0 \equiv \sum_{t=0}^{\infty} \beta^t C_t^{1-\gamma}$ represents the discounted utility of the representative agent when the reform is implemented. We also decompose the overall welfare effect $\Delta$ into the sum of short-run welfare, $\Delta_{SR}$, and medium-to-long-run welfare, $\Delta_{LR}$. We compute $\Delta_{SR}$ over the first three year after the implementation of the reform (see the Appendix for the analytical details).[42]

As shown in Table 6, absent business cycle fluctuations, the welfare effect of each reform is positive. Overall, consumption should increase by 1.79 percent to make the household indifferent to implementing or not a product market reform; the consumption gain of reducing firing costs and unemployment benefits amount to 0.16 and 1.11 percent of steady-state consumption, respectively. However, product market deregulation and the removal of firing costs reduce welfare in the short run. The loss is more pronounced in the case of a product market reforms, since $\Delta_{SR} = -3.15$ percent of the initial steady-state consumption (see Table 6). In other words, the recessionary effects of these two reforms can have sizable welfare implications in the aftermath of deregulation.

For each of the reforms we consider, long-run welfare gains are tied to efficiency gains along the job creation margin, corresponding to a reduction in the wedge, $\Sigma_{JC}$. (We report the long-run responses of the inefficiency wedges in the Appendix.) Intuitively, lowering barriers to entry boosts product creation and erodes markups, pushing the marginal revenue product of new and existing jobs towards the efficient level; the reduction in unemployment benefits and firing costs realign the flow value of unemployment and the continuation value of new matches, respectively, toward their social optimum. In addition, the reduction in barriers to entry and unemployment benefits increases efficiency along two other margins: job destruction, by increasing the marginal revenue product of the marginal job, and capital accumulation, by raising the marginal revenue product of $K$.

However, market reforms present important efficiency tradeoffs. For instance, the removal of firing costs increases inefficiency along the job destruction margin $\Sigma_{JD}$. This happens because positive firing costs counterbalance the distortionary effect of high barriers to entry and unemployment benefits on the job destruction rate. 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.[43] Similarly, the product creation wedge $\Sigma_{PC}$ increases following product market deregulation. In this case, producer entry externalities imply that when the number of producers increases, the markup $\mu_t$ falls less than the consumers' benefit to variety $\nu(N_t)$, since $\mu_t - 1 = (\sigma N_t)^{-1}$, while $\upsilon(N_t) \equiv (2\sigma N_t)^{-1}$, widening $\Sigma_{PC}$. Quantitatively, however, this trade-off is less severe compared to the one induced by a reduction in firing costs, which explains why lowering administrative barriers to entry is significantly more beneficial.[44]

[42] The horizon corresponds to the average length of time a government is in office in euro area countries (World Bank, Database of Political Institutions), providing a reasonable estimate of the time frame over which governments motivated by shorter-term electoral incentives evaluate the consequences of deregulation.

[43] As shown in Section 7, the long-run gains from removing firing costs increase significantly when the initial level of $F$ is higher than the value implied by our benchmark calibration. By contrast, welfare falls if the initial level of $F$ is sufficiently low—below 5 percent of steady-state wages. Intuitively, in the first case, the efficiency gains along the job creation margin outweigh the efficiency losses along the job destruction margin.

[44] Bilbiie et al. (2008) show that when translog externalities are the only distortion in the market economy, a Pigovian tax on dividends that appropriately reduces the number of producers on the market is efficient. Chugh and Ghironi (2011) show that endogenizing public finance considerations does not affect

*5.2.2. Business cycle*

We now study how market deregulation affects the welfare cost of business cycle, defined relatively to a counterfactual economy in which aggregate productivity, $Z_t$, is constant and equal to one. For a given level of regulation $r$, we compute the percentage of steady-state consumption $\Delta_{BC}$ that households would accept sacrificing in order to get rid of aggregate fluctuations: $[C^r(1-\Delta_{BC}/100)]^{(1-\gamma)} = (1-\beta)W_0$, where now $W_0 \equiv E_0 \sum_{t=0}^{\infty} \beta^t C_t^{r\,1-\gamma}$ is the conditional expected discounted utility of the representative agent in the stochastic economy. In order to compute $\Delta_{BC}$, we approximate the lifetime utility to the second order (together with a second-order approximation of the policy functions). Following Schmitt-Grohe and Uribe (2007), we focus on conditional welfare in order to account for the transitional effects to the stochastic steady state.

As shown in Table 6, market reforms have important consequences for the welfare costs of business cycles. Lowering barriers to entry and unemployment benefits reduces the welfare cost of business cycles from 1.48 percent of pre-deregulation steady-state consumption to 0.66 and 0.19 percent, respectively. In contrast, the removal of firing costs increases the cost of fluctuations above 3.51 percent of pre-deregulation steady-state consumption. To understand these results, notice first that in the presence of steady-state distortions, the cost of business cycles (up to the second order) depends endogenously on both the mean and volatility of consumption (Benigno and Woodford, 2005; Sutherland, 2002, and Woodford, 2003).[45] In turn, the endogenous connection between macroeconomic volatility and the average level of consumption around which the economy fluctuates explains why market reforms induce sizable effects on the cost of business cycles.[46]

Consider the case of product market deregulation. As discussed above, lowering barriers to entry leads to a moderation of markups and firm-profit volatility. Since the creation of new differentiated products is sensitive to uncertainty about and anticipation of future profits, lower firm-level volatility increases, on average, producer entry over the business cycle. Thus, not only markups are less volatile, but their average value is lower, boosting the marginal revenue product of capital and labor. Accordingly, the mean and volatility of labor and capital wedges fall. (We report the cyclical response of the inefficiency wedges in the Appendix.) A reduction in unemployment benefits has similar effects, since this reform lowers the workers' outside option, makes wages more procyclical and stabilizes the marginal revenue product of labor. As a result, firm entry, vacancy posting, and capital accumulation increase, on average, relative to their pre-deregulation levels, while job destruction falls. Ultimately, both reforms increase average consumption, bridging the gap with the nonstochastic economy.

Lowering firing restrictions has an opposite effect. As discussed above, when barriers to entry and unemployment benefits are high, removing firing costs substantially increases aggregate and firm-level volatility. In turn, higher volatility implies that inefficient fluctuations in the allocation of resources become more costly. Two forces are at work. First, on average, more volatile profits dampen producer entry, increasing the distortionary effects of producers' markups. Second, higher volatility in the absence of firing costs induces more pronounced asymmetries between economic expansions and contractions. Intuitively, with zero firing costs, more jobs are created during booms, while a larger number of matches are destroyed in recessions. Since job creation requires investment (due to search frictions), but firing is costless, on average employment losses outweigh employment gains. In turn, lower average employment constitutes an additional source of inefficiency, since the unemployment rate is already suboptimally high in the absence of aggregate shocks. Ultimately, inefficient fluctuations in markups and job destruction (captured by the widening of the job destruction wedge), reduce average consumption by more than 4 percent relative to the nonstochastic economy.

### 5.3. Normative implications

Policymakers can exploit policy-interdependence to increase the welfare gains of market reforms. As shown by Table 6, relative to individual policy changes, joint deregulation induces more sizable long-run gains, smaller transition costs, and lower welfare costs of business cycles. The reason is that when barriers to entry and unemployment benefits are low, the removal of firing costs no longer trades off efficiency gains along the job creation margin with efficiency losses along the job destruction margin. This happens because once barriers to entry and unemployment benefits are reduced, the need to correct distortions along the job destruction margin is mitigated. Therefore, the removal of firing restrictions opens the door to large efficiency gains in job creation.

Finally, since joint reforms can be implemented in alternative ways, transition costs might be a function of the way joint deregulation is implemented. To understand whether this is the case, we compare the adjustment following a simultaneous reform with the adjustment to a reform in which product and labor markets are lowered sequentially.[47] Table 6 shows that a simultaneous reform significantly reduces transition costs by inducing a quicker adjustment to the new steady state. This finding relates to Blanchard and Giavazzi (2003), who argue that product market deregulation may reduce the opposition to labor market reforms by reducing workers' incentives to fight for their share of rents. Our results complement their

this result. In our context, such a policy could restore efficiency along the product creation margin (by realigning the benefit of product variety with the incentive for product creation), but at the cost of further distorting job creation and destruction together with capital accumulation. This is the reason why the reduction in red tape (which increases $N$) is overall beneficial in our model.

[45] In contrast, household's welfare does not depend on first-order endogenous terms if the steady state is undistorted.

[46] Up to second order, the presence of uncertainty affects the constant term of the decision rules. For this reason, the average value of endogenous variables can be significantly different from their nonstochastic steady state values.

[47] We first lower product (labor) market regulation. Then, after the economy has completed the transition to the new steady state, we deregulate the labor (product) market.

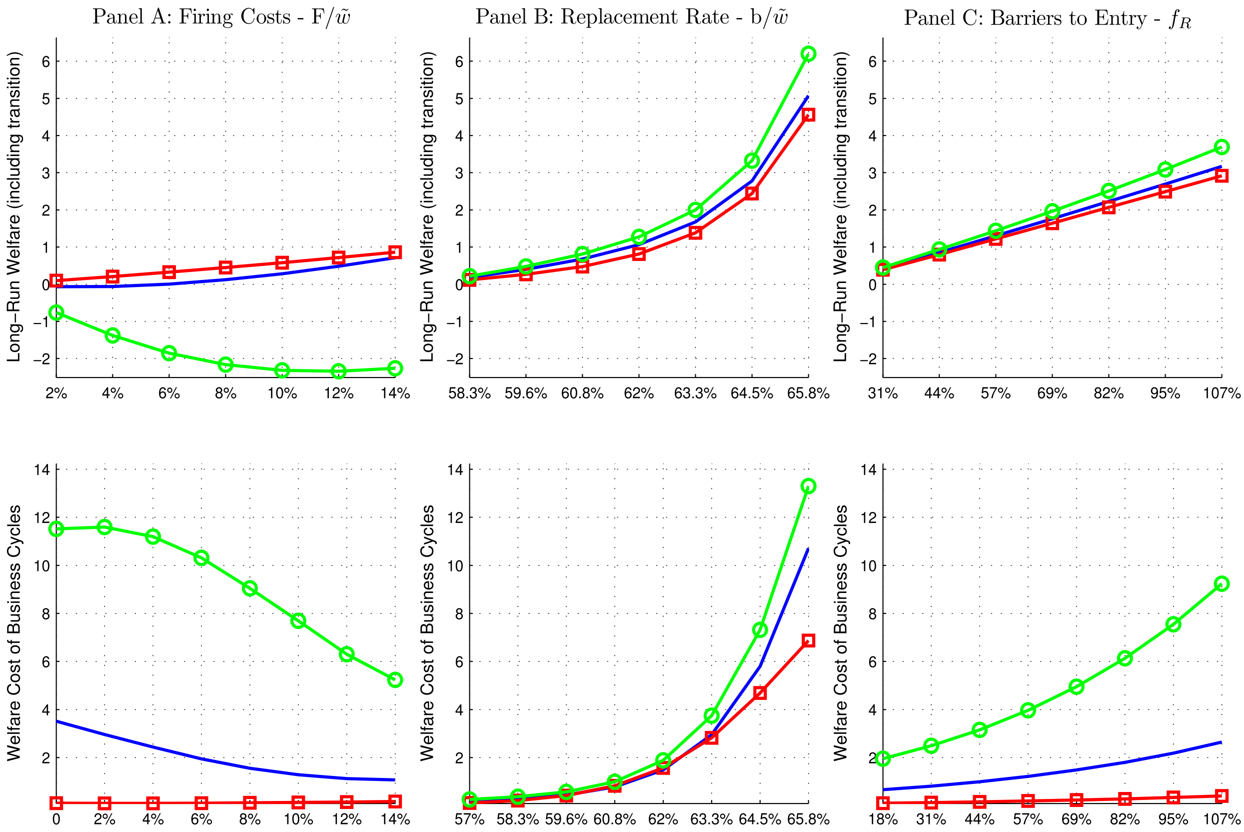


**Fig. 8.** Sensitivity analysis. Each panel refers to a specific dimension of regulation $R$, where $R = (F, b, f_R)$. The vertical axis on the first row shows the long-run welfare effects (including transition dynamics) of reducing $R$ to its U.S. counterpart; the horizontal axis represents the initial value of $R$. The vertical axis on the second row shows the welfare cost of business cycles implied by the level of regulation $R$ (on the horizontal axis). In each panel, the other dimensions of regulation are: (i) kept at the euro area level (*solid line*); (ii) set at the U.S. level (*squared-point line*); (iii) increased by 50 percent relative to the euro area level (*circled-point line*).

perspective, showing that policymakers need to trade off the beneficial effects of using product market reforms alone to reduce the conflict between insiders and outsiders with the larger costs of implementing product market reforms in the presence of rigid labor markets.

## 6. Sensitivity analysis

To conclude, we assess the robustness of our findings to alternative model parameterizations. First, we consider alternative values for the regulation parameters and reforms of different size. For each regulation parameter, we construct a grid with extreme values that are, respectively, 75 percent higher and 75 percent lower relative to the benchmark calibration. Then, for each new level of regulation, we compute the welfare cost of business cycles and the long-run welfare effect of deregulating to the U.S. level (including transition dynamics). Fig. 8 (solid line) shows that the welfare gains following a reduction in $f_R$ and $b$ are essentially monotone in the size of the reform (both in the long run and over the cycle). Similarly, the increase in the welfare cost of business cycle is larger the larger the reduction in firing costs. Moreover, consistent with our previous results, we find that the consequences of removing firing restrictions are systematically affected by the level of barriers to entry and unemployment benefit. When $f_R$ and $b$ are low (at the U.S. level), setting $F$ to zero substantially increases long-run welfare yet leaving unaffected the welfare costs of business cycle (see the squared point line in Fig. 8, top left and left bottom). In contrast, when $f_R$ and $b$ are extremely high (50 percent higher relative to the euro area calibration), the removal of firing costs generates sizable welfare losses, both in the long run and over the cycle (see the circled-point line in Fig. 8, left bottom).[48]

Next, we turn to the model calibration. Since our calibration strategy combines values from the literature and parameters that are chosen to match selected targets in the data, we investigate the robustness of our results along both dimensions.

[48] By contrast, Fig. 8 shows that the welfare consequences of reducing unemployment benefits and barriers to entry are not particularly sensitive to the level of firing costs. This is not surprising, since, as explained before, low levels of $f_R$ and $b$ dampen the quantitative importance of firing costs to begin with.

We focus on parameters and targets whose value is debated in the literature. Specifically, we consider alternative values for the matching function elasticity, $\varepsilon$, the workers' bargaining power, $\eta$, and the risk aversion coefficient, $\gamma$. Moreover, we target different values for the average markup, $\mu$, the size of vacancy costs, $\kappa$, relative to the average wage, the fraction of jobs destruction accounted for by firm exit, $\delta$, and the technological component of entry costs, $f_T$. Finally, we set investment adjustment costs, $\nu$, to zero. The details about the sensitivity analysis are relegated to the Appendix. We show there that none of our results are significantly affected by the alternative calibrations we consider. Notice that, for all the empirically plausible scenarios we analyze, departures from the Hosios condition do not change quantitatively the efficiency trade-offs highlighted in Section 5, leaving the welfare implications of market reform unaffected.

Finally, we study how the timing of production in labor and product markets affects the results. In contrast to the benchmark model, we assume that new matches and new firms start producing immediately upon their creation, partly relaxing the frictions that characterize product and job creation. As discussed in the Appendix, our results are robust to these alternative timing assumptions. The only difference is that the removal of firing costs no longer induces an appreciable short-run increase in unemployment. Nevertheless, despite the small reduction in transition costs, the removal of firing restrictions in the presence of high barriers to entry and unemployment benefits continues to be highly detrimental for welfare, since the increase in the welfare cost of business cycles remains substantial.

## 7. Conclusions

We developed a model with endogenous product creation, labor market frictions and capital accumulation to study the effects of deregulation in goods and labor markets. We found that market reforms entail important dynamic effects. First, reforms can have short-run recessionary effects, despite being expansionary in the long run. Second, joint deregulation in product and labor markets reduces aggregate volatility, leading to a sizable reduction in the welfare costs of business cycles. Yet, individual reforms produce contrasting effects. From a normative perspective, policymakers can increase welfare and efficiency by exploiting policy-interdependence, since joint deregulation reduces both the level and volatility of wedges that distort agents' equilibrium decisions.

The finding of non-negligible short-run costs associated to market reforms suggests that deregulation may call for active policies supporting aggregate demand during the transitory adjustment.[49] Moreover, our results offer an alternative explanation for the historical aversion of governments to implement structural reforms: transition costs associated with market deregulation can be enough to dissuade policymakers motivated by shorter-term electoral incentives. This argument adds to the political economy literature on reforms, which traditionally focuses on the conflict between insiders and outsiders; see Blanchard and Giavazzi (2003) and Saint-Paul (1999).

## Appendix A. Supplementary material

Supplementary material related to this article can be found online at http://dx.doi.org/10.1016/j.red.2015.10.002.

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[49] Recent contributions have addressed the relationship between market reforms and the conduct of monetary policy. In a two-country, monetary-union version of the present model, Cacciatore et al. (2013) show that the optimal monetary policy response to deregulation is expansionary. Eggertsson et al. (2014) and Fernandez-Villaverde et al. (2014) address the consequences of market reforms at the zero lower bound on nominal interest rates. Both studies treat reforms as exogenous markup reductions, abstracting from producer entry dynamics and labor market frictions.

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