Market Deregulation and Optimal Monetary Policy in a Monetary Union*

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Abstract

This paper addresses the consequences of product and labor market deregulation for monetary policy in a two-country monetary union with endogenous product creation and labor market frictions. We show that when regulation is high in both countries, optimal policy requires significant departures from price stability both in the long run and over the business cycle. The adjustment to market reform requires expansionary policy to reduce transition costs, but deregulation reduces static and dynamic inefficiencies, making price stability more desirable once the transition is complete. International synchronization of reforms can eliminate policy tradeoffs generated by asymmetric deregulation.

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1 Introduction

The wave of crises that began in 2008 reheated the debate on market deregulation as a tool to improve economic performance. Calls for removal, or at least reduction, of regulation in goods and labor markets have been part of the policy discussions on both sides of the Atlantic.[1] The argument is that more flexible markets would foster a more rapid recovery from the recession generated by the crisis and, in general, would result in better economic performance. Deregulation of product markets would accomplish this by facilitating producer entry, boosting business creation, and enhancing competition; deregulation of labor markets would do it by facilitating reallocation of resources and speeding up the adjustment to shocks. Results in the academic literature support these arguments, but they do not address the consequences of market deregulation for the conduct of macroeconomic policy.[2] In a recent IMF Staff Discussion Note, Barkbu, Rahman, Valdés, and Staff (2012) discuss the effects of market reforms in Europe and argue for these supply-side policies to be accompanied by active policies supporting aggregate demand: When the benefits of structural market reforms take time to materialize, there is room for demand-side macroeconomic policy to reduce transition costs. Important questions remain open for researchers and policymakers: What is the optimal policy response to the dynamics triggered by goods and labor market reform? How does deregulation affect the central bank's long-run inflation target? And how does optimal policy change as reforms affect the characteristics of the business cycle?

This paper addresses these questions from the perspective of monetary policy in a monetary union. We study how deregulation that increases flexibility in product and/or labor markets affects the long-run inflation target of the welfare-maximizing central bank of a monetary union; how the central bank

[1] The title on the front page of the February 18, 2012 issue of *The Economist* ("Over-regulated America") and the discussion of increasing regulation of U.S. product markets are indicative of the attention to the issue in the United States. In August of 2011, in the midst of Europe's sovereign debt crisis, then European Central Bank President Jean-Claude Trichet and President-to-be Mario Draghi took the unprecedented step of addressing a letter to the Italian government making market deregulation a condition for the central bank's intervention in support of Italian government bonds. More recently, see President Draghi's Introductory Statement to the press conference of September 6, 2012 (available at http://www.ecb.europa.eu/press/pressconf/2012/html/is120906.en.html), or the European Commission's report on the European Union's Macroeconomic Imbalance Procedure of April 10, 2013 (available at http://ec.europa.eu/economy_finance/publications/occasional_paper/2013/pdf/com(2013)_199_final_en.pdf).

[2] See, for instance, Blanchard and Giavazzi (2003), Cacciatore and Fiori (2011), Dawson and Seater (2011), Fiori, Nicoletti, Scarpetta, and Schiantarelli (2012), Griffith, Harrison, and Macartney (2007), and Messina and Vallanti (2007).

responds to the transition dynamics generated by the deregulation; and how deregulation affects the conduct of optimal monetary policy over the business cycle. We do this in a two-country, dynamic, stochastic, general equilibrium (DSGE) model of a monetary union with endogenous product creation subject to sunk costs as in Bilbiie, Ghironi, and Melitz (2012)—BGM below—and search-and-matching frictions in labor markets as in Diamond (1982a,b) and Mortensen and Pissarides (1994)—DMP below. The model contains the most parsimonious set of ingredients that allow us to capture key empirical features of product and labor market regulation and reform. Sunk entry costs in product markets reflect both a technological constraint and barriers to entry induced by regulation. Deregulation of product markets reduces the size of sunk entry costs (by cutting "red tape"). In labor markets, deregulation is modeled as a reduction of unemployment benefits and employment protection (captured by the workers' bargaining power). We introduce nominal rigidities in the form of costly price and wage adjustment. We calibrate the model using parameter values from the literature and to match features of macroeconomic data for Europe's Economic and Monetary Union (EMU), and we show that the model successfully reproduces several features of EMU's business cycles when the union's central bank follows an interest rate rule that reproduces the historical behavior of the European Central Bank (ECB). We then study how deregulation affects the optimal monetary policy chosen by a Ramsey central bank in a variety of scenarios for the monetary union, including the possibility of product and labor market asymmetries across countries.

We find that regulation in goods and labor markets has a significant effect on optimal monetary policy. First, when regulation is high, the Ramsey-optimal policy prescribes a positive long-run inflation target of 1.2 percent and significant departures from the historical Taylor rule (which, in turn, approximates a policy of price stability). Total welfare gains from optimal policy are not negligible: Implementing the optimal policy increases welfare by approximately 0.5 percent of annual steady-state consumption under the historical rule. Second, the optimal response to product and/or labor market deregulation is more expansionary than historical behavior, with a beneficial effect on welfare during the transition.[3] When the effects of deregulation are fully materialized, the welfare gap between his-

[3] In the case of joint product and labor market deregulation in one country, the welfare gain from the Ramsey-optimal

torical and Ramsey policy is narrower, and price stability is more desirable both in the long run and over the business cycle, for the country that undertakes reforms. The welfare gap, however, remains large in the country that does not deregulate its markets. Third, there are gains from international synchronization of market reforms: The welfare gain from deregulation under the Ramsey-optimal policy is larger if market reforms are implemented simultaneously across countries.

The intuition for our results is straightforward. We show that high regulation in goods and labor markets implies that steady-state markups are too high and job creation too low. Inefficiency wedges with respect to the first-best allocation are sizable. Regulation makes cyclical unemployment fluctuations too volatile, which amplifies their welfare cost. The Ramsey policymaker uses positive long-run inflation to mitigate long-run inefficiencies, and (s)he uses departures from price stability over the cycle to stabilize job creation (at the cost of more volatile product creation).

Deregulation (even asymmetric across countries) reduces real distortions in goods and labor markets. Since the benefits take time to materialize, the Ramsey central bank expands monetary policy more aggressively than the historical ECB to generate lower markups and boost job creation along the transition. Once the beneficial effects of reforms are fully materialized, there is less need of positive long-run inflation to close inefficiency gaps, and price stability over the cycle is less costly for economies that deregulated their markets. International spillovers from asymmetric deregulation across countries are positive but small. As a result, the costs of the historical policy of near-price stability continue to be relatively high in rigid countries, at approximately 0.5 percent of annual steady-state consumption. The welfare benefits of optimal policy depend on the union-wide pattern of deregulation. Asymmetric deregulation introduces a new policy tradeoff for the Ramsey central bank, because optimal policy must strike a balance between countries that differ in the desirability of price stability both in the long run and over the cycle. Internationally synchronized reforms remove this tradeoff, resulting in larger welfare gains from optimal policy: Market reforms are beneficial for welfare under both historical and Ramsey-optimal policy, but they are more beneficial if monetary policy is chosen optimally,

policy (relative to historical policy) over a five-year horizon is 0.26 percent of annual pre-deregulation steady-state consumption in the country that deregulates and 0.46 percent in the other.

and the benefit increases if reforms are synchronized. From the perspective of deregulating countries, the welfare benefit of optimal policy relative to the historical Taylor rule is larger if optimal policy is implemented in a symmetrically deregulated monetary union.

Before discussing how our paper contributes to the literature, we note what the paper does not do. While the recent crises have re-heated the debate on market reform, this debate pre-dates the crises (for instance, Blanchard and Giavazzi's, 2003, seminal article). Therefore, we do not cast our exercise in terms of a crisis response—in which deregulation may be implemented as part of the response to a crisis—and our results on monetary policy do not provide a lens to interpret the ECB's behavior during Europe's sovereign debt crisis.[4] We assume that deregulation lowers producer entry costs, unemployment benefits, and employment protection in the European countries in our model to the corresponding levels in the United States. We abstract from optimal regulation, fiscal policy considerations (including fiscal aspects of market regulation), and strategic interactions between policymakers, and we assume full commitment in all our policy exercises, including full commitment to permanent deregulations. (The assumption of commitment in our analysis of monetary policy is standard practice in the literature on Ramsey-optimal policy.) We also abstract from distributional consequences of reforms. While these are important topics for future research, our choices were motivated by the goal of obtaining a set of intuitive, benchmark results.

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 in general equilibrium. Blanchard and Giavazzi (2003) and Hopenhayn and Rogerson (1993) are seminal contributions in this vein.[5] Another strand of research investigates the dynamic ef-

[4] The zero lower bound on interest rates is among the concerns for current monetary policymaking in the Euro Area. We verified that this constraint never binds in our exercises. For the implications of this constraint for structural reforms in Europe, see Eggertsson, Ferrero, and Raffo (2013) and Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2011). Both these papers do not feature producer entry dynamics and DMP labor market frictions. They treat reforms as exogenous reductions in price and wage markups, which have deflationary consequences. By contrast, product and labor market deregulations have inflationary effects in our model, as increased business creation and a higher value of job matches put upward pressure on wages.

[5] Other contributions include Alessandria and Delacroix (2008), Ebell and Haefke (2009), and Felbermayr and Prat (2011).

fects of market deregulation, including transition dynamics and business cycle implications of reforms.[6] To the best of our knowledge, our study is the first attempt to investigate how market deregulation affects the conduct of monetary policy in a model that features the product and labor market dynamics at the heart of policy debates.[7]

By incorporating a dynamic model of product creation over the business cycle, our paper also contributes to the recent literature that studies how endogenous entry and product variety affect business cycles dynamics in closed and open economies. Bergin and Corsetti (2008, 2013), Bilbiie, Fujiwara, and Ghironi (2011), Cacciatore and Ghironi (2012), Faia (2012), and Lewis (2010) analyze optimal monetary policy in models with endogenous producer entry, while Chugh and Ghironi (2011) focus on optimal fiscal policy in the BGM framework. We contribute to this literature by studying how a determinant of producer entry—regulation—impacts the conduct of monetary policy.

The focus on monetary policy connects our study to the vast literature on monetary transmission and optimal monetary policy in New Keynesian models. We share the finding of optimal deviations from price stability with several existing studies. Abstracting from market regulation, our model features well-understood channels through which positive inflation reduces static and dynamic distortions. In the long-run, positive inflation in product prices is optimal when the benefit of product variety to consumers falls short of the market incentive for product creation under flexible prices, as in Bilbiie, Fujiwara, and Ghironi (2011). In the short-run, optimal deviations from price stability arise because of the presence of both price and wage rigidity (as in Erceg, Henderson, and Levin, 2000, and Thomas, 2008), steady-state distortions induced by (exogenous) monopoly power of firms with endogenous labor supply (as in Benigno and Woodford, 2005, and Faia, 2009), and incomplete international financial markets (as in Corsetti, Dedola, and Leduc, 2010).[8] Our work adds to this

[6] For instance, Cacciatore and Fiori (2011) and Veracierto (2008). Cacciatore and Fiori extend Blanchard and Giavazzi's (2003) analysis to a DSGE framework. They study the transition dynamics following goods and labor market deregulation, as well as its effects on the business cycle. Veracierto considers the consequences of firing costs for business cycle dynamics.

[7] Sibert and Sutherland (2000) study how the incentives of policymakers to undertake costly labor market reforms depend on the international monetary regime (noncooperative monetary policy versus a monetary union).

[8] Short-run departures from price stability arise also in Arseneau and Chugh's (2008) sticky-wage DMP model with exogenous government spending and Ramsey-optimal monetary and tax policy. Government spending alone has been shown to imply deviations from short-run price stability in several studies. See Adão, Correia, and Teles (2003), Khan, King, and Wolman (2003), and Woodford (2003, Ch. 6.5).

literature along two dimensions. First, we show that market regulation constitutes a hitherto unexplored motive for non-zero optimal inflation, both in the long-run and over the business cycle: The level of market regulation matters for the quantitative importance of the distortions discussed above in generating departures from price stability.[9] Second, we show that optimal departures from short-run price stability also emerge as the optimal monetary policy *response* to market deregulation.

By allowing for asymmetries between countries in our monetary union, we contribute also to the study of optimal monetary policy in economies with potentially heterogeneous regions or sectors.[10] While we cast our model and discussion in terms of a two-country monetary union and we choose EMU for our calibration, it is straightforward to re-cast the model (and re-calibrate it) to apply its lessons to the United States (itself a monetary union of states with potentially asymmetric state-level regulations). An important insight of our analysis in the European context is that the beneficial effects of structural reforms may come at the cost of weaker current accounts, at least initially. While market reforms are generally viewed as a way to improve competitiveness and rebalance external positions in European policy debates and some academic literature (for instance, Corsetti, Martin, and Pesenti, 2013), explicit consideration of the transition dynamics highlights a worsening of the external balance among the possible transition costs of reforms.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 describes monetary policy: We consider a historical rule for the ECB's interest rate setting and the Ramsey-optimal policy. To build intuition for the tradeoffs facing the Ramsey authority, Section 4 discusses the distortions and inefficiency wedges that characterize the market economy. Section 5 studies optimal monetary under high regulation. Section 6 addresses the consequences of deregulation for monetary policy. Section 7 discusses the benefits from international synchronization of reforms. Section 8 concludes.

[9] Our result that price stability is costly in highly regulated economies is consistent with Blanchard and Galí's (2010) findings on the consequences of labor market imperfections for optimal monetary policy.

[10] Aoki (2001) and Benigno (2004) focus on heterogeneity in nominal rigidity.

2 The Model

We model a monetary union that consists of two countries, Home and Foreign. Foreign variables are denoted with a superscript star. We use the subscript d to denote quantities and prices of a country's own goods consumed domestically, and the subscript x to denote quantities and prices of exports. We focus on the Home economy in presenting our model, with the understanding that analogous equations hold for Foreign. We abstract from monetary frictions that would motivate a demand for cash currency in each country, and we model our monetary union as a cashless economy following Woodford (2003).

Each economy in the union is populated by a unit mass of atomistic households, where each household is an extended family with a continuum of members along the unit interval. In equilibrium, some family members are unemployed, while others are employed. As common in the literature, we assume that family members perfectly insure each other against variation in labor income due to changes in employment status, so that there is no *ex post* heterogeneity across individuals in the household (see Andolfatto, 1996, and Merz, 1995).

Household Preferences

The representative household in the Home economy maximizes the expected intertemporal utility function $E_t \sum_{s=t}^{\infty} \beta^{s-t}[u(C_s) - l_s v(h_s)]$, where $\beta \in (0,1)$ is the discount factor, C_t is a consumption basket that aggregates domestic and imported goods as described below, l_t is the number of employed workers, and h_t denotes hours worked by each employed worker. Period utility from consumption, $u(\cdot)$, and disutility of effort, $v(\cdot)$, satisfy the standard assumptions.

The consumption basket C_t aggregates bundles $C_{d,t}$ and $C^*_{x,t}$ of Home and Foreign consumption varieties in Armington form with elasticity of substitution $\phi > 0$:

$$C_t = \left[(1-\alpha)^{\frac{1}{\phi}} C_{d,t}^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} C_{x,t}^{*\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \quad 0 < \alpha < 1.$$

A similar basket describes consumption in the Foreign country. In each country's consumption basket, $1-\alpha$ is the weight attached to the country's own output bundle and captures the degree of home bias in preferences. Preferences are biased in favor of domestic goods whenever $\alpha < 1/2$. The consumption-based price index that corresponds to the basket C_t is given by $P_t = \left[(1-\alpha)P_{d,t}^{1-\phi} + \alpha P_{x,t}^{*1-\phi}\right]^{\frac{1}{1-\phi}}$. Departures of α from 1/2 induce deviations from purchasing power parity in our model, implying $P_t \neq P_t^*$ (except in a symmetric steady state).

Following BGM, the number of consumption goods available in each country is endogenously determined. Denote with Ω_d and Ω_x^* the overall numbers of Home and Foreign goods over which the preference aggregators $C_{d,t}$ and $C_{x,t}^*$ are defined. At any given t, only subsets of goods $\Omega_{d,t} \subset \Omega_d$ and $\Omega_{x,t}^* \subset \Omega_x^*$ are actually available for consumption at Home.

We assume that the aggregators $C_{d,t}$ and $C_{x,t}^*$ take a translog form following Feenstra (2003a,b). As a result, the elasticity of substitution across varieties within each sub-basket $C_{d,t}$ and $C_{x,t}^*$ (and $C_{d,t}^*$ and $C_{x,t}$ in the Foreign consumption basket) is an increasing function of the number of goods available. The translog assumption allows us to capture the pro-competitive effect of goods market deregulation on (flexible-price) markups. As shown in BGM and Cacciatore and Fiori (2011), lower entry barriers in production of goods result in increased entry, a larger number of available goods, and—by inducing higher substitutability—lower markups.[11,12]

Translog preferences are characterized by defining the unit expenditure function (i.e., the price index) associated with the preference aggregator. Let $p_{d,t}(\omega)$ be the price of a variety ω produced and sold at Home, and $p_{x,t}^*(\omega^*)$ the price of a variety ω^* produced in the Foreign country and exported to

[11] As argued in BGM, 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.

[12] Translog preferences have been found to have appealing empirical properties in a variety of contexts. BGM show that translog preferences and endogenous producer entry result in markup dynamics that are remarkably close to U.S. data. Bergin and Feenstra (2000, 2001) find that a translog expenditure function makes it possible for macro models to generate empirically plausible endogenous persistence by virtue of the implied demand-side pricing complementarities. Rodríguez-López (2011) obtains plausible properties for exchange rate pass-through, markup dynamics, and cyclical responses of firm-level and aggregate variables to shocks. For a review of applications of the translog expenditure function in the trade literature, see Feenstra (2003b).

Home. The unit expenditure function on the basket of domestic goods $C_{d,t}$ is given by:

$$\ln P_{d,t} = \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}}\right) + \frac{1}{N_t}\int_{\omega\in\Omega_{d,t}} \ln p_{d,t}(\omega)d\omega + \frac{\sigma}{2N_t}\int_{\omega\in\Omega_{d,t}}\int_{\omega'\in\Omega_{d,t}} \ln p_{d,t}(\omega)(\ln p_{d,t}(\omega) - \ln p_{d,t}(\omega'))d\omega d\omega',$$

where $\sigma > 0$, N_t is the total number of Home products available at time t, and $\tilde{N}$ is the mass of Ω_d. The unit expenditure function on the basket of imported goods $C^*_{x,t}$ is instead given by:

$$\ln P^*_{x,t} = \frac{1}{2\sigma}\left(\frac{1}{N^*_t} - \frac{1}{\tilde{N}^*}\right) + \frac{1}{N^*_t}\int_{\omega^*\in\Omega^*_{x,t}} \ln p^*_{x,t}(\omega^*)d\omega^* + \frac{\sigma}{2N^*_t}\int_{\omega^*\in\Omega^*_{x,t}}\int_{\omega^{*\prime}\in\Omega^*_{x,t}} \ln p^*_{x,t}(\omega^*)(\ln p^*_{x,t}(\omega^*) - \ln p^*_{x,t}(\omega^{*\prime}))d\omega^* d\omega^{*\prime},$$

where N^*_t is the total number of Foreign products available at time t, and $\tilde{N}^*$ is the mass of Ω^*_x.[13]

Production

In each country, there are two vertically integrated production sectors. In the upstream sector, perfectly competitive firms use labor to produce a non-tradable intermediate input. In the downstream sector, monopolistically competitive firms purchase intermediate inputs and produce the differentiated varieties that are sold to consumers in both countries. This production structure greatly simplifies the introduction of labor market frictions in the model.

Intermediate Goods Production

There is a unit mass of intermediate producers. Each of them employs a continuum of workers. Labor markets are characterized by search and matching frictions as in the DMP framework. To hire

[13] Since we will abstract from producer heterogeneity and endogenous determination of the range of traded consumption variety, the total number of Home (Foreign) varieties available to Home (Foreign) consumers will also be the number of varieties imported by Foreign (Home). This will imply $mass(\Omega_d) = mass(\Omega_x)$, $mass(\Omega_{d,t}) = mass(\Omega_{x,t})$, $mass(\Omega^*_d) = mass(\Omega^*_x)$, and $mass(\Omega^*_{d,t}) = mass(\Omega^*_{x,t})$. Ghironi and Melitz (2005) introduce heterogeneity and endogenous determination of the traded set in an international macroeconomic model with C.E.S. Dixit-Stiglitz preferences.

new workers, firms need to post vacancies, incurring a cost of κ units of consumption per vacancy posted. (Results are not affected significantly if we assume quadratic costs of vacancy posting.) The probability of finding a worker depends on a constant-return-to-scale matching technology, which converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches, $M_t = \chi U_t^{1-\varepsilon} V_t^{\varepsilon}$, where $\chi > 0$ and $0 < \varepsilon < 1$. Each firm meets unemployed workers at a rate $q_t \equiv M_t/V_t$. As in Krause and Lubik (2007) and other studies, we assume that newly created matches become productive only in the next period. For an individual firm, the inflow of new hires in $t+1$ is therefore $q_t \upsilon_t$, where υ_t is the number of vacancies posted by the firm in period t. In equilibrium, $\upsilon_t = V_t$.

Firms and workers separate exogenously with probability $\lambda \in (0, 1)$.[14] Separation happens only between firms and workers who were active in production in the previous period. As a result the law of motion of employment, l_t (those who are working at time t), in a given firm is given by $l_t = (1-\lambda) l_{t-1} + q_{t-1} \upsilon_{t-1}$.

As Arsenau and Chugh (2008), we use Rotemberg's (1982) model of nominal rigidity and assume that firms face a quadratic cost of adjusting the hourly nominal wage rate, w_t. The real cost of changing the nominal wage between period $t-1$ and t is $\vartheta \pi_{w,t}^2/2$ per worker, where $\vartheta \geq 0$ is in units of consumption, and $\pi_{w,t} \equiv (w_t/w_{t-1}) - 1$ is the net wage inflation rate. If $\vartheta = 0$, there is no cost of wage adjustment.

The representative intermediate firm produces output $y_t^I = Z_t l_t h_t$, where Z_t is exogenous aggregate productivity. The assumption of a unit mass of intermediate producers ensures that y_t^I is also the total output of the intermediate sector. We assume that Z_t and Z_t^* follow a bivariate $AR(1)$ process in logs, with Home (Foreign) productivity subject to innovations ϵ_t (ϵ_t^*). The diagonal elements of the autoregressive matrix Φ, Φ_{11} and Φ_{22}, measure the persistence of exogenous productivity and are strictly between 0 and 1, and the off-diagonal elements Φ_{12} and Φ_{21} measure productivity spillovers.

[14] Endogenous separation would require the introduction of worker heterogeneity. In principle, this would make it possible to study the consequences of reductions in firing costs as in Cacciatore and Fiori (2011). However, introducing worker heterogeneity in the presence of nominal wage stickiness would pose a complicated technical challenge. While abstracting from these ingredients is a limit in the light of policy debates (for instance, in Italy), we conjecture based on Cacciatore and Fiori's results that the additional complication would not alter our main messages.

The productivity innovations ϵ_t and ϵ_t^* are normally distributed with zero mean and variance-covariance matrix $\Sigma_{\epsilon,\epsilon^*}$.

Intermediate goods producers sell their output to final producers at a real price φ_t in units of consumption. Intermediate producers choose the number of vacancies, υ_t, and employment, l_t, to maximize the expected present discounted value of their profit stream:

$$E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{u_{C,s}}{u_{C,t}} \left(\varphi_s Z_s l_s h_s - \frac{w_s}{P_s} l_s h_s - \kappa \upsilon_s - \frac{\vartheta}{2} \pi_{w,s}^2 l_s \right),$$

where $u_{C,t}$ denotes the marginal utility of consumption in period t, subject to the law of motion of employment. Future profits are discounted with the stochastic discount factor of domestic households, who are assumed to own Home firms.

Combining the first-order conditions for vacancies and employment yields the following job creation equation:

$$\frac{\kappa}{q_t} = E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) \frac{\kappa}{q_{t+1}} + \varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right] \right\}, \quad (1)$$

where $\beta_{t,t+1} \equiv \beta u_{C,t+1}/u_{C,t}$ is the one-period-ahead stochastic discount factor. The job creation condition states that, at the optimum, the vacancy creation cost incurred by the firm per current match is equal to the expected discounted value of the vacancy creation cost per future match, further discounted by the probability of current match survival $1-\lambda$, plus the future profits from the time-t match. Profits from the match are the difference between the future marginal revenue product from the match and its wage cost, including nominal wage adjustment costs.

Wage and Hours The nominal wage is the solution to an individual Nash bargaining problem, and the wage payment divides the match surplus between workers and firms. Due to the presence of nominal rigidity, we assume that bargaining occurs over the nominal wage rather than the real wage, following Arseneau and Chugh (2008), Gertler, Sala, and Trigari (2008), and Thomas (2008). With zero costs of nominal wage adjustment ($\vartheta = 0$), the real wage that emerges would be identical to the one obtained from bargaining directly over the real wage. This is no longer the case in the presence of adjustment costs.

We relegate the details of wage determination to a separate Appendix. We show there that the equilibrium sharing rule can be written as $\eta_{w,t}H_t = (1-\eta_{w,t})J_t$, where $\eta_{w,t}$ is the equilibrium bargaining share of firms, H_t is worker surplus, and J_t is firm surplus (see the Appendix for the expressions). As in Gertler and Trigari (2009), the equilibrium bargaining share is time-varying due to the presence of wage adjustment costs. Absent these costs, we would have a time-invariant bargaining share $\eta_{w,t} = \eta$, where η is the weight of firm surplus in the Nash bargaining problem. Importantly, wage rigidity implies that $\eta_{w,t}$ is procyclical, and its steady-state level is an increasing function of wage and product price inflation.

The bargained wage satisfies:

$$\begin{aligned} \frac{w_t}{P_t}h_t &= \eta_{w,t}\left(\frac{v(h_t)}{u_{C,t}}+b\right)+(1-\eta_{w,t})\left(\varphi_t Z_t h_t-\frac{\vartheta}{2}\pi^2_{w,t}\right) \\ &+E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_{w,t})-(1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\}, \end{aligned} \tag{2}$$

where $v(h_t)/u_{C,t}+b$ is the worker's outside option (the utility value of leisure plus an unemployment benefit b), and ι_t is the probability of becoming employed at time t, defined by $\iota_t \equiv M_t/U_t$. With flexible wages, the third term in the right-hand side of this equation reduces to $(1-\eta)\,\iota_t E_t\left(\beta_{t,t+1}J_{t+1}\right)$, or, in equilibrium, $\kappa\,(1-\eta)\,\iota_t/q_t$. In this case, the real wage bill per worker is a linear combination—determined by the constant bargaining parameter η—of the worker's outside option and the marginal revenue product generated by the worker (net of wage adjustment costs) plus the expected discounted continuation value of the match to the firm (adjusted for the probability of employment). The stronger the bargaining power of firms (the higher η), the smaller the portion of the net marginal revenue product and continuation value to the firm appropriated by workers as wage payments, while the outside option becomes more relevant. When wages are sticky, bargaining shares are endogenous, and so is the distribution of surplus between workers and firms. Moreover, the current wage bill reflects also expected changes in bargaining shares.

As common practice in the literature, we assume that hours per worker are determined by firms and workers in a privately efficient way to maximize the joint surplus of the employment relation, $J_t + H_t$. (See, among others, Thomas, 2008, and Trigari, 2009.) Maximization yields a standard intratemporal optimality condition for hours worked that equates the marginal revenue product of hours per worker to the marginal rate of substitution between consumption and leisure: $v_{h,t}/u_{C,t} = \varphi_t Z_t$, where $v_{h,t}$ is the marginal disutility of effort.

Final Goods Production

In each country, there is a continuum of monopolistically competitive final-sector firms, each of them producing a different variety.[15] Final goods are produced using domestic intermediate inputs, and they are sold domestically and abroad.[16]

The producer of final good ω at Home faces the following domestic and Foreign demands for its output:

$$y_{d,t}(\omega) = (1-\alpha)\sigma \ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right)\frac{P_{d,t}}{p_{d,t}(\omega)}\left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y_t^C, \tag{3}$$

$$y_{x,t}(\omega) = \alpha\sigma \ln\left(\frac{\bar{p}_{x,t}}{p_{x,t}(\omega)}\right)\frac{P_{x,t}}{p_{x,t}(\omega)}\left(\frac{P_{x,t}}{P_t^*}\right)^{-\phi} Y_t^{C*}, \tag{4}$$

where

$$\ln \bar{p}_{d,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t}\int_{\omega\in\Omega_{d,t}} \ln p_{d,t}(\omega) d\omega \quad \text{and} \quad \ln \bar{p}_{x,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t}\int_{\omega\in\Omega_{x,t}} \ln p_{x,t}(\omega) d\omega$$

are the maximum prices that a domestic producer can charge in the Home and Foreign markets while still having a positive market share. In the demand expressions (3) and (4), Y_t^C and Y_t^{C*} denote aggregate demand of the final consumption basket at Home and abroad, recognizing that aggregate

[15] Following the convention in BGM, Ghironi and Melitz (2005), and much macroeconomic literature, we refer to an individual final-good producer as a firm. However, as discussed in BGM and Ghironi and Melitz (2005), final-sector productive units in the model are best interpreted as product lines at multi-product firms whose boundaries we leave unspecified by exploiting continuity. In this interpretation, producer entry and exit capture the product-switching dynamics within firms documented by Bernard, Redding, and Schott (2010).

[16] We do not assume separate productivity shocks in the final production sector, which implies that marginal production cost in this sector is simply φ_t. However, if we re-cast intermediate-sector firms as the "labor-intensive" departments of (integrated) final-sector firms, Z_t measures the effectiveness of labor in final goods production.

demand of the final basket in each country includes sources other than household consumption. Aggregate demand in each country takes the same Armington form as the country's consumption basket, with the same elasticity of substitution $\phi > 0$ between demand sub-bundles of Home and Foreign products ($Y_{d,t}$ and $Y^*_{x,t}$ at Home, and $Y^*_{d,t}$ and $Y_{x,t}$ in Foreign), which take the same translog form as the sub-bundles in consumption. This ensures that the consumption price index and the price sub-indexes for the translog consumption aggregators in each country are also the price index and sub-indexes for aggregate demand of the final basket and sub-bundles.

Absent trade costs, and since all goods are traded in the model, the law of one price holds, implying that: $p_{x,t}(\omega) = p_{d,t}(\omega)$ and $\bar{p}_{x,t} = \bar{p}_{d,t}$. Differently from Bergin and Feenstra (2001), translog preferences do not imply pricing-to-market in our model. This happens because producers face the same elasticity of substitutions across domestic and export markets when all goods are traded.[17] The only difference implied by translog preferences relative to the C.E.S. case is that the symmetric elasticity of substitution is not constant, but it varies in response to changes in the number of competitors.

Total demand for final Home producer ω can then be written as:

$$y_{d,t}(\omega) + y_{x,t}(\omega) = \sigma \ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right) \frac{P_{d,t}}{p_{d,t}(\omega)} \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} \left[(1-\alpha)Y_t^C + \alpha Q_t^{\phi} Y_t^{C*}\right].$$

We introduce price stickiness by following Rotemberg (1982) and assuming that final producers must pay a quadratic price adjustment cost $\Gamma_t(\omega) \equiv \nu \pi^2_{d,t}(\omega) p_{d,t}(\omega)(y_{d,t}(\omega) + y_{x,t}(\omega))/2$, where $\nu \geq 0$ determines the size of the adjustment cost (prices are flexible if $\nu = 0$) and $\pi_{d,t}(\omega) \equiv (p_{d,t}(\omega)/p_{d,t-1}(\omega)) - 1$.[18] When a new final-good firm sets the price of its output for the first time, we appeal to symmetry across producers and interpret the $t-1$ price in the expression of the price adjustment cost as the notional price that the firm would have set at time $t-1$ if it had been producing in that period. An intuition for this simplifying assumption is that all producers (even those that are

[17] See the Appendix for the proof. The absence of trade barriers from our model is consistent with the operation of the European Union's Single Market. Transition to the euro narrowed price dispersion across country markets (Martin and Méjean, 2013), supporting the law of one price as a reasonable first approximation to reality.

[18] The total real adjustment cost can be interpreted as the bundle of goods that the firm needs to purchase when implementing a price change. The size of this bundle is assumed to be larger when the size of the firm (measured by its revenue) increases.

setting the price for the first time) must buy the bundle of goods $\Gamma_t(\omega)/P_t$ when implementing a price decision.[19]

Total real profits are given by $d_t(\omega) = \left[p_{d,t}(\omega)\left(1 - \nu\pi^2_{d,t}(\omega)/2\right)/P_t - \varphi_t\right](y_{d,t}(\omega) + y_{x,t}(\omega))$. All profits are returned to households as dividends. Firms maximize the expected present discounted value of the stream of current and future real profits: $E_t \sum_{s=t}^{\infty} [\beta(1-\delta)]^{s-t}(u_{C,s}/u_{C,t})\, d_s(\omega)$. Future profits are discounted with the Home household's stochastic discount factor, as Home households are assumed to own Home final goods firms. As discussed below, there is a probability $\delta \in (0,1)$ that each final good producer is hit by an exogenous, exit-inducing shock at the end of each period. Therefore, discounting is adjusted for the probability of firm survival.

Optimal price setting implies that the (real) output price $\rho_{d,t}(\omega) \equiv p_{d,t(\omega)}/P_t$ is equal to a markup $\mu_t(\omega)$ over marginal cost φ_t: $\rho_{d,t}(\omega) = \mu_t(\omega)\varphi_t$. The endogenous, time-varying markup $\mu_t(\omega)$ is given by $\mu_t(\omega) \equiv \theta_t(\omega)/\left[(\theta_t(\omega) - 1)\,\Xi_t\right]$, where $\theta_t(\omega) = -\partial \ln (y_{d,t}(\omega) + y_{x,t}(\omega))/\partial \ln \rho_{d,t}(\omega)$ denotes the price elasticity of total demand for variety ω, and:

$$\begin{aligned}
\Xi_t \equiv\ & 1 - \frac{\nu}{2}\pi^2_{d,t}(\omega) \\
& + \frac{\nu}{\theta_t(\omega) - 1}\left\{ \begin{array}{c} (\pi_{d,t}(\omega) + 1)\,\pi_{d,t}(\omega) \\ -E_t\left[\beta_{t,t+1}(1-\delta)(\pi_{d,t+1}(\omega)+1)\,\pi_{d,t+1}(\omega)\frac{\rho_{d,t+1}(\omega)}{\rho_{d,t}(\omega)}\left(\frac{y_{d,t+1}(\omega)+y_{x,t+1}(\omega)}{y_{d,t}(\omega)+y_{x,t}(\omega)}\right)\right] \end{array} \right\}.
\end{aligned}$$

There are two sources of endogenous markup variation in our model: First, translog preferences imply that substitutability across varieties increases with the number of available varieties. As a consequence, the price elasticity of total demand facing producer ω increases when the number of Home producers is larger. Second, price stickiness introduces an additional source of markup variation as the cost of adjusting prices gives firms an incentive to change their markups over time in order to

[19] As noted in Bilbiie, Ghironi, and Melitz (2008a), this assumption is consistent with both Rotemberg (1982) and our timing assumption below. Specifically, new entrants behave as the (constant number of) price setters in Rotemberg, where an initial condition for the price is dictated by nature. In our framework, new entrants at any time t who start producing and setting prices at $t+1$ are subject to an analogous assumption. Moreover, the assumption that a new entrant, at the time of its first price decision, knows what will turn out to be the average Home product price last period is consistent with the assumption that entrants start producing only one period after entry, hence being able to observe the average product price during the entry period. Symmetry of the equilibrium will imply $p_{d,t-1}(\omega) = p_{d,t-1} \forall \omega$. Bilbiie, Ghironi, and Melitz (2008a) show that relaxing the assumption that new price setters are subject to the same rigidity as incumbents yields significantly different results only if the average rate of product turnover is unrealistically high.

smooth price changes across periods. When prices are flexible ($\nu = 0$), only the first source of markup variation is present, and the markup reduces to $\theta_t(\omega)/(\theta_t(\omega) - 1)$.

Given the law of one price, the real export price (relative to the Foreign price index P_t^*) is given by $\rho_{x,t}(\omega) \equiv p_{x,t}(\omega)/P_t^* = p_{d,t}(\omega)/P_t^* = \rho_{d,t}(\omega)/Q_t = \mu_t(\omega)\varphi_t/Q_t$, where Q_t is the consumption-based real exchange rate: $Q_t \equiv P_t^*/P_t$.

Producer Entry and Exit Prior to entry, final sector firms face a sunk entry cost $f_{E,t}$ in units of intermediate input.[20] Sunk entry costs reflect both a technological constraint ($f_{T,t}$) and administrative costs related to regulation ($f_{R,t}$), i.e., $f_{E,t} \equiv f_{T,t} + f_{R,t}$. In every period t, there is an unbounded mass of prospective entrants in the final goods sector in each country. Prospective entrants are forward-looking and form rational expectations of their future profits d_s in any period $s > t$ subject to the exogenous probability δ of incurring an exit-inducing shock at the end of each period. Following BGM and Ghironi and Melitz (2005), we introduce a time-to-build lag in the model and assume that entrants at time t will start producing only at $t + 1$. Prospective entrants compute their expected post-entry value e_t, given by the expected present discounted value of the stream of per-period profits d_s: $e_t = E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^{s-t} (u_{C,s}/u_{C,t}) d_s$. Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition $e_t = \varphi_t f_{E,t}$.[21] Our assumptions on exit shocks and the timing of entry and production imply that the law of motion for the number of producing Home firms is given by $N_t = (1 - \delta)(N_{t-1} + N_{E,t-1})$.

Household Budget Constraint and Intertemporal Decisions

The representative household can invest in two types of assets: shares in mutual funds of final-sector and intermediate-sector firms and a non-contingent, internationally traded bond denominated in units of the common currency.[22] Investment in the mutual fund of final-sector firms in the stock market is

[20] This assumption replicates the assumption in BGM and Ghironi and Melitz (2005) that the same input is used to produce existing varieties and create new ones.

[21] This condition holds as long as the mass of new entrants $N_{E,t}$ is positive. We verify that this condition is never violated in our exercises.

[22] For simplicity, we assume extreme home bias in equity holdings and rule out international trade in firm shares. See Hamano (2011) for a version of the Ghironi-Melitz (2005) model with international trade in equities.

the mechanism through which household savings are made available to prospective entrants to cover their entry costs. Since there is no entry in the intermediate sector (and, therefore, no need to channel resources from households for the financing of such entry), we do not model trade in intermediate-sector equity explicitly, but simply assume that the profits of intermediate sector firms are rebated to households in lump-sum fashion.[23]

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

Let A_{t+1} denote nominal bond holdings at Home entering period $t+1$. To induce steady-state determinacy and stationary responses to temporary shocks in the model, we follow Turnovsky (1985) and, more recently, Benigno (2009), and we assume a quadratic cost of adjusting bond holdings $\tau \left(A_{t+1}/P_t\right)^2/2$ (in units of Home consumption). This cost is paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion.

The Home household's period budget constraint is:

$$A_{t+1} + P_t \frac{\tau}{2}\left(\frac{A_{t+1}}{P_t}\right)^2 + P_t C_t + x_{t+1}\left(N_t + N_{E,t}\right) P_t e_t =$$

$$(1+i_t) A_t + x_t P_t N_t \left(d_t + e_t\right) + w_t l_t h_t + P_t b \left(1 - l_t\right) + T_t^G + T_t^F + T_t^I,$$

[23] Even if intermediate producers are perfectly competitive, our assumptions on the labor market imply that their profits are not zero. To understand this, note that as long as the wage negotiated by workers and firms is inside the bargaining set (and, therefore, smaller than or equal to the firm's outside option), the surplus from a match that goes to the firm is positive. Since all workers are identical, the total surplus of the intermediate sector is positive, and so is the profit rebated to households.

where i_t is the nominal interest rate on the internationally traded bond (the policy instrument of the monetary union's central bank), T_t^G is a lump-sum transfer (or tax) from the government, T_t^F is a lump-sum rebate of the cost of adjusting bond holdings from the intermediaries to which it is paid, and T_t^I is a lump-sum rebate of profits from intermediate goods producers.[24] We use the timing convention in Obstfeld and Rogoff (1995) for the nominal interest rate: i_{t+1} is the interest rate between t and $t+1$, and it is known with certainty in period t.

Let $a_{t+1} \equiv A_{t+1}/P_t$ denote Home real bond holdings. Euler equations for bond and share holdings are:

$$\begin{aligned} 1+\tau a_{t+1} &= \beta\left(1+i_{t+1}\right) E_t\left[\frac{u_{C,t+1}}{u_{C,t}}\frac{1}{\left(1+\pi_{C,t+1}\right)}\right], \\ e_t &= \beta\left(1-\delta\right) E_t\left[\frac{u_{C,t+1}}{u_{C,t}}\left(d_{t+1}+e_{t+1}\right)\right], \end{aligned}$$

where $\pi_{C,t} \equiv \left(P_t/P_{t-1}\right)-1$ is net consumer price inflation. As expected, forward iteration of the equation for shares and absence of speculative bubbles yield the expression for firm value used in the free entry condition above.[25] We present the details of the symmetric equilibrium of our model economy in the Appendix, and we limit ourselves to presenting the law of motion for net foreign assets below.

Net Foreign Assets and the Trade Balance

Bonds are in zero net supply, which implies the equilibrium condition $a_{t+1}+Q_t a_{t+1}^*=0$ in all periods. We show in the Appendix that Home net foreign assets are determined by:

$$a_{t+1}=\frac{1+i_t}{1+\pi_{C,t}}a_t+N_t\rho_{d,t}y_{x,t}-N_t^* Q_t\rho_{d,t}^* y_{x,t}^*.$$

[24] In equilibrium,

$$T_t^G=-P_t b\left(1-l_t\right), \quad T_t^F=P_t\frac{\tau}{2}\left(\frac{A_{t+1}}{P_t}\right)^2, \quad \text{and} \quad T_t^I=P_t\left(\varphi_t Z_t l_t h_t-\frac{w_t}{P_t}l_t h_t-\kappa V_t-\frac{\vartheta}{2}\pi_{w,t}^2 l_t\right).$$

[25] We omit the transversality conditions that must be satisfied to ensure optimality.

Denoting the real interest rate with r_t, we have $1 + r_t = (1 + i_t) / (1 + \pi_{C,t})$, and the change in net foreign assets between t and $t+1$ is determined by the current account: $a_{t+1} - a_t = CA_t \equiv r_t a_t + TB_t$, where TB_t is the trade balance: $TB_t \equiv N_t \rho_{d,t} y_{x,t} - N_t^* Q_t \rho_{d,t}^* y_{x,t}^*$.

3 Monetary Policy

To close the model described in the previous section, we must specify the behavior of monetary policy. We compare the Ramsey-optimal conduct of monetary policy to a representation of historical behavior for the central bank, captured by a standard rule for interest rate setting in the spirit of Taylor (1993), Woodford (2003), and much other literature. Before describing this interest-rate setting rule, however, we must address an issue that concerns the data that are actually available to the central bank in its historical policymaking, and hence the empirically-relevant variables that enter the theoretical representation of historical policy. We turn to this issue next.

Data-Consistent Variables and Historical Monetary Policy

In the presence of endogenous producer entry and preferences that exhibit "love for variety," variables measured in units of consumption do not have a direct counterpart in the data. This point is highlighted by Ghironi and Melitz (2005). As the economy experiences entry of Home and Foreign firms, the welfare-consistent aggregate price index P_t can fluctuate even if product prices remain constant. In the data, however, aggregate price indexes do not take these variety effects into account.[26] To resolve this issue, we follow Ghironi and Melitz (2005) and BGM and introduce the data-consistent price index $\tilde{P}_t \equiv \Omega_t^{\frac{1}{\phi-1}} P_t$, where Ω_t is an adjustment for product variety defined by:

$$\Omega_t \equiv (1-\alpha) \exp\left(\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t}\right) + \alpha \exp\left(\frac{\tilde{N}^* - N_t^*}{2\sigma \tilde{N}^* N_t^*}\right),$$

where $\exp(X)$ denotes the exponential of X to avoid confusion with the notation for firm value. Given any variable X_t in units of consumption, we then construct its data-consistent counterpart as

[26] There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010).

$X_{R,t} \equiv X_t/\Omega_t^{\frac{1}{\phi-1}}$. (Additional details are in the Appendix.)

The European Central Bank has a mandate of price stability defined in terms of a (harmonized) index of consumer price inflation. Since we will calibrate the model to features of EMU, this motivates our specification of the historical rule for interest-rate setting as a rule in which policy responds to movements in a country-weighted average of data-consistent CPI inflation and data-consistent GDP gaps relative to the equilibrium with flexible wages and prices:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i) \left(1 + \tilde{\pi}^U_{C,t}\right)^{\varrho_\pi} \left(\tilde{Y}^U_{g,t}\right)^{\varrho_Y} \right]^{1-\varrho_i}, \tag{5}$$

where $\tilde{\pi}^U_{C,t} \equiv \tilde{\pi}^{\frac{1}{2}}_{C,t} \tilde{\pi}^{*\frac{1}{2}}_{C,t}$ is data-consistent, union-wide CPI inflation, and $\tilde{Y}^U_{g,t} \equiv \tilde{Y}^{\frac{1}{2}}_{g,t} \tilde{Y}^{*\frac{1}{2}}_{g,t}$ is the data-consistent, union-wide GDP gap. (All union-wide variables below are defined as $X^U_t \equiv X^{\frac{1}{2}}_t X^{*\frac{1}{2}}_t$.)

Table 1 summarizes the key equilibrium conditions of the model, including the policy rule (5). We rearranged some equations appropriately for transparency of comparison to the planner's optimum obtained below, which we will use to build intuition for the tradeoffs facing the Ramsey policymaker. The table contains 21 equations that determine 21 endogenous variables of interest: $C_t, C^*_t, \rho_{d,t}, \rho^*_{d,t}, l_t, l^*_t, V_t, V^*_t, N_t, N^*_t, w_t/P_t, w^*_t/P^*_t, h_t, h^*_t, \pi_{w,t}, \pi^*_{w,t}, \pi_{C,t}, \pi^*_{C,t}, i_{t+1}, Q_t,$and a_{t+1}. (Other variables that appear in the table are determined as described above.)

Ramsey-Optimal Monetary Policy

The Ramsey authority maximizes aggregate welfare under the constraints of the competitive economy. Let $\{\Lambda_{1,t}, ..., \Lambda_{20,t}\}^\infty_{t=0}$ be the Lagrange multiplier associated to the equilibrium conditions in Table 1 (excluding the interest-rate setting rule).[27] The Ramsey problem consists of choosing

$$\{\pi_{C,t}, \pi^*_{C,t}, \pi_{w,t}, \pi^*_{w,t}, C_t, C^*_t, l_t, l^*_t, V_t, V^*_t, J_t, J^*_t, h_t, h^*_t, \rho_{d,t}, \rho^*_{d,t}, N_{t+1}, N^*_{t+1}, Q_t, i_{t+1}, a_{t+1}\}^\infty_{t=0},$$

$$\text{and } \{\Lambda_{1,t}, ..., \Lambda_{20,t}\}^\infty_{t=0}$$

[27] We assume that the other variables that appear in the table have been substituted out by using the appropriate equations and definitions above.

to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2} \left(u\left(C_t\right) - l_t v\left(h_t\right) \right) + \frac{1}{2} \left(u\left(C_t^*\right) - l_t^* v\left(h_t^*\right) \right) \right] \tag{6}$$

subject to the constraints in Table 1 (excluding the interest rate rule).[28]

As common practice in the literature, we write the original non-stationary Ramsey problem in a recursive stationary form by enlarging the planner's state space with additional (pseudo) co-state variables. Such co-state variables track the value to the planner of committing to the pre-announced policy plan along the dynamics.

The Ramsey planner uses its policy instrument (the interest rate) to address the consequences of a set of distortions that exist in the market economy. To understand these distortions and the tradeoffs they create for optimal policy, it is instructive to compare the equilibrium conditions of the market economy summarized in Table 1 to those implied by the solution to a first-best, optimal planning problem. This allows us to define inefficiency wedges for the market economy (relative to the planner's optimum) and describe Ramsey policy in terms of its implications for these wedges.

4 Inefficiency Wedges

In this section, we discuss the sources of distortion in the market economy by comparing the market outcome to the first-best allocation chosen by a benevolent social planner for the monetary union as a whole. We present the details of the planning problem in the Appendix. Table 2 summarizes the equilibrium conditions for the efficient allocation.

Comparing the equilibrium conditions in the decentralized economy (Table 1) to those for the planned economy (Table 2) allows us to identify the distortions at work in our model and define inefficiency wedges relative to the efficient allocation. Table 3 summarizes the distortions that characterize the decentralized economy.

Our model features several sources of distortion: Some are familiar ingredients in New Keynesian

[28] In the primal approach to Ramsey policy problems described by Lucas and Stokey (1983), the competitive equilibrium is expressed in terms of a minimal set of relations involving only real allocations. In the presence of sticky prices and wages, it is impossible to reduce the Ramsey planner's problem to a maximization problem with a single implementability constraint.

macroeconomics; Others arise from our microfoundation of product and labor market dynamics and frictions. The distortions affect five margins of adjustment and the resource constraint for consumption output:

- **Product creation margin:** Comparing the term in square brackets in equation (7) in Table 1 to the term in square brackets in equation (7) in Table 2 implicitly defines the inefficiency wedge along the market economy's product creation margin (see the Appendix for details). The wedge $\Sigma_{PC,t}$ is a combination of several distortions. Bilbiie, Ghironi, and Melitz (2008b) show that time-variation of markups is inefficient. In our model, the markup is time-varying because of translog preferences and sticky prices. We summarize this source of inefficiency with the distortion effect $\Upsilon_{\mu,t} \equiv \mu_{t-1}/\mu_t - 1$. Moreover, both price stickiness and translog preferences imply that the (time-varying) net markup is not aligned with the benefit of product variety to consumers, resulting in the misalignment effect $\Upsilon_{N,t} \equiv \mu_{t-1}\left(1 - 1/\mu_t - \nu\pi_{d,t}^2/2\right) - 1/(2\sigma N_t)$. These distortions are at work in Bilbiie, Fujiwara, and Ghironi (2011—BFG, as denoted in the Introduction). The product creation margin in our model is distorted also by the existence of a non-technological component, $f_{R,t}$, of the overall entry cost, $f_{E,t}$, which results in the regulation distortion $\Upsilon_{R,t} \equiv f_{R,t}$.[29] Absent these distortions ($\Upsilon_{\mu,t} = \Upsilon_{N,t} = \Upsilon_{R,t} = 0$), the product creation wedge $\Sigma_{PC,t}$ is equal to 1.

- **Job creation margin:** Comparing the term in square brackets in equation (9) in Table 1 to the term in square brackets in equation (9) in Table 2 implicitly defines the inefficiency wedge along the market economy's job creation margin (see the Appendix for details; equation (11) in Table 1 determines the real wage in the market economy). The wedge $\Sigma_{JC,t}$ is also a combination of several distortions. Monopoly power distorts the job creation decision by inducing a suboptimally low return from vacancy posting, captured by $\Upsilon_{\varphi,t} \equiv (1/\mu_t) - 1$. Failure of the Hosios condition (for which equality of the firm's bargaining share and the vacancy elasticity

[29] Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2011) consider the case $f_{R,t} = -\tau_t^E f_{T,t}$ and discuss the determination of optimal product creation subsidies τ_t^E in a first- or second-best environment, respectively. We focus on the consequences of an exogenous deregulation that reduces non-technological barriers to entry, abstracting from the issue of optimal entry subsidies (or taxes).

of the matching function is necessary for efficiency) is an additional distortion in this margin, measured by $\Upsilon_{\eta,t} \equiv \eta_{w,t} - \varepsilon$. This is affected both by the flexible-wage value of the bargaining share (η, which can be different from ε) and the presence of wage stickiness, which makes the equilibrium bargaining share endogenous to inflation. Therefore, sticky wages are sufficient to generate a wedge between private and social returns to vacancy posting. Moreover, sticky wages distort job creation also by affecting the outside option of firms through the additional term $\Upsilon_{\pi_w,t} \equiv \vartheta \pi_{w,t}^2/2$. Finally, unemployment benefits increase the workers' outside option above its efficient level: $\Upsilon_{b,t} \equiv b$. (As for product market regulation, we do not discuss the optimal determination of unemployment benefits, and we simply take b as exogenous.) When $\Upsilon_{\varphi,t} = \Upsilon_{\eta,t} = \Upsilon_{b,t} = \Upsilon_{\pi_w,t} = 0$, the real wage is determined by

$$\frac{w_t}{P_t} h_t = \varepsilon \frac{v(h_t)}{u_{C,t}} + (1-\varepsilon)\rho_{d,t} Z_t h_t + \kappa \left(1-\varepsilon\right) \iota_t / q_t,$$

and the job creation wedge $\Sigma_{JC,t}$ is equal to 1.

- **Labor supply margin:** With endogenous labor supply, monopoly power in product markets induces a misalignment of relative prices between consumption goods and leisure. This is the distortion that characterizes standard New Keynesian models with monopolistic competition. Following established practice, we define the associated wedge as the reciprocal of the markup: $\Sigma_{h,t} \equiv 1/\mu_t$, which is time-varying for the presence of translog preferences and sticky prices. This distortion is at work also in BFG. Efficiency along this margin requires $\Sigma_{h,t} = 1$ (or $\Upsilon_{\varphi,t} = 0$). (The prescription of price stability that arises from many New Keynesian models in which price stickiness is the only cause of markup variation can be interpreted as a prescription of smoothing the dynamics of the wedge $\Sigma_{h,t}$.)

- **Cross-country risk sharing margin:** Incomplete markets imply inefficient risk sharing between Home and Foreign households, resulting in the distortion $\Upsilon_{Q,t} \equiv \left(u_{C^*,t}/u_{C,t}\right)/Q_t$. The departure of relative consumption from the perfect risk sharing outcome is also affected by the costs of adjusting bond holdings (the distortion $\Upsilon_{a,t} \equiv \tau a_{t+1}$ and its Foreign mirror image in the Euler equations for Home and Foreign holdings of bonds). We summarize the combined effect of these distortions with the financial inefficiency wedge $\Sigma_{RS,t} \equiv (u_{C^*,t}/u_{C,t})/Q_t = \Upsilon_{Q,t}$. Efficiency along this margin requires $\Sigma_{RS,t} = 1$.

- **International relative price margin:** Adjustment of international relative prices in the model is summarized by the condition that ties real exchange rate dynamics to relative inflation in consumer price indexes: $Q_t/Q_{t-1} = \left(1 + \pi^*_{C,t}\right)/(1 + \pi_{C,t})$. With sticky wages and prices, as long as the model does not satisfy the conditions such that a fixed exchange rate is optimal, monetary union distorts this margin of adjustment by removing adjustment through the nominal exchange rate.[30] Unfortunately, this distortion cannot be summarized by an analytically defined wedge relative to the planner's optimum, because the planned economy does not feature nominal rigidity. (A consequence of this is that there is no expression for this distortion in Table 3.)

- **Consumption resource constraint:** Sticky wages and prices and "red tape" imply diversion of resources from consumption and creation of new product lines and vacancies, with the distortions $\Upsilon_{\pi_w,t} \equiv \vartheta \pi^2_{w,t}/2$, $\Upsilon_{\pi_d,t} \equiv \nu \pi^2_{d,t}/2$, and $\Upsilon_{R,t}$. The associated wedge (defined by the sum of these distortions: $\Sigma_{Y^C,t} \equiv \Upsilon_{\pi_w,t} + \Upsilon_{\pi_d,t} + \Upsilon_{R,t} N_{E,t}$) is zero under flexible wages and prices, and without "red tape" in product creation.

The market allocation is efficient only if all the distortions are eliminated and the associated inefficiency wedges are closed at all points in time. Efficiency can be achieved only if the following two conditions are jointly satisfied: (i) Countries are fully symmetric at each point in time; and (ii) governments in each country have access to an appropriate set of distortionary and lump-sum fiscal instruments that are optimally chosen *together* with monetary policy. Full symmetry across countries is required to overcome the consequences of financial market incompleteness and the fixed nominal exchange rate. Optimal fiscal policy realigns benefit from variety and markup, eliminates the

[30] With flexible exchange rates, it would be $Q_t/Q_{t-1} = \left(1 + \pi^*_{C,t}\right) S_t / \left[\left(1 + \pi_{C,t}\right) S_{t-1}\right]$, where S_t is the nominal exchange rate (units of Home currency per unit of Foreign currency). Note that this distortion from the irrevocably fixed exchange rate is at work also when asset markets are complete.

effects of monopoly power, and sets unemployment benefits and product regulation (as modeled in our paper) to zero.[31] In the symmetric case, optimal monetary policy would then set producer price inflation to zero (which would also ensure zero wage inflation under full symmetry). Since we abstract from optimal fiscal policy and focus on asymmetric shocks, it follows that we work in a second-best environment in which the efficient allocation cannot be achieved. In this second-best environment, the Ramsey central bank optimally uses its leverage on the economy via the sticky-price and sticky-wage distortions, trading off their costs (including the resource costs) against the possibility of addressing the distortions that characterize the market economy under flexible wages and prices. As we show below, although the model features multiple distortions, several of them have the same qualitative implications for optimal policy. Therefore, the Ramsey central bank actually faces a small number of policy tradeoffs—with intuitive policy implications—both in the long run and over the business cycle.

5 Optimal Monetary Policy with High Market Regulation

We begin our discussion of optimal policy by characterizing the Ramsey-optimal monetary policy in the presence of high market regulation. First, we discuss the tradeoffs that determine the long-run policy outcome and the Ramsey allocation over the business cycle. Then we turn to a numerical illustration that substantiates these intuitions. In all the figures below, the impulse responses of the inefficiency wedges that we plot show the percent changes of the wedge deviations from efficiency.

Tradeoffs and Intuitions

Optimal Monetary Policy in the Long Run

It is immediate to verify that long-run inflation is always symmetric across countries regardless of symmetry or asymmetry of the calibration. This result follows from the presence of a common nominal interest rate in the monetary union and the steady-state Euler equations of households: $1 + \pi_d = 1 + \pi_C = \beta(1 + i) = 1 + \pi_C^* = 1 + \pi_d^*$. Moreover, wage inflation is always equal to producer price

[31] See Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2011) for discussions of optimal fiscal policy in the BGM model.

inflation: $\pi_d = \pi_{w.}$

Our interest in this section is in how the Ramsey central bank determines the optimal common inflation rate π_d to address the distortions discussed in Section 4. To begin understanding policy incentives in the long run, notice that a symmetric long-run equilibrium with constant endogenous variables eliminates some of these distortions: A constant markup removes the markup variation distortion from the product creation margin ($\Upsilon_\mu = 0$); Symmetry across countries removes the risk-sharing distortion of incomplete markets, and constant, zero net foreign assets eliminate the effect of asset adjustment costs; Finally, symmetry also eliminates the international relative price distortion of monetary union by implying $Q = 1$ (as a result of symmetry, $\Upsilon_Q = \Sigma_{RS} = 1$ and $\Upsilon_a = 0$).

All the remaining steady-state distortions but the costs of wage and price adjustment require a reduction of markups. As discussed in Bilbiie, Ghironi, and Melitz (2008b) and BFG, translog preferences imply that the steady-state, flexible-price markup is higher than the benefit of product variety to the consumer. *Ceteris paribus*, this results in suboptimal product creation. Smaller net markups contribute to realigning the firms' incentive for product creation and the consumers' benefit from variety. Moreover, a smaller markup narrows the wedge in labor supply and results in increased vacancy posting by firms. A decrease in steady-state markups can be achieved by means of positive net inflation. At the same time, since $\pi_d = \pi_w$, positive inflation implies a departure from the Hosios condition (the steady-state level of $\eta_{w,t}$ rises above ε), increasing the bargaining power of firms. Compared to the zero inflation outcome, the Ramsey authority chooses a positive long-run inflation rate that reduces the inefficiency wedges in product creation (Σ_{PC}), job creation (Σ_{JC}), and labor supply (Σ_h). However, the Ramsey authority must trade the beneficial welfare effects of reducing these distortions against the costs of non-zero inflation implied by allocating resources to price and wage changes and by the departure from the Hosios condition.

Optimal Monetary Policy over the Business Cycle

Stochastic fluctuations in aggregate productivity modify the policy tradeoffs facing the Ramsey authority by reintroducing the distortions eliminated by symmetry and absence of time variation in steady state. Moreover, Ramsey-optimal long-run policy does not close the remaining steady-state inefficiency wedges completely. Thus, the Home and Foreign economies fluctuate around a steady state where markups and unemployment are inefficiently high. As a result, shocks trigger larger fluctuations in product and labor markets (in both economies) than in the efficient allocation: Both producer entry and unemployment are suboptimally volatile.

What are the policy tradeoffs facing the Ramsey central bank over the business cycle? First, as in steady state, there is a tension between the beneficial effects of manipulating inflation and its costs. Second, there is a tradeoff between stabilizing price inflation (which contributes to stabilizing markups) and wage inflation (which stabilizes unemployment) in the country affected by a shock. Therefore, it is impossible to stabilize unemployment and markups jointly. Third, there is a tension between stabilizing the Home and Foreign economies in response to asymmetric shocks.

These three policy tradeoffs explain why a policy of price stability can be suboptimal: Under this policy, wage inflation is too volatile, and markup stabilization correspondingly too strong. Following fluctuations in aggregate productivity, sticky wages and positive unemployment benefits generate real wage rigidities, i.e., a positive (negative) productivity shock is not fully absorbed by the rise (fall) of the real wage, affecting job creation over the cycle. Higher Home productivity pushes the real wage above its steady-state level, as the real value of existing matches has increased. Under a policy of price stability, the effect of wage stickiness is magnified, since the real wage becomes even more rigid. Firms post too many vacancies and, in equilibrium, nominal wage adjustment costs are too large.[32]

Numerical Illustration

We now present the results of a numerical exercise that substantiates the intuitions above and allows us to evaluate the welfare gains from implementing optimal policy relative to the ECB's historical behavior. We interpret periods as quarters and calibrate the model to match Euro Area macroeconomic data from 1985:Q1 to 2007:Q4. (Following standard practice, we set parameter values so that the

[32] Notice, however, that a policy that completely stabilizes wage inflation is also suboptimal. In this case, there would be too much inflation and markup volatility, and the response of unemployment would be too small.

model replicates long-run features of the data in the zero-inflation steady state.) In the Appendix, we present a detailed description of our calibration, which is assumed symmetric across countries. We also provide a detailed discussion of the impulse responses to a Home productivity shock and the second-moment properties of the model under the historical policy. We show that the model successfully replicates several features of the Euro Area business cycle, including (at least qualitatively) moments that represent a traditional challenge for international business cycle models. The Appendix presents also a summary of results obtained from a sensitivity analysis on the values of several key parameters. Our results are robust to the alternative calibrations we consider.

Long Run

Table 4 shows that the optimal long-run target for net inflation under the high regulation scenario of our historical calibration is indeed positive and equal to 1.20 percent—in the range of the ECB's mandate. (All results in Table 4 and the following tables are annualized.) The finding of an optimal positive long-run inflation is in contrast with the prescription of near zero inflation delivered by the vast majority of New Keynesian models. While the costs of inflation outweigh the benefits of reducing other distortions in those models, this is no longer the case with a richer microfoundation of product and labor markets.[33]

Table 4 also presents the welfare gain from implementing the long-run optimal policy relative to the ECB's historical behavior. We measure the long-run welfare gains of the Ramsey policy in the two countries (which are equal by symmetry) by computing the percentage increase Δ in consumption that would leave the household indifferent between policy regimes. To compute this welfare gain avoiding spurious welfare reversals, we assume identical initial conditions across different monetary policy regimes and include transition dynamics in the computation. Specifically, we assume that all the state variables are set at their steady-state levels under the historical policy at time $t = -1$, regardless

[33] A similar result arises in BFG's closed economy model with a Walrasian labor market and flexible wages. Cacciatore and Ghironi (2012) show that labor market frictions and sticky wages are sufficient to generate significant departures from zero optimal long-run inflation under flexible exchange rates. We experimented with lower values of the price stickiness parameter ν and found higher values of optimal long-run inflation as its cost decreases. Price indexation generates the same result in BFG.

of the monetary regime from $t = 0$ on. (Details on our welfare computations are in the Appendix.) Table 4 shows that the welfare gains from the Ramsey-optimal policy amount to approximately 0.21 percent of annualized steady-state consumption.[34]

Business Cycle

Figure 1 (dashed lines) shows impulse responses to a Home productivity increase under the Ramsey-optimal policy. Solid lines present the responses under the historical policy, explained in detail in the Appendix. The figure includes the impulse response of investment, defined as $I_t \equiv N_{E,t}e_t$.

Consistent with the intuition above, the Ramsey authority generates a smaller increase in wage inflation and a larger departure from price stability (disinflation) at Home relative to the historical rule (which implements a policy of near price stability, defined as zero deviation of inflation from trend). Both prices and wages fall in Foreign. Unemployment falls at Home, but the optimal policy causes it to rise in Foreign. Historical ECB behavior (and price stability) result in positive employment comovement across countries. In contrast, the Ramsey authority pushes unemployment rates in opposite directions by engineering wage disinflation rather than inflation in the Foreign country and a reduction in Foreign firms' bargaining share. This results in higher unemployment in the relatively less productive economy. In the Home country, producers have a weaker incentive to post vacancies as more stable wage inflation implies that their effective bargaining power rises by less than under the historical policy. Lower job creation translates into smaller employment gains, which reduces domestic aggregate demand for Home and Foreign goods. Trade linkages and risk sharing imply positive comovement of GDP and consumption across countries under both historical and optimal policies. While the standard New Keynesian prescription of price stability amounts to a prescription of procyclical monetary policy, with expansion in response to favorable productivity shocks to mimic the flexible-price equilibrium, optimal policy in our monetary union with multiple distortions is more countercyclical than historical behavior. The Ramsey central bank induces a larger drop in inflation (and markups) in both countries following an expansionary shock at Home (and it expands more aggressively in the

[34] Our results are not sensitive to the choice of (identical) initial conditions for the state variables.

opposite case of a contractionary shock).[35]

Table 5 shows that the welfare loss from not implementing optimal policy over the business cycle is 0.19 percent of annualized, steady-state consumption: Optimal departures from price stability lower the cost of business cycles from 0.94 percent of steady-state consumption under the historical policy to 0.75 percent. Overall, the implementation of optimal monetary policy over the cycle and in the long run increases welfare by approximately 0.5 percent of steady-state consumption under the market status quo.

6 Optimal Monetary Policy and Market Deregulation

How does market deregulation affect optimal monetary policy? Structural policy changes pose a set of challenges for the central bank. First, reforms have permanent effects that may alter the optimal long-run inflation target. Second, monetary policy can shape the dynamic adjustment to the new long-run equilibrium during the transition period. Third, deregulation affects the way economies respond to aggregate shocks, with consequences for the optimal conduct of monetary policy over the business cycle. Finally, new policy tradeoffs emerge for the central bank if deregulation is asymmetric across members of the monetary union, raising the question of desirability of coordinated reforms. We use numerical illustrations to substantiate the general intuitions that we weave in the discussion below.

In our exercises, product market deregulation is interpreted as a permanent decrease of regulatory barriers to product creation, f_R. Labor market reform is instead a permanent reduction of unemployment benefits, b, and employment protection, proxied by the workers' bargaining power parameter $1-\eta$ as in Blanchard and Giavazzi (2003). We treat deregulations as unanticipated, permanent policy shocks that are fully implemented in the impact period.[36] We assume that the policy parameters f_R, b, and $1-\eta$ are lowered to the corresponding U.S. levels, a standard benchmark for flexible markets.

[35] In the standard New Keynesian model, higher inflation is associated with a falling markup. The contemporaneous occurrence of falling inflation and markups in our model is a result of labor market frictions that induce marginal costs to rise in the impact period of expansionary shocks. It follows that markups must fall to ensure falling output prices.

[36] Deregulations involving changes in legislation are likely anticipated by the time they happen, and deregulations may be implemented over time. However, our assumption is a useful benchmark in the absence of information on the duration of parliamentary debates, legislative processes, and implementation periods.

Pissarides (2003) reports that it takes (on average) 9 days to fulfill entry requirements in the U.S. The implied value of f_R is 0.16. Unemployment benefits, b, are tied to the average replacement rate $b/(wh)$. The U.S. replacement rate documented by OECD (2004) is 0.54. To pin down the change in workers' bargaining power $1-\eta$, we use the fact that U.S. employment protection legislation indexes reported by OECD (2004), adjusted for worker coverage by our own calculations, are approximately one third of those for European countries. The implied value of $1-\eta$ is 0.25, not far from the estimates in Flinn (2006).

Dynamic Adjustment and Long-Run Effects of Market Deregulation

We begin by studying the optimal monetary policy response to Home market deregulation during the transition dynamics and in the long run.[37] Given the large size of the deregulation shocks, we compute the responses to these shocks without relying on local approximations by using the Newton-type algorithm first proposed by Laffargue (1990). The details of the algorithm can be found in Juillard (1996).

Product Market Deregulation

To understand the optimal monetary policy response to product market deregulation, it is useful first to inspect the dynamic adjustment and new long-run equilibrium under historical policy. As shown in Figure 2 (solid lines), a reduction in barriers to entry at Home generates profitable investment opportunities and product creation. Under financial autarky, this would require households to cut consumption and increase savings to finance the expansion in entry: Since incumbents and new entrants are not more productive, expansion of entry after deregulation requires higher saving under financial autarky, as noted by Ghironi and Melitz (2005). With an open capital account, increased entry can

[37] It could be argued that the initial scenario we consider—in which both countries start at high levels of regulation and one of them deregulates—captures features of the dynamics after Germany's structural reforms initiated by then Chancellor Gerhard Schröder in 2003. The current debate in Europe would have the countries with rigid markets catch up with Germany. Our model does not capture the tax reductions that were part of the German experience. We explored the scenario in which Foreign deregulates its markets starting from a situation in which Home's markets are already flexible. The dynamics of the Foreign country in that case are very similar to those of the Home country described below. Details are available on request.

also be financed by borrowing from abroad. As a result, the deregulating economy runs a current account deficit during the first part of the transition.[38] Consumption rises on impact at Home as part of the external borrowing is used to increase current consumption in anticipation of higher permanent future income. Producer entry boosts job creation, lowering unemployment, and wages increase. The initial effect of a product market reform is inflationary, which erodes markups on impact. Financial and trade linkages imply significant spillovers to Foreign along the transition. As Foreign consumers invest at Home, Foreign consumption falls, and unemployment rises. Furthermore, Home's terms of trade ($TOT_t \equiv p_{x,t}/p^*_{x,t}$) improve in response to the deregulation, with a negative wealth effect abroad.

In the second part of the transition, the larger number of available domestic products lowers markups at Home, boosting GDP, consumption and job creation. In turn, the Foreign economy recovers due to increased demand for its products at Home.

How do the responses to deregulation change under the Ramsey-optimal policy? As before, we assume that initial conditions are given by the rigid steady state under the historical policy (which features zero inflation). Figure 2 (dashed lines) shows that the Ramsey policy generates higher consumption and lower unemployment in the first two years after the reform. The Ramsey allocation initially induces smaller product creation by increasing inflation, i.e., reducing the real present discounted value of entry. This happens because the economy starts from a situation in which markups are too high, $\Upsilon_N > 0$, and incumbents are too small, $\Upsilon_\varphi > 0$. However, the Ramsey planner anticipates that the new long-run equilibrium will feature lower markups and a larger number of producers of more significant size. Therefore, the optimal policy reduces markups, boosts incumbent firm size, and increases employment at Home in anticipation of these long-run effects. Relative to historical policy, the Ramsey-optimal policy reduces the job creation wedge $\Sigma_{JC,t}$ during the transition to the new long-run equilibrium. The product creation wedge $\Sigma_{PC,t}$, instead, falls on impact but is then temporarily widened. This happens because the short-run increase in inflation translates into lower

[38] The current account initially deteriorates across all deregulation scenarios we consider. Policymakers (for instance, ECB President Mario Draghi in his September 6, 2012 press conference) and academic literature (for instance, Corsetti, Martin, and Pesenti, 2013) often refer to market reforms as a way to improve competitiveness and rebalance external positions. Our results show that the beneficial effects of structural reforms may come at the cost of weaker current accounts at least initially.

product creation in the immediate aftermath of the deregulation.

Employment, GDP, and consumption in the Foreign, rigid economy are also favorably affected by the Ramsey policy on impact due to the larger demand for Foreign goods in the deregulating economy. The optimal policy reduces the job creation wedge during the transition also in Foreign. Similar to Home, the product creation wedge falls on impact, but then increases, associated with lower product creation in the relatively less attractive business environment during the transition. Finally, notice that both Home and Foreign benefit from improved risk-sharing under the Ramsey-optimal policy, i.e., the inefficiency wedge $\Sigma_{RS,t}$ is reduced at each point in time relative to the historical policy.

As time passes, the differences between Ramsey policy and historical rule vanish, at least in the deregulating economy. In the long run, Home product market deregulation reduces (or leaves virtually unaffected) all Home and Foreign inefficiency wedges with the exception of cross-country risk-sharing. The optimal long-run inflation target remains positive but is smaller than under high regulation.

To understand this result, it is useful to inspect how deregulation affects inefficiency wedges in the long run. First, recall that the markup is constant in steady state, and so $\Upsilon_\mu = 0$. Moreover, under the historical long-run zero net inflation, the Hosios condition implied by our calibration ensures that $\eta = \varepsilon$ and $\Upsilon_\eta = \Upsilon_{\pi_w} = \Upsilon_{\pi_d} = 0$. Finally, product market regulation does not change the value of unemployment benefits, leaving Υ_b unaffected. Thus, three distortions remain at the zero-inflation steady state: $\Upsilon_N = (\mu - 1) - 1/(2\sigma N)$, the misalignment between the consumers' benefit from variety and the profit incentives for new entrants; $\Upsilon_\varphi = (1/\mu) - 1$, measuring the monopoly power distortion on labor supply and job creation; and $\Upsilon_Q = (u_{C^*,t}/u_C)/Q$, the incomplete markets distortion (because the deregulation created an asymmetry across countries).

As barriers to entry fall, the number of products in the economy increases. With zero net inflation, the fall in markups due to increased competition is larger than the reduction in the consumers' benefit from variety, since $\partial\Upsilon_N/\partial N = -1/\left(2\sigma N^2\right) < 0$. It follows that lower regulatory costs reduce the misalignment between benefit from variety and incentives for product creation. Moreover, the reduction in markups also reduces the distortion Υ_φ,since $\partial\Upsilon_\varphi/\partial N = -1/\left(\sigma N^2\right) < 0$. Intermediate input producers have stronger incentives to post vacancies, households have stronger incentives to supply effort, and employment and hours get closer to the respective efficient levels. Finally, given the asymmetric nature of the reform, the incomplete markets wedge is wider by construction. Absent complete markets, the increase in Home consumption is not fully shared by Foreign.

Long-run responses under the Ramsey-optimal policy are very similar to those under the historical rule because the reduction in the first two distortions dominates the planner's incentives and results in lower steady-state optimal inflation (1.07 percent, as shown in Table 4).

Table 4 shows that product market reform is highly beneficial for the deregulating country already under the historical policy, as welfare gains amount to 5 percent of annualized consumption at Home. There is a modest prosper-thy-neighbor effect, as welfare rises by approximately 0.2 percent of steady state consumption in Foreign.[39]

Table 4 also reveals that the welfare gains from implementing the optimal policy response to deregulation are positive but not large, in particular for the reforming country (the relative gain is approximately 0.1 percent of steady state consumption). In other words, welfare gains from the optimal policy along the transition have little impact on the lifetime welfare effect of the reform, which is dominated by the reduction of long-run inefficiency wedges operated by the deregulation. The welfare gain from Ramsey policy is also reduced in Foreign, but to a smaller extent: Product market distortions in the rigid economy are still in place, and welfare gains from non-zero long-run inflation are more significant at 0.2 percent of steady-state consumption.

Before turning to the effects of labor market reform, it is worth briefly discussing a potential policy tradeoff posed by asymmetric deregulation in a monetary union. As noted above, long-run inflation rates are equalized across countries regardless of asymmetric regulation. This suggests that, in the presence of asymmetric reforms, the Ramsey authority faces—at least in principle—an additional tradeoff: While a flexible product market requires less inflation, the rigid member of the monetary

[39] We find that market deregulation improves welfare at Home and abroad across all the exercises we perform. However, the welfare effects of the reforms are not clear-cut *ex ante*: Although each individual form of regulation is distortionary in the model, it is the interaction of regulatory and other distortions with monetary policy that determines the welfare outcome in our second-best environment.

union still benefits from a higher long-run inflation target. As a result, the optimal policy must strike a balance between these two opposing needs. Table 4 shows that the Ramsey central bank makes both countries better off. Even if Ramsey inflation is not as high as without any deregulation, Home's reform has positive international spillovers that reduce the need for inflation abroad.

Labor Market Deregulation

We now study the consequences of a Home labor market reform in which unemployment benefits, b, and employment protection legislation, η, are lowered to their corresponding U.S. levels. As before, we begin by describing the dynamic adjustment and the long-run equilibrium under the historical monetary policy. As shown by Figure 3 (solid lines), labor market reform immediately boosts aggregate consumption, since households immediately increase demand in anticipation of higher future income. Different from product market reform, producer entry drops in the aftermath of labor market deregulation. As vacancy posting increases, the expected cost of filling a vacancy rises, pushing up the equilibrium price of intermediate inputs. This makes producer entry more costly. In a sense, incumbent firms have a competitive advantage relative to potential entrants since they do not have to incur the sunk cost to benefit from the labor market reform.

The international adjustment to an asymmetric labor market reform also does not involve costs for the non-reforming trading partner. A larger increase in Home's aggregate demand generates positive spillovers for Foreign consumption and employment. These positive effects are short-lived, however. As time passes, falling wages in the flexible economy lower marginal costs, and terms of trade depreciation induces expenditure switching toward Home goods. Current account deficit in the first part of the transition allows Home households to sustain higher consumption in anticipation of the long-run increase in income.

The adjustment under the Ramsey-optimal policy implies smaller markups and higher employment along the transition. This results in a smaller wedge in job creation margin, with a temporary increase in the product creation wedge, both at Home and Foreign. The intuition mirrors that for product market reform. Regardless of the nature of deregulation, the Ramsey authority ensures that inflationary pressure stimulates job creation and reduces markups along the first part of the transition, before the positive effects of deregulation are fully materialized. The effects of Ramsey policy in the Foreign economy are large and positive during the transition, since consumption and employment comove positively with Home.

Table 4 shows that labor market reform is highly beneficial for the deregulating country, with a welfare gain of approximately 3.5 percent of steady-state consumption. Moreover, the reform generates some positive welfare effects also in the Foreign economy. To understand this result, notice that changes in labor market regulation directly affect two distortions: The reduction in unemployment benefits brings the workers' outside option closer to the (real) costs of labor effort, lowering real wages and stimulating vacancy posting. The increase in the firms' bargaining power, instead, implies that η is now greater than the elasticity of matches to vacancies, ε, a departure from the Hosios condition. It turns out that the labor market reform is beneficial even if the Hosios condition is violated post-deregulation. In our second best environment, the rigid, distorted steady state features suboptimally low job creation: The increase in η brings employment closer to the social optimum.

As before, the discrepancies between Ramsey and historical allocations vanish in the long run. As time passes, the need to stimulate vacancy posting and reduce markups is reduced since deregulation per se reduces inefficiency wedges. Table 4 shows that the optimal level of long-run inflation falls in response to asymmetric labor market deregulation. Mirroring product market deregulation, the welfare gain from implementing the optimal monetary policy in response to the labor market deregulation is not large for the reforming economy. The positive effects of smaller long-run distortions dominate results, narrowing the welfare gap between historical and Ramsey policy at Home. The Ramsey policy instead remains relatively more desirable in the Foreign country.

Product and Labor Market Deregulation

Figure 4 presents the adjustment following joint deregulation in goods and labor markets. The dynamic adjustment qualitatively mirrors that to product market reform. Quantitatively, the positive effect on consumption and employment is reinforced on impact and in the long run. Table 4 shows that joint market reform is more beneficial than deregulation of product or labor market alone, even if there is some substitutability across reforms, since the welfare gain is smaller than the sum of the gains from individual reforms.[40] The relative gain from Ramsey policy (with respect to the historical rule) becomes even smaller for the reforming country since reform of both markets further reduces real distortions in the new long-run equilibrium.

Deregulation and Optimal Monetary Policy over the Business Cycle

Market deregulation affects domestic and international adjustment to aggregate shocks. As a result, it alters the policy tradeoffs facing the central bank over the business cycle. In this section, we study these effects and evaluate their consequences for policy.

Product Market Deregulation

Figure 5 contrasts the effects of a one percent Home productivity shock before and after Home product market deregulation under the historical policy rule. When barriers to entry are relaxed, the economy fluctuates around a steady state with a larger number of firms, smaller markups, and smaller producer-level profits. Therefore, the present discounted value of entry varies by less (in percentage of the steady state) in response to aggregate disturbances, dampening markup fluctuations and product market dynamics. This effect, combined with a tighter labor market after the deregulation, implies that the employment response to shocks is also muted. (Notice that productivity shocks put less pressure on nominal wage inflation after the deregulation, since the increase in the surplus from existing matches is smaller.) Computing the second moments of business cycles in the post-deregulation environment shows that volatility and persistence of output and employment fall in the reforming country, but the effect on Foreign dynamics and international business cycles is very small. (See the Appendix for details.)

The welfare cost of business cycles falls significantly in the more flexible economy—by approximately 20 percent (Table 5)—while it falls only slightly in the rigid country. This is explained by the

[40] See Cacciatore and Fiori (2011) for a detailed discussion of substitutability across reforms. The result is consistent with the empirical evidence in Fiori, Nicoletti, Scarpetta, and Schiantarelli (2012).

fact that Home markups are less volatile with a flexible product market, resulting in less volatile employment. In contrast, the welfare costs of business cycles in the Foreign economy are not significantly affected since they remain dominated by domestic rigidities.

Turning to the Ramsey-optimal policy, Figure 6 shows that the Ramsey authority becomes less aggressive after the deregulation. Deregulation (even if asymmetric across countries and limited to product markets) ameliorates domestic and international policy trade-offs. At Home, a more flexible product market dampens volatility for the same reasons as under historical policy. Moreover, stabilization of cyclical fluctuations at Home requires less Foreign wage deflation because Home demand for Foreign goods is higher to begin with, and the resource switching effect of Ramsey policy is mitigated.

Table 5 shows that deregulation narrows the welfare gap between historical and Ramsey-optimal policy at Home as deregulation reduces the need for policy activism. The welfare gain from Ramsey policy increases slightly in the country that remains rigid.

Labor Market Deregulation

Home labor market reform affects the propagation of aggregate shocks through the cyclical behavior of the workers' outside option. Labor market flexibility makes job creation less responsive to shocks: Lower unemployment benefits and smaller worker bargaining power imply that adjustment takes place increasingly through the real wage, reducing job flows over the cycle. Table 5 shows that the welfare effects of the reform mimic those of product market deregulation. Under the historical policy rule, the welfare cost of business cycles falls by almost 50 percent. The rigid country (Foreign) benefits slightly more from optimal policy following deregulation, while the gain from optimal policy becomes significantly smaller for Home.

Product and Labor Market Deregulation

Table 5 shows that deregulation of both product and labor markets at Home has a larger welfare effect than individual reforms. Deregulation of both markets accomplishes the most significant moderation of Home's aggregate fluctuations (see the Appendix for details), and the welfare cost of business cycles under the historical policy is lowest at 0.54 percent of steady-state consumption. The welfare gain from Ramsey-optimal policy is correspondingly minimized. At the same time, however, the welfare gain from optimal policy is further magnified in the rigid country.

To summarize, across all scenarios, asymmetric deregulation across countries reduces the benefit from optimal policy in the country that deregulates but increases it in the country that remains rigid. The intuition is straightforward: The flexible economy has less need of an active policy that takes distortions explicitly into account. The focus of Ramsey-optimal activism correspondingly shifts toward the rigid country, which increases its gain from optimal policy.

7 International Coordination of Reforms

To what extent can coordination (i.e., synchronization) of market reforms improve welfare and how does it affect monetary policy? We have seen that asymmetric deregulation is beneficial for both members of our model monetary union. Reforms by one country alone are sufficient to improve domestic and international policy tradeoffs facing the Ramsey central bank. However, asymmetric deregulation translates in heterogeneous real rigidities across countries, posing, at least in principle, an additional challenge for the conduct of monetary policy. In the long run, the Ramsey authority targets a single union-wide inflation rate, trading off asymmetric needs of inflation across heterogenous countries. Over the cycle, optimal policy is relatively less aggressive for the flexible country compared to the rigid one. When the two economies are simultaneously hit by similar shocks, inflation stabilization may be too strong (weak) in the flexible (rigid) country. Symmetric market deregulation across countries could then further improve policy tradeoffs. To address this issue, we repeat the same policy experiments of Section 6 assuming that both countries undertake deregulation in goods and labor markets. Tables 4 and 5 summarize the results. (For brevity, we do not present impulse responses. They are available upon request.)

We find that there are gains from international coordination of reforms due to improved stabilization of aggregate fluctuations. In particular, synchronized reforms eliminate the heterogeneous needs of inflation stabilization in rigid and flexible countries. In the long run, the reduction in inflation is larger with symmetric deregulation. From a welfare perspective, the addition of Foreign deregulation has a small impact on the gain from optimal monetary policy relative to historical behavior for Home, although Home benefits more significantly from Foreign deregulation for given monetary policy regime. Foreign gains significantly from deregulation for given monetary policy, with smaller gains from Ramsey-optimal policy relative to the historical policy, as expected.

8 Conclusions

We studied the implications of market deregulation for the conduct of optimal monetary policy in a monetary union. A key message of the paper is that high levels of regulation in goods and labor markets generate sizable static and dynamic distortions that call for active monetary policy in the long run and over the business cycle. A policy of strict price stability is costly in terms of welfare. Expansionary monetary policy can reduce transition costs by generating lower markups and stimulating job creation in the aftermath of market reforms. However, once the economies in the monetary union have reached the new long-run equilibrium, real distortions in product and labor markets are reduced, and the need for inflation to correct market inefficiencies correspondingly mitigated. We showed that there is an international dimension of deregulation, as asymmetric product and labor market reforms across countries can generate new policy tradeoffs for a welfare maximizing monetary authority. Coordination of reforms can mitigate these tradeoffs. Finally, we showed that the transition costs of deregulation can include an initial worsening of the external balance.

Our paper provides a formal analysis of the interaction between market reforms and aggregate demand policies touched upon in the policy literature (Barkbu, Rahman, Valdés, and Staff, 2012), and it sheds additional light on the costs of a narrow focus on price stability in highly regulated economies (Blanchard and Galí, 2010). Important avenues for future research include explicit analysis of deregulation as part of the response to crises, optimal regulation, fiscal policy, strategic policy interactions, the possibility of imperfect commitment, and distributional issues.

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TABLE 1: MODEL SUMMARY

$1=(1-\alpha)\left[\rho_{d,t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{1-\phi}+\alpha\left[Q_t\rho^*_{d,t}\exp\left(\frac{\tilde{N}^*-N^*_t}{2\sigma\tilde{N}^*N^*_t}\right)\right]^{1-\phi}$	(1)
$1=(1-\alpha)\left[\rho^*_{d,t}\exp\left(\frac{\tilde{N}^*-N^*_t}{2\sigma\tilde{N}^*N^*_t}\right)\right]^{1-\phi}+\alpha\left[\frac{\rho_{d,t}}{Q_t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{1-\phi}$	(2)
$Z_tl_th_t=N_t(y_{d,t}+y_{x,t})+\left(\frac{N_{t+1}}{1-\delta}-N_t\right)f_{E,t}$	(3)
$Z^*_tl^*_th^*_t=N^*_t(y^*_{d,t}+y^*_{x,t})+\left(\frac{N^*_{t+1}}{1-\delta}-N^*_t\right)f^*_{E,t}$	(4)
$l_t=(1-\lambda)l_{t-1}+q_{t-1}V_{t-1}$	(5)
$l^*_t=(1-\lambda)l^*_{t-1}+q^*_{t-1}V^*_{t-1}$	(6)
$1=(1-\delta)E_t\left\{\beta_{t,t+1}\frac{\rho_{d,t+1}}{\rho_{d,t}}\left[\frac{\mu_t}{\mu_{t+1}}\frac{f_{E,t+1}}{f_{E,t}}+\frac{\mu_t}{f_{E,t}}\left(1-\frac{1}{\mu_{t+1}}-\frac{\nu}{2}\pi^2_{d,t}\right)(y_{d,t+1}+y_{x,t+1})\right]\right\}$	(7)
$1=(1-\delta)E_t\left\{\beta^*_{t,t+1}\frac{\rho^*_{d,t+1}}{\rho^*_{d,t}}\left[\frac{\mu^*_t}{\mu^*_{t+1}}\frac{f^*_{E,t+1}}{f^*_{E,t}}+\frac{\mu^*_t}{f^*_{E,t}}\left(1-\frac{1}{\mu^*_{t+1}}-\frac{\nu}{2}\pi^{*2}_{d,t}\right)\left(y^*_{d,t+1}+y^*_{x,t+1}\right)\right]\right\}$	(8)
$1=E_t\left\{\beta_{t,t+1}\left[(1-\lambda)\frac{q_t}{q_{t+1}}+\frac{q_t}{\kappa}\left(\varphi_{t+1}Z_{t+1}h_{t+1}-\frac{w_{t+1}}{P_{t+1}}h_{t+1}-\frac{\vartheta}{2}\pi^2_{w,t+1}\right)\right]\right\}$	(9)
$1=E_t\left\{\beta^*_{t,t+1}\left[(1-\lambda)\frac{q^*_t}{q^*_{t+1}}+\frac{q^*_t}{\kappa}\left(\varphi^*_{t+1}Z^*_{t+1}h^*_{t+1}-\frac{w^*_{t+1}}{P^*_{t+1}}h^*_{t+1}-\frac{\vartheta}{2}\pi^{*2}_{w,t+1}\right)\right]\right\}$	(10)
$\frac{w_t}{P_t}h_t=\eta_{w,t}\left(\frac{v(h_t)}{u_{C,t}}+b\right)+(1-\eta_{w,t})\left(\varphi_tZ_th_t-\frac{\vartheta}{2}\pi^2_{w,t}\right)$ $+E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_{w,t})-(1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\}$	(11)
$\frac{w^*_t}{P^*_t}h^*_t=\eta^*_{w,t}\left(\frac{v(h^*_t)}{u_{C^*,t}}+b^*\right)+(1-\eta^*_{w,t})\left(\varphi^*_tZ^*_th^*_t-\frac{\vartheta}{2}\pi^{*2}_{w,t}\right)$ $+E_t\left\{\beta^*_{t,t+1}J^*_{t+1}\left[(1-\lambda)(1-\eta^*_{w,t})-(1-\lambda-\iota^*_t)(1-\eta^*_{w,t+1})\frac{\eta^*_{w,t}}{\eta^*_{w,t+1}}\right]\right\}$	(12)
$v_{h,t}/u_{C,t}=\varphi_tZ_t$	(13)
$v_{h^*,t}/u_{C^*,t}=\varphi^*_tZ^*_t$	(14)
$\pi_{w,t}=\frac{w^r_t}{w^r_{t-1}}\pi_{C,t}$	(15)
$\pi^*_{w,t}=\frac{w^{r*}_t}{w^{r*}_{t-1}}\pi^*_{C,t}$	(16)
$1+i_{t+1}=(1+i_t)^{\varrho_i}\left[(1+i)\left(1+\tilde{\pi}^U_{C,t}\right)^{\varrho_\pi}\left(\tilde{Y}^U_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}$	(17)
$1+\tau a_{t+1}=\beta\left(1+i_{t+1}\right)E_t\left(\frac{u_{C,t+1}}{u_{C,t}}\frac{1}{1+\pi_{C,t+1}}\right)$	(18)
$1-\tau Q_ta_{t+1}=\beta\left(1+i_{t+1}\right)E_t\left(\frac{u_{C^*,t+1}}{u_{C^*,t}}\frac{1}{1+\pi^*_{C,t+1}}\right)$	(19)
$\frac{Q_t}{Q_{t-1}}=\frac{1+\pi^*_{C,t}}{1+\pi_{C,t}}$	(20)
$a_{t+1}=\frac{1+i_t}{1+\pi_{C,t}}a_t+N_t\rho_{d,t}y_{x,t}-N^*_tQ_t\rho^*_{d,t}y^*_{x,t}$	(21)

Note: $C, C^*, \rho_d, \rho^*_d, l, l^*, V, V^*, N, N^*, w/P, w^*/P^*, h, h^*, \pi_w, \pi^*_w, \pi_C, \pi^*_C, i, Q, a$ are the 21 endogenous variables determined by these equations. Other variables that appear in the table are determined as described in the text.

TABLE 2: SOCIAL PLANNER

$1=(1-\alpha)\left[\rho_{d,t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{1-\phi}+\alpha\left[Q_t\rho^*_{d,t}\exp\left(\frac{\tilde{N}^*-N^*_t}{2\sigma\tilde{N}^*N^*_t}\right)\right]^{1-\phi}$	(1)
$1=(1-\alpha)\left[\rho^*_{d,t}\exp\left(\frac{\tilde{N}^*-N^*_t}{2\sigma\tilde{N}^*N^*_t}\right)\right]^{1-\phi}+\alpha\left[\frac{1}{Q_t}\rho_{d,t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{1-\phi}$	(2)
$Z_t l_t h_t = N_t(y_{d,t}+y_{x,t})+\left(\frac{N_{t+1}}{1-\delta}-N_t\right)f_{T,t}$	(3)
$Z^*_t l^*_t h^*_t = N^*_t(y^*_{d,t}+y^*_{x,t})+\left(\frac{N^*_{t+1}}{1-\delta}-N^*_t\right)f^*_{T,t}$	(4)
$l_t=(1-\lambda)l_{t-1}+\chi(1-l_{t-1})^{1-\varepsilon}V^{\varepsilon}_{t-1}$	(5)
$l^*_t=(1-\lambda)l^*_{t-1}+\chi(1-l^*_{t-1})^{1-\varepsilon}V^{*\varepsilon}_{t-1}$	(6)
$1=(1-\delta)E_t\left\{\beta_{t,t+1}\frac{\rho_{d,t+1}}{\rho_{d,t}}\left[\frac{f_{T,t+1}}{f_{T,t}}+\frac{1}{2\sigma N_{t+1}f_{T,t}}\left(y_{d,t+1}+y_{x,t+1}\right)\right]\right\}$	(7)
$1=(1-\delta)E_t\left\{\beta^*_{t,t+1}\frac{\rho^*_{d,t+1}}{\rho^*_{d,t}}\left[\frac{f^*_{T,t+1}}{f^*_{T,t}}+\frac{1}{2\sigma N^*_{t+1}f^*_{T,t}}\left(y^*_{d,t+1}+y^*_{x,t+1}\right)\right]\right\}$	(8)
$1=E_t\left\{\beta_{t,t+1}\left[\varepsilon\frac{q_t}{\kappa}\left(\rho_{d,t+1}Z_{t+1}h_{t+1}-\frac{v(h_{t+1})}{u_{C,t+1}}\right)+\left[1-\lambda-(1-\varepsilon)\,\iota_{t+1}\right]\frac{q_t}{q_{t+1}}\right]\right\}$	(9)
$1=E_t\left\{\beta^*_{t,t+1}\left[\varepsilon\frac{q^*_t}{\kappa}\left(\rho^*_{d,t+1}Z^*_{t+1}h^*_{t+1}-\frac{v(h^*_{t+1})}{u_{C^*,t+1}}\right)+\left[1-\lambda-(1-\varepsilon)\,\iota^*_{t+1}\right]\frac{q^*_t}{q^*_{t+1}}\right]\right\}$	(10)
$\frac{v_{h,t}}{u_{C,t}}=\rho_{d,t}Z_t$	(11)
$\frac{v_{h^*,t}}{u_{C^*,t}}=\rho^*_{d,t}Z^*_t$	(12)
$Q_t=\frac{u_{C^*,t}}{u_{C,t}}$	(13)

Note: $C, C^*, \rho_d, \rho^*_d, l, l^*, V, V^*, h, h^*, N, N^*, Q_t$ are the 13 endogenous variables determined by these equations. Other variables that appear in the table are determined as described in the text.

TABLE 3: DISTORTIONS

$\Upsilon_{\mu,t}\equiv\frac{\mu_{t-1}}{\mu_t}-1$	time-varying markup*, product creation
$\Upsilon_{N,t}\equiv\mu_{t-1}\left(1-\frac{1}{\mu_t}-\frac{\nu}{2}\pi^2_{d,t}\right)-\frac{1}{2\sigma N_t}$	misalignment between markup and benefit from variety*, product creation
$\Upsilon_{R,t}\equiv f_{R,t}$	regulation costs, product creation, resource constraint
$\Upsilon_{\varphi,t}\equiv\frac{1}{\mu_t}-1$	monopoly power and time-varying markup*, job creation and labor supply
$\Upsilon_{\eta,t}\equiv\eta_{w,t}-\varepsilon$	failure of the Hosios condition**, job creation
$\Upsilon_{b,t}\equiv b$	unemployment benefits, job creation
$\Upsilon_{Q,t}\equiv\frac{u_{C^*,t}}{u_{C,t}}/Q_t$	incomplete markets, risk sharing
$\Upsilon_{a,t}\equiv\tau a_{t+1}$	cost of adjusting bond holdings, risk sharing
$\Upsilon_{\pi_w,t}\equiv\frac{\vartheta}{2}\pi^2_{w,t}$	wage adjustment costs, resource constraint and job creation
$\Upsilon_{\pi_d,t}\equiv\frac{\nu}{2}\pi^2_{d,t}$	price adjustment costs, resource constraint

* From translog preferences and sticky prices.

** From sticky wages and/or $\eta\neq\varepsilon$.

Table 4: WELFARE EFFECTS OF REFORMS – NON STOCHASTIC STEADY STATE

Market Reform	ΔWelfare (Historical)		ΔWelfare (Ramsey)		Ramsey Inflation
	Home	Foreign	Home	Foreign	
Status Quo	0%	0%	0.21%	0.21%	1.20%
Asymmetric PMR	5.00%	0.22%	5.09%	0.41%	1.07%
Asymmetric LMR	3.32%	0.21%	3.44%	0.39%	1.00%
Asymmetric JOINT	7.38%	0.38%	7.41%	0.55%	0.96%
Symmetric PMR	5.22%	5.22%	5.30%	5.30%	1.00%
Symmetric LMR	3.51%	3.51%	3.61%	3.61%	0.85%
Symmetric JOINT	7.72%	7.72%	7.76%	7.76%	0.76%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;
JOINT ≡ Product and Labor Market Reform; Asymmetric ≡ Home country reform;
Symmetric ≡ Home and Foreign country reform;
ΔWelfare (Historical) ≡ Welfare change under historical policy;
ΔWelfare (Ramsey) ≡ Welfare change under Ramsey policy.

Table 5: WELFARE EFFECTS OF REFORMS — STOCHASTIC STEADY STATE

Market Reform	Welfare Cost (Historical)		Welfare Cost (Ramsey)	
	Home	Foreign	Home	Foreign
Status Quo	0.94%	0.94%	0.75%	0.75%
Asymmetric PMR	0.78%	0.93%	0.65%	0.72%
Asymmetric LMR	0.55%	0.92%	0.50%	0.70%
Asymmetric JOINT	0.54%	0.92%	0.49%	0.69%
Symmetric PMR	0.77%	0.77%	0.62%	0.62%
Symmetric LMR	0.54%	0.54%	0.46%	0.46%
Symmetric JOINT	0.53%	0.53%	0.45%	0.45%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;
JOINT ≡ Product and Labor Market Reform; Asymmetric ≡ Home country reform;
Symmetric ≡ Home and Foreign country reform;
Welfare Cost (Historical) ≡ Welfare cost of business cycles under historical policy;
Welfare Cost (Ramsey) ≡ Welfare cost of business cycles under Ramsey policy.

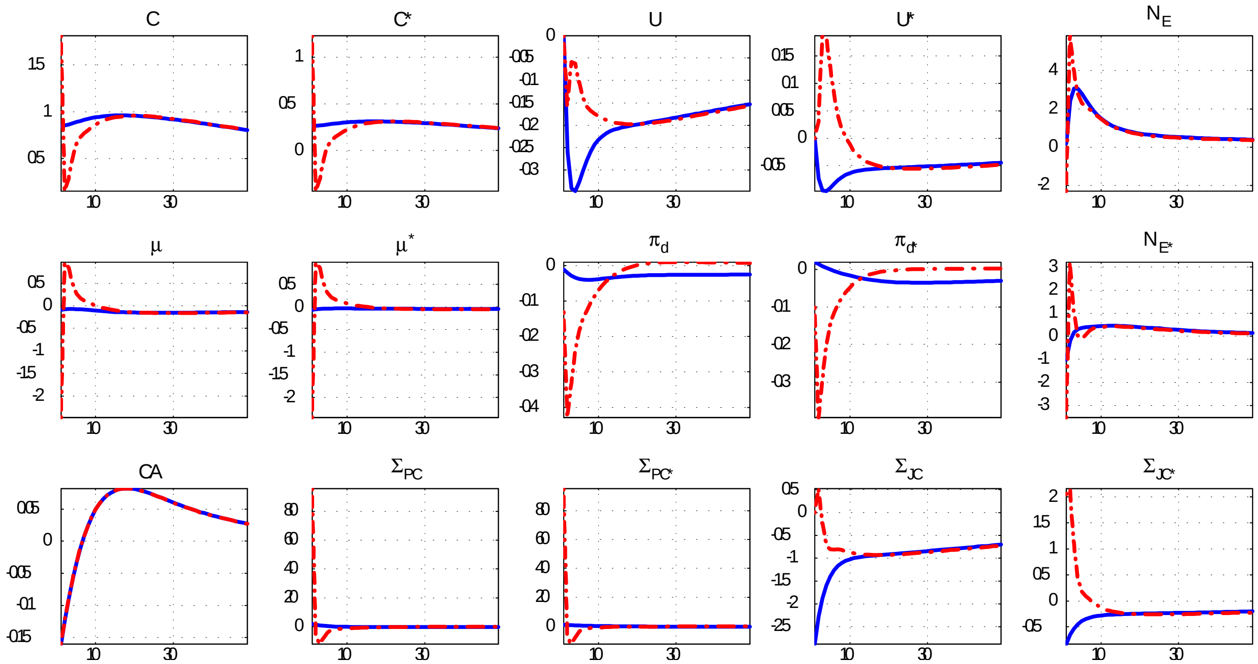

Figure 1: Home Productivity Shock, High Regulation, Historical Policy (Solid Lines) versus Optimal Policy (Dashed Lines). Variables are in percentage deviations from the steady state. U, U^*, π_d and π_{d^*} are in deviations from the steady state.

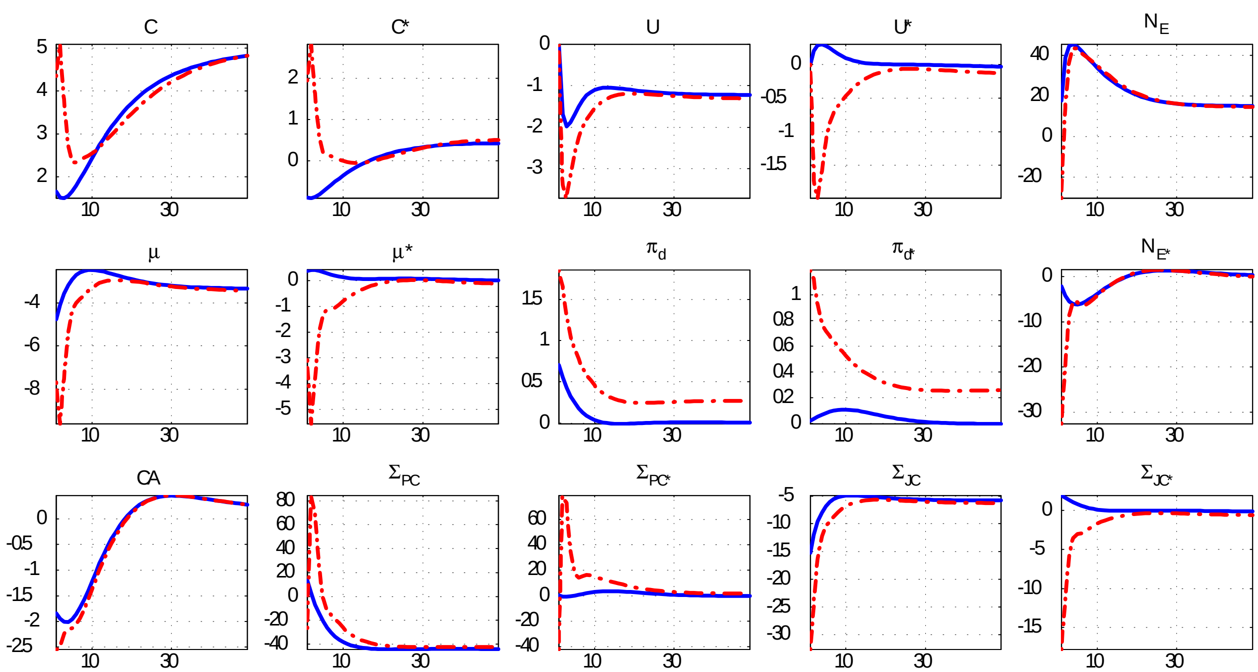

Figure 2: Home Product Market Deregulation, Historical Policy (Solid Lines) versus Optimal Policy (Dashed Lines).Variables are in percentage deviations from the Taylor rigid steady state. U, U^*, π_d and π_{d^*} are in deviations from the steady state.

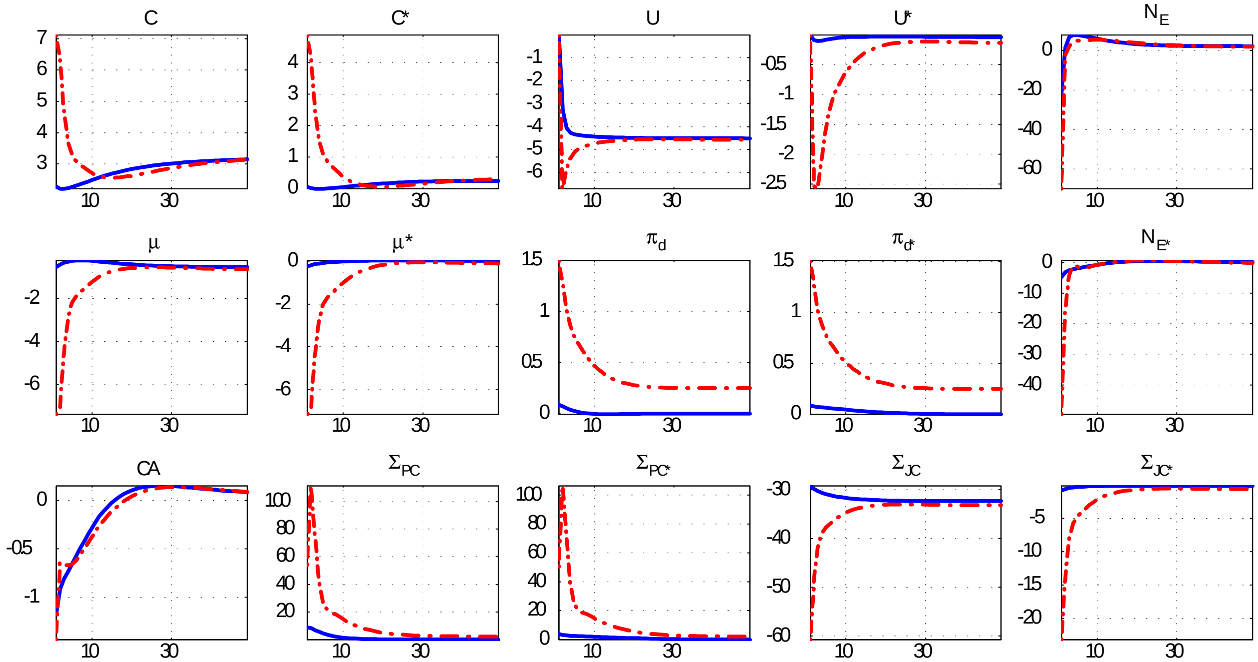

Figure 3: Home Labor Market Deregulation, Historical Policy (Solid Lines) versus Optimal Policy (Dashed Lines). Variables are in percentage deviations from the Taylor rigid steady state. U, U^*, π_d and π_{d^*} are in deviations from the steady state.

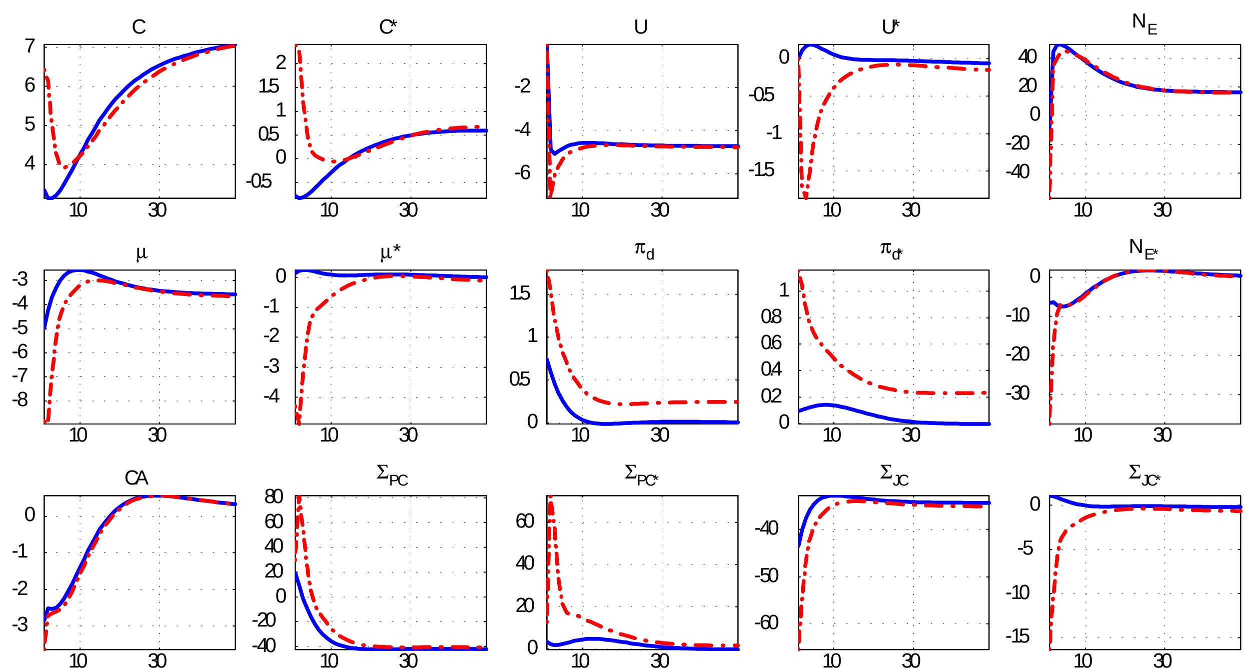

Figure 4: Home Joint Deregulation, Historical Policy (Solid Lines) versus Optimal Policy (Dashed Lines). Variables are in percentage deviations from the Taylor rigid steady state. U, U^*, π_d and π_{d^*} are in deviations from the steady state.

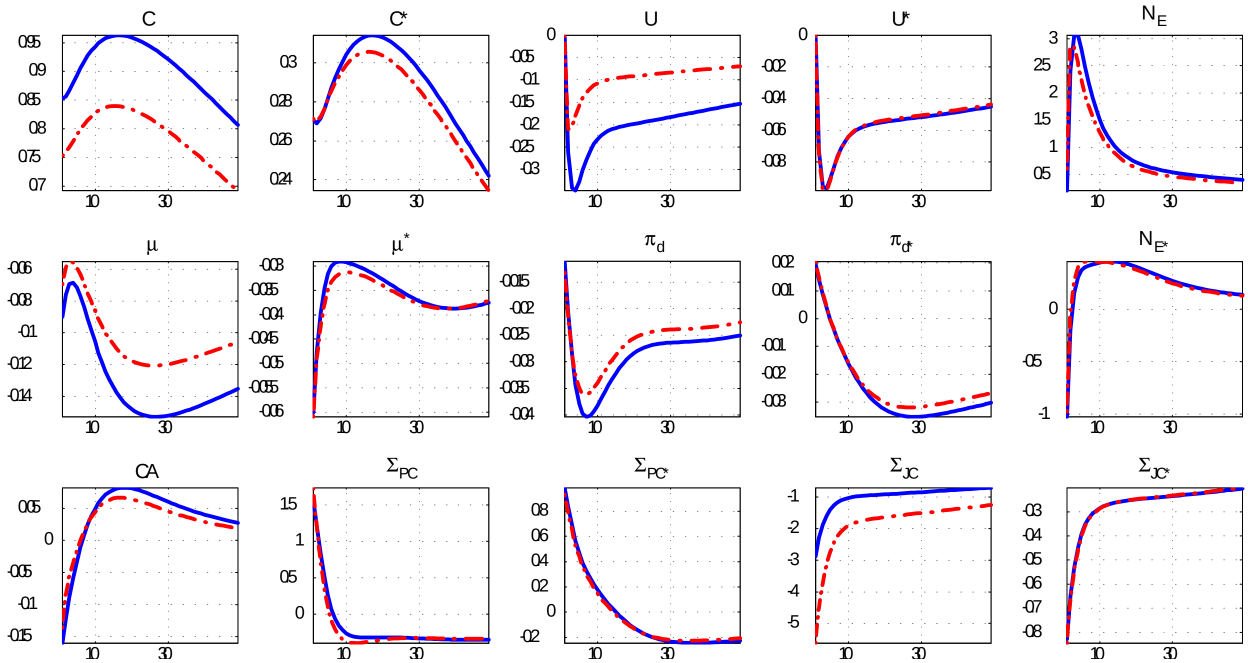

Figure 5: Home Productivity Shock, Historical Policy, High Regulation (Solid Lines) versus Low Regulation (Dashed Lines). Variables are in percentage deviations from the steady state. U, U^{*}, π_d and π_{d^*} are in deviations from the steady state.

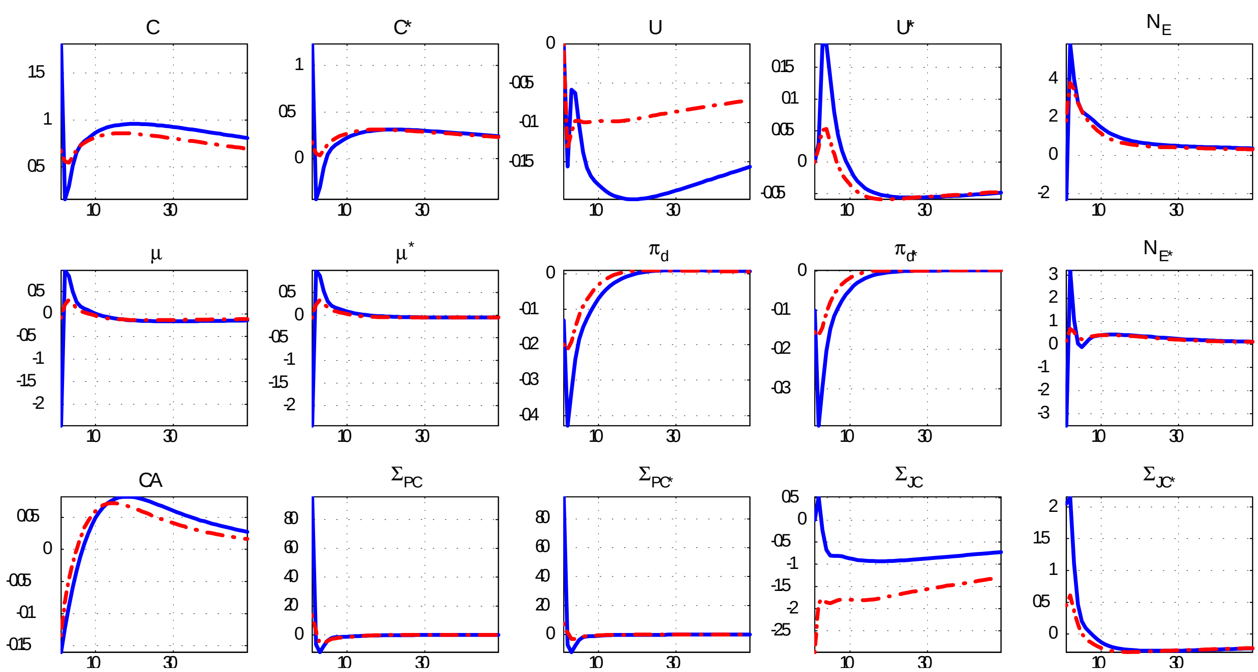

Figure 6: Home Productivity Shock, Optimal Policy, High Regulation (Solid Lines) versus Low Regulation (Dashed Lines). Variables are in percentage deviations from the steady state. U, U^{*}, π_d and π_{d^*} are in deviations from the steady state.

Appendix

A. Wage Determination

Let J_t be the real value of an existing, productive match for a producer, determined by:

$$J_t = \varphi_t Z_t h_t - \frac{w_t}{P_t} h_t - \frac{\vartheta}{2} \pi_{w,t}^2 + E_t \beta_{t,t+1} (1 - \lambda) J_{t+1}. \quad (7)$$

Intuitively, J_t is the per-period marginal value product of the match, $\varphi_t Z_t h_t$, net of the wage bill and costs incurred to adjust wages, plus the expected discounted continuation value of the match in the future.[41]

Next, denote with W_t the worker's asset value of being matched, and with $U_{u,t}$ the value of being unemployed. The value of being employed at time t is given by the real wage bill the worker receives plus the expected future value of being matched to the firm. With probability $1 - \lambda$ the match will survive, while with probability λ the worker will be unemployed. As a result:

$$W_t = \frac{w_t}{P_t} h_t + E_t \left\{ \beta_{t,t+1} \left[(1 - \lambda) W_{t+1} + \lambda U_{u,t+1} \right] \right\}. \quad (8)$$

The value of unemployment is given by:

$$U_{u,t} = \frac{v(h_t)}{u_{C,t}} + b + E_t \left\{ \beta_{t,t+1} [\iota_t W_{t+1} + (1 - \iota_t) U_{u,t+1}] \right\}. \quad (9)$$

In this expression, $v(h_t)/u_{C,t}$ is the utility gain from leisure in terms of consumption, b is an unemployment benefit from the government (financed with lump sum taxes), and ι_t is the probability of becoming employed at time t, equal to the ratio between the total number of matches and the total number of workers searching for jobs at time t: $\iota_t \equiv M_t/U_t$.

Equations (8) and (9) imply that the worker's surplus $H_t \equiv W_t - U_{u,t}$ is determined by:

$$H_t = \frac{w_t}{P_t} h_t - \left(\frac{v(h_t)}{u_{C,t}} + b \right) + (1 - \lambda - \iota_t) E_t \left(\beta_{t,t+1} H_{t+1} \right). \quad (10)$$

Nash bargaining maximizes the joint surplus $J_t^\eta H_t^{1-\eta}$ with respect to w_t, where $\eta \in (0, 1)$ is the firm's bargaining power. The first-order condition implies:

$$\eta H_t \frac{\partial J_t}{\partial w_t} + (1 - \eta) J_t \frac{\partial H_t}{\partial w_t} = 0, \quad (11)$$

where:

$$\frac{\partial J_t}{\partial w_t} = -\frac{h_t}{P_t} - \vartheta \frac{\pi_{w,t}}{w_{t-1}} + (1 - \lambda) \vartheta E_t \left[\beta_{t,t+1} (1 + \pi_{w,t+1}) \frac{\pi_{w,t+1}}{w_t} \right], \quad (12)$$

and:

$$\frac{\partial H_t}{\partial w_t} = \frac{h_t}{P_t}. \quad (13)$$

The sharing rule can then be rewritten as:

$$\eta_{w,t} H_t = (1 - \eta_{w,t}) J_t, \quad (14)$$

[41] Note that equations (1) and (7) together imply that there is a difference between the value of an existing match to the producer and the vacancy creation cost per match today (which becomes productive tomorrow), reflecting the expected discounted change in the per-period profitability of the match between today and tomorrow. If matches were productive immediately, it would be $J_t = \kappa/q_t$.

where:

$$\eta_{w,t} = \frac{\eta}{\eta - (1-\eta)\left(\frac{\partial H_t}{\partial w_t} / \frac{\partial J_t}{\partial w_t}\right)}. \tag{15}$$

Equation (14) shows that, as in Gertler and Trigari (2009), bargaining shares are time-varying due to the presence of wage adjustment costs. Absent wage adjustment costs, we would have $\partial J_t/\partial w_t = -\partial H_t/\partial w_t$ and a time-invariant bargaining share $\eta_{w,t} = \eta$.

Equation (2) in the main text for the bargained wage implies that the value of a match to a producer can be rewritten as:

$$J_t = \eta_{w,t}\left[\varphi_t Z_t h_t - \frac{\vartheta}{2}\pi_{w,t}^2 - \left(\frac{v(h_t)}{u_{C,t}} + b\right)\right] + E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)\eta_{w,t} + (1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\}. \tag{16}$$

The second term in the right-hand side of this equation reduces to $[1-\lambda-(1-\eta)\,\iota_t]\,E_t\left(\beta_{t,t+1}J_{t+1}\right)$ when wages are flexible. The firm's equilibrium surplus is the share η of the marginal revenue product generated by the worker, net of wage adjustment costs and the worker's outside option, plus the expected discounted future surplus, adjusted for the probability of continuation, $1-\lambda$, and the portion appropriated by the worker, $(1-\eta)\,\iota_t$. Sticky wages again introduce an effect of expected changes in the endogenous bargaining shares.

B. No Pricing to Market

Focus first on the case of flexible prices. A Home firm selling at Home chooses $p_{d,t}(\omega)$ to maximize:

$$E_t \sum_{s=t}^{\infty} [\beta(1-\delta)]^{s-t} \frac{u_{C,s}}{u_{C,t}} \left(\frac{p_{d,s}(\omega)}{P_s} - \varphi_s\right) y_{d,s}(\omega),$$

subject to:

$$y_{d,t}(\omega) = (1-\alpha)\sigma \ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right) \frac{P_{d,t}}{p_{d,t}(\omega)} \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y_t^C.$$

The optimal price of domestic sales is determined by:

$$\frac{p_{d,t}(\omega)}{P_t} = \left[1 + \ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right)\right]\varphi_t. \tag{17}$$

When selling abroad, the firm chooses $p_{x,t}(\omega)$ to maximize:

$$E_t \sum_{s=t}^{\infty} [\beta(1-\delta)]^{s-t} \frac{u_{C,s}}{u_{C,t}} \left(Q_s\frac{p_{x,s}(\omega)}{P_s^*} - \varphi_s\right) y_{x,s}(\omega),$$

subject to:

$$y_{x,t}(\omega) = \alpha\sigma \ln\left(\frac{\bar{p}_{x,t}}{p_{x,t}(\omega)}\right) \frac{P_{x,t}}{p_{x,t}(\omega)} \left(\frac{P_{x,t}}{P_t^*}\right)^{-\phi} Y_t^{C*},$$

and the optimal export price is determined by:

$$\frac{p_{x,t}(\omega)}{P_t} = \left[1 + \ln\left(\frac{\bar{p}_{x,t}}{p_{x,t}(\omega)}\right)\right]\varphi_t. \tag{18}$$

Pricing-to-market arises if $p_{d,t}(\omega) \neq p_{x,t}(\omega)$ in equilibrium, but the Armington form of the consumption aggregator implies that this never happens. To see this, recall first the definition of the reservation prices (the maximum prices that can be charged while still having positive market share):

$$\ln \bar{p}_{d,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t} \int_{\omega \in \Omega_{d,t}} \ln p_{d,t}(\omega) d\omega,$$

$$\ln \bar{p}_{x,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t} \int_{\omega \in \Omega_{x,t}} \ln p_{x,t}(\omega) d\omega.$$

In the symmetric equilibrium, all firms that serve the Home market are also exporters. It follows that:

$$\ln \bar{p}_{d,t} = \frac{1}{\sigma N_t} + \ln p_{d,t}, \quad \text{and} \quad \ln \bar{p}_{x,t} = \frac{1}{\sigma N_t} + \ln p_{x,t}.$$

As a result:

$$\ln \left(\frac{\bar{p}_{d,t}}{p_{d,t}} \right) = \frac{1}{\sigma N_t} = \ln \left(\frac{\bar{p}_{x,t}}{p_{x,t}} \right).$$

Substituting this into the optimal price equations (17) and (18), we have:

$$\frac{p_{d,t}}{P_t} = \left(1 + \frac{1}{\sigma N_t} \right) \varphi_t = \frac{p_{x,t}}{P_t}.$$

Thus, there is no pricing-to-market under flexible prices. This happens because the Armington aggregator implies that the ratios of reservation prices to optimal prices for Home producers in the Home and Foreign markets depend only on the identical number of Home firms that serve domestic and export markets.

The extension to the sticky-price case is straightforward under the assumption that prices are sticky in the currency of producers, an assumption that is always satisfied in a monetary union.

C. Symmetric Equilibrium

The aggregate stock of employed labor in the Home economy in period t is determined by $l_t = (1-\lambda) l_{t-1} + q_{t-1} V_{t-1}$. Furthermore, symmetry across final producers implies that $\theta_t(\omega) = \theta_t = 1 + \sigma N_t$. Hence, $\rho_{d,t}(\omega) = \rho_{d,t}$ and $\rho_{x,t}(\omega) = \rho_{x,t}$.[42] Wage inflation and consumer price inflation are tied by $1 + \pi_{w,t} = \left(w_t^r / w_{t-1}^r \right) (1 + \pi_{C,t})$, where w_t^r denotes the real wage, w_t / P_t, at time t. Producer price inflation and consumer price inflation are such that $1 + \pi_{d,t} = \left(\rho_{d,t} / \rho_{d,t-1} \right) (1 + \pi_{C,t})$. Home and Foreign consumer price inflation are such that $1 + \pi_{C,t} = (Q_{t-1}/Q_t) \left(1 + \pi_{C,t}^* \right)$.

The equilibrium price index satisfies:

$$1 = (1-\alpha) \left[\rho_{d,t} \exp \left(\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t} \right) \right]^{1-\phi} + \alpha \left[\rho_{x,t}^* \exp \left(\frac{\tilde{N}^* - N_t^*}{2\sigma \tilde{N}^* N_t^*} \right) \right]^{1-\phi},$$

where $\exp(X)$ denotes the exponential of X.

Labor market clearing requires:

$$l_t = \frac{N_{E,t} f_{E,t}}{Z_t h_t} + \frac{N_t (y_{d,t} + y_{x,t})}{Z_t h_t}.$$

[42] The (flexible-price) price elasticity does not depend on N_t^* because of the assumption of an Armington aggregator of Home and Foreign sub-bundles. This same assumption implies that the price elasticity facing a Foreign producer in both markets depends on N_t^*, but not N_t.

Aggregate demand of the consumption basket must be equal to the sum of consumption, the costs of posting vacancies, and the costs of adjusting wages and prices:

$$Y_t^C = C_t + \kappa V_t + \frac{\vartheta}{2}\pi_{w,t}^2 l_t + \frac{\nu}{2}\pi_{d,t}^2 \rho_{d,t}(y_{d,t} + y_{x,t})N_t.$$

We define GDP, denoted with Y_t, as total income: the sum of labor income, dividend income from final producers, and profit income from intermediate producers. Formally: $Y_t \equiv (w_t/P_t)\, l_t h_t + N_t d_t + T_t^i$.

D. The Law of Motion for Net Foreign Assets

Recall the representative household's budget constraint:

$$A_{t+1} + P_t \frac{\tau}{2}\left(\frac{A_{t+1}}{P_t}\right)^2 + P_t C_t + x_{t+1}\left(N_t + N_{E,t}\right) P_t e_t = \tag{19}$$
$$(1+i_t)A_t + x_t P_t N_t (d_t + e_t) + w_t l_t h_t + P_t b(1-l_t) + T_t^G + T_t^F + T_t^I.$$

In equilibrium, $x_t = x_{t+1} = 1$ for all t. The budget constraint of the government implies:

$$T_t^G = -P_t b(1-l_t).$$

Moreover,

$$T_t^F = P_t \frac{\tau}{2}\left(\frac{A_{t+1}}{P_t}\right)^2,$$

and:

$$T_t^I = P_t\left(\varphi_t Z_t l_t h_t - \frac{w_t}{P_t} l_t h_t - \kappa V_t - \frac{\vartheta}{2}\pi_{w,t}^2 l_t\right).$$

Therefore:

$$A_{t+1} + P_t C_t + N_{E,t} e_t = (1+i_t)A_t + P_t N_t (d_t + e_t) + P_t \varphi_t Z_t l_t h_t - P_t \kappa V_t - P_t \frac{\vartheta}{2}\pi_{w,t}^2 l_t. \tag{20}$$

It is possible to simplify the consolidated budget constraint of the economy further. To begin, notice that:

$$d_t = \left(\rho_{d,t} - \varphi_t\right)\left(y_{d,t} + y_{x,t}\right) - \frac{\nu}{2}\pi_{d,t}^2\left(y_{d,t} + y_{x,t}\right)\rho_{d,t}.$$

It follows that, after substituting and rearranging, equation (20) can be rewritten in real terms as:

$$a_{t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + N_t\left(\rho_{d,t} - \varphi_t\right)\left(y_{d,t} + y_{x,t}\right) + \varphi_t Z_t l_t h_t - \left[\begin{array}{c} C_t + N_{E,t} e_t + \kappa V_t + \frac{\vartheta}{2}\pi_{w,t}^2 l_t \\ +\frac{\nu}{2}\pi_{d,t}^2\left(y_{d,t} + y_{x,t}\right)\rho_{d,t} N_t \end{array}\right]. \tag{21}$$

Next, recall the expression for Home's aggregate demand of the consumption basket:

$$Y_t^C = C_t + \kappa V_t + \frac{\vartheta}{2}\pi_{w,t}^2 l_t + \frac{\nu}{2}\pi_{d,t}^2 \rho_{d,t}(y_{d,t} + y_{x,t})N_t.$$

Then, equation (21) becomes:

$$a_{t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + N_t\left(\rho_{d,t} - \varphi_t\right)\left(y_{d,t} + y_{x,t}\right) + \varphi_t Z_t l_t h_t - \left(Y_t^C + N_{E,t} e_t\right).$$

Finally, recall that free entry implies $e_t = \varphi_t f_{E,t}$, and labor market clearing requires $N_t \varphi_t\left(y_{d,t} + y_{x,t}\right) +$

$N_{E,t}\varphi_t f_{E,t} = \varphi_t Z_t l_t h_t$. It follows that home's net foreign assets entering period $t+1$ are determined by the gross interest income on the asset position entering period t plus the difference between home's total production and total demand (or absorption) of consumption:

$$a_{t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + N_t \rho_{d,t} \left(y_{d,t} + y_{x,t}\right) - Y_t^C. \tag{22}$$

A similar equation holds in Foreign:

$$a_{t+1}^* = \frac{1+i_t}{1+\pi_{C,t}^*} a_t^* + N_t^* \rho_{d,t}^* \left(y_{d,t}^* + y_{x,t}^*\right) - Y_t^{C*}. \tag{23}$$

Now, multiply equation (23) by Q_t and subtract the resulting equation from (22). Recall that $1+\pi_{C,t} = (Q_{t-1}/Q_t)\left(1+\pi_{C,t}^*\right)$ and use the bond market clearing condition $a_{t+1} + Q_t a_{t+1}^* = 0$ in all periods. It follows that:

$$a_{t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + \frac{1}{2}\left[N_t \rho_{d,t}\left(y_{d,t} + y_{x,t}\right) - N_t^* Q_t \rho_{d,t}^* \left(y_{d,t}^* + y_{x,t}^*\right)\right] - \frac{1}{2}\left(Y_t^C - Q_t Y_t^{C*}\right). \tag{24}$$

This is the familiar result that net foreign assets depend positively on the cross-country differential in production of final consumption output and negatively on relative absorption.

Notice next that home absorption of consumption must equal absorption of consumption output from home firms and output from foreign firms:

$$Y_t^C = N_t \rho_{d,t} y_{d,t} + N_t^* \rho_{x,t}^* y_{x,t}^* = N_t \rho_{d,t} y_{d,t} + N_t^* Q_t \rho_{d,t}^* y_{x,t}^*,$$

where we used the fact that $\rho_{x,t}^* = Q_t \rho_{d,t}^*$. Similarly,

$$Y_t^{C*} = N_t^* \rho_{d,t}^* y_{d,t}^* + N_t \rho_{x,t} y_{x,t} = N_t^* \rho_{d,t}^* y_{d,t}^* + N_t \frac{\rho_{d,t}}{Q_t} y_{x,t},$$

where we used $\rho_{x,t} = \rho_{d,t}/Q_t$. Substituting these results into equation (24) yields net foreign assets as a function of interest income on the initial asset position and the trade balance:

$$a_{t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + N_t \rho_{d,t} y_{x,t} - N_t^* Q_t \rho_{d,t}^* y_{x,t}^*.$$

E. Data-Consistent Variables

We follow Ghironi and Melitz (2005) and BGM, and we construct an average price index $\tilde{P}_t$ as:

$$\tilde{P}_t = \Omega_t^{\frac{1}{\phi-1}} P_t,$$

where P_t is the welfare-based price index:

$$P_t = \left\{(1-\alpha)\left[p_{d,t} \exp\left(\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t}\right)\right]^{1-\phi} + \alpha \left[p_{x,t}^* \exp\left(\frac{\tilde{N}^* - N_t^*}{2\sigma \tilde{N}^* N_t^*}\right)\right]^{1-\phi}\right\}^{\frac{1}{1-\phi}},$$

and Ω_t is the variety effect:

$$\Omega_t \equiv (1-\alpha)\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)+\alpha\exp\left(\frac{\tilde{N}^*-N_t^*}{2\sigma\tilde{N}^*N_t^*}\right).$$

The average price index $\tilde{P}_t$ is closer to the actual CPI data constructed by statistical agencies than the welfare-based index P_t, and, therefore, it is the data-consistent CPI implied by the model. In turn, given any variable X_t in units of consumption, its data-consistent counterpart is:

$$X_{R,t} \equiv \frac{X_t P_t}{\tilde{P}_t} = \frac{X_t}{\Omega_t^{\frac{1}{\phi-1}}}.$$

F. Social Planner Allocation

The benevolent social planner chooses $\{C_t, C_t, l_t, l_t^*, V_t, V_t^*, h_t, h_t^*, Y_{d,t}, Y_{d,t}^*, Y_{x,t}, Y_{x,t}^*, N_{t+1}, N_{t+1}^*\}_{t=0}^{\infty}$ to maximize the welfare criterion (6) subject to six constraints (three for each economy). In the list of variables chosen by the planner, $Y_{d,t}, Y_{d,t}^*, Y_{x,t}$, and $Y_{x,t}^*$ denote the sub-bundles of country-specific final goods that enter the Armington aggregator for total absorption of consumption output (Y_t^C and Y_t^{C*}) in each country. As usual, we present relevant equations for the Home economy, with the understanding that analogous equations hold in Foreign.

The first constraint is that intermediate inputs are used to produce final goods and create new product lines:

$$Z_t l_t h_t = \exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)(Y_{d,t}+Y_{x,t}) + \left(\frac{N_{t+1}}{1-\delta}-N_t\right)f_{T,t}, \tag{25}$$

where the exponential term converts units of consumption sub-bundles into units of intermediate inputs. Note that the only entry cost that is relevant to the social planner is the technological component of the overall entry cost $f_{E,t}$ facing firms in the decentralized economy. We denote the Lagrange multiplier associated to the constraint (25) with ϖ_t, which corresponds to the social marginal cost of producing an extra unit of intermediate output.

The second constraint is that total output can be used for consumption and vacancy creation:

$$C_t + \kappa V_t = \left[(1-\alpha)^{\frac{1}{\phi}} Y_{d,t}^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} Y_{x,t}^{*\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}. \tag{26}$$

The Lagrange multiplier associated to this constraint, ξ_t, represents the social marginal utility of consumption resources. In the social planner's environment, $Y_t^C = C_t + \kappa V_t$. Note that, as for the technological cost of product creation $f_{T,t}$, we assume that the cost of vacancy posting κV_t is a feature of technology—the technology for job creation—that characterizes also the planner's environment. (This is a standard assumption in the literature on the DMP model.)

Finally, the third constraint is that the stock of labor in the current period is equal to the number of workers that were not exogenously separated plus previous period matches that become productive in the current period:

$$l_t = (1-\lambda)l_{t-1} + \chi(1-l_{t-1})^{1-\varepsilon}V_{t-1}^{\varepsilon}. \tag{27}$$

The Lagrange multiplier associated to this constraint, ζ_t, denotes the real marginal value of a match to society.

The first-order condition for consumption implies that $\xi_t = u_{C,t}$. The demand schedules for Home output are obtained by combining the first-order conditions with respect to $Y_{d,t}$, $Y_{x,t}$, $Y_{d,t}^*$ and $Y_{x,t}^*$:

$$Y_{d,t} = (1-\alpha)\left[\frac{\varpi_t}{\xi_t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{-\phi} Y_t^C, \qquad Y_{x,t} = \alpha\left[\frac{\varpi_t}{\xi_t^*}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{-\phi} Y_t^{C*}. \tag{28}$$

Using the results in (28) and the analogs for Foreign output, it is possible to re-write equation (26) as:

$$1 = (1-\alpha)\left[\frac{\varpi_t}{\xi_t}\exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)\right]^{1-\phi} + \alpha\left[\frac{\varpi_t^*}{\xi_t}\exp\left(\frac{\tilde{N}^*-N_t^*}{2\sigma\tilde{N}^*N_t^*}\right)\right]^{1-\phi}$$

The optimality condition for N_{t+1} equates the cost of creating a new product to its expected discounted benefit:

$$f_{T,t}\varpi_t = \beta(1-\delta)E_t\left\{\varpi_{t+1}\left[f_{T,t+1} + \exp\left(\frac{\tilde{N}-N_{t+1}}{2\sigma\tilde{N}N_{t+1}}\right)\frac{1}{2\sigma N_{t+1}}\left(\frac{Y_{d,t+1}+Y_{x,t+1}}{N_{t+1}}\right)\right]\right\}. \tag{29}$$

The first-order conditions for vacancies and employment yield:

$$\frac{\kappa}{q_t} = \beta E_t\left\{\frac{\xi_{t+1}}{\xi_t}\left[\varepsilon\left(\frac{\varpi_{t+1}}{\xi_{t+1}}Z_{t+1}h_{t+1} - \frac{v\left(h_{t+1}\right)}{\xi_{t+1}}\right) + \left[1-\lambda-\left(1-\varepsilon\right)\iota_{t+1}\right]\frac{\kappa}{q_{t+1}}\right]\right\}, \tag{30}$$

where $q_t \equiv M_t/V_t = \chi\left[(1-l_t)/V_t\right]^{1-\varepsilon}$ is the probability of filling a vacancy implied by the matching function $M_t = \chi\left(1-l_t\right)^{1-\varepsilon}V_t^{\varepsilon}$, and $\iota_t \equiv M_t/\left(1-l_t\right) = \chi\left[V_t/(1-l_t)\right]^{\varepsilon}$ is the probability for a worker to find a job. Equation (30) shows that the expected cost of filling a vacancy κ/q_t must be equal to its (social) expected benefit. The latter is given by the value of output produced by one worker net of the disutility of labor, augmented by the continuation value of the match.

Finally, the first-order condition for hours implies $v_{h,t} = \varpi_t Z_t$.

Table 2 summarizes the equilibrium conditions for the planned economy. To facilitate the comparison between planned and market economy, we define the following relative prices for the planner's equilibrium: $\rho_{d,t} \equiv \varpi_t/\xi_t$, $\rho_{d,t}^* \equiv \varpi_t^*/\xi_t^*$, $\rho_{x,t} \equiv \varpi_t/\xi_t^*$, and $\rho_{x,t}^* \equiv \varpi_t^*/\xi_t$. Defining the social real exchange rate as $Q_t \equiv \xi_t^*/\xi_t$, the planner's outcome is characterized by optimal risk sharing: $Q_t = u_{C^*,t}/u_{C,t}$. Moreover, the law of one price holds also in the planned economy $\rho_{x,t} = \rho_{d,t}/Q_t$ and $\rho_{x,t}^* = Q_t\rho_{d,t}^*$. Finally, recall that $Y_{d,t}$ represents the aggregate demand for Home goods at Home. The amount of output produced by each Home firm for the Home market is given by $y_{d,t} = \exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)Y_{d,t}/N_t$. Analogously, the amount of output produced by each Home firm for the export market is $y_{x,t} = \exp\left(\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}\right)Y_{x,t}/N_t$.

G. Inefficiency Wedges

Comparing the term in square brackets in equation (7) in Table 1 to the term in square brackets in equation (7) in Table 2 implicitly defines the inefficiency wedge along the market economy's product creation margin. Specifically, the product creation wedge is defined as:

$$\Sigma_{PC,t} \equiv \left\{\left(1-\delta\right)\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma_C}\frac{\rho_{d,t+1}}{\rho_{d,t}}\left[\frac{f_{T,t+1}}{f_{T,t}} + \frac{1}{2\sigma N_{t+1}f_{T,t}}\left(y_{d,t+1}+y_{x,t+1}\right)\right]\right\}^{-1},$$

where all variables are evaluated at the decentralized allocations under Ramsey-optimal policy and historical policy.

Similarly, comparing the term in square brackets in equation (9) in Table 1 to the term in square brackets in equation (9) in Table 2 implicitly defines the inefficiency wedge along the market economy's job creation margin:

$$\Sigma_{JC,t} \equiv \left\{ \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma_C} \left[\varepsilon \frac{q_t}{\kappa} \left(\rho_{d,t+1} Z_{t+1} h_{t+1} - \frac{h_{t+1}^{1+\gamma_h} / (1+\gamma_h)}{(C_{t+1})^{-\gamma_C}} \right) + \left[1 - \lambda - (1-\varepsilon)\, \iota_{t+1}\right] \frac{q_t}{q_{t+1}} \right] \right\}^{-1},$$

where all variables are evaluated at the decentralized allocations under Ramsey-optimal policy and historical policy.

The impulse responses of these wedges show the percent variations of the wedge deviations from efficiency. Formally, we plot the response of $\left(|\Sigma_{PC,t} - 1| - |\Sigma_{PC} - 1|\right) / \left(|\Sigma_{PC} - 1|\right)$, and similarly for the job creation wedge. We consider absolute values because what matters is the deviation from efficiency (be it positive or negative).

H. Calibration

Table A.1 summarizes the calibration, which is assumed symmetric across countries. (Variables without time indexes denote steady-state levels. We set the discount factor β to 0.99, implying an annual real interest rate of 4 percent. The period utility function is given by $u_t = C_t^{1-\gamma_C}/(1-\gamma_C) - l_t h_t^{1+\gamma_h} / (1+\gamma_h)$. The risk aversion coefficient γ_C is equal to 2, while the Frisch elasticity of labor supply $1/\gamma_h$ is set to 0.2, a value consistent with empirical micro estimates.[43] To calibrate the translog parameter, σ, we proceed as follows. In Ghironi and Melitz's (2005) model with Dixit-Stiglitz (1977) preferences, the elasticity of substitution across product varieties is set to 3.8 following Bernard, Eaton, Jensen, and Kortum (2003). We set σ so that our model with translog preferences implies the same steady-state markup as Ghironi and Melitz's calibration.[44] As Ghironi and Melitz, we set substitutability between Home and Foreign goods in the consumption aggregator, ϕ, to 3.8.[45] The degree of home bias $1 - \alpha$ is set to 0.8, a conventional value in the literature. To ensure steady-state determinacy and stationarity of net foreign assets, we set the bond adjustment cost τ to 0.0025 as in Ghironi and Melitz (2005).

The scale parameter for the cost of adjusting prices, ν, is equal to 80, as in Bilbiie, Ghironi, and Melitz (2008a). We choose ϑ, the scale parameter of nominal wage adjustment costs, so that the model reproduces the volatility of unemployment relative to GDP observed in the data. This implies $\vartheta = 60$.

We keep technological entry costs not related to bureaucratic procedures constant: $f_{T,t} = f_T$ in all periods. Following Barseghyan and DiCecio (2011), we assume that f_T is 18 percent of quarterly output. As a proxy for goods market regulation in the Euro Area, we consider a weighted average of regulation costs across member countries, with weights equal to the contributions of individual countries' GDPs to Euro Area total GDP. To calibrate the initial value of entry costs related to regulation, f_R, we use Pissarides's (2003) index of entry delay, which computes the number of business days that it takes (on average) to fulfill entry requirements. Following Ebell and Haefke (2009), we convert this index in months of lost output. The implied cost of regulation is 69 percent of quarterly steady-state output.

[43] The value of this elasticity has been a source of controversy in the literature. Students of the business cycle tend to work with elasticities that are higher than microeconomic estimates, typically unity and above. Most microeconomic studies, however, estimate this elasticity to be much smaller, between 0.1 and 0.6. For a survey of the literature, see Card (1994). Our results are not affected significantly if we hold hours constant at the optimally determined steady-state level.

[44] This implies a 36 percent markup of price over marginal cost. It may be argued that this is too high. However, in our model, free entry ensures that firms earn zero profit net of entry cost. This means that firms price at average cost (inclusive of the entry cost). Thus, although our calibration implies a fairly high markup over marginal cost, it delivers plausible results with respect to pricing and average cost.

[45] The conventional choice of 1.5 for this Armington elasticity does not alter any of our main results significantly.

We set unemployment benefits, b, so that the model reproduces the average replacement rate, $b/(wh)$, for the Euro Area reported by OECD (2004). The elasticity of the matching function, ε, is equal to 0.6, as estimated by Blanchard and Diamond (1989) and used in much subsequent literature. The flexible-wage bargaining share of firms, η, is equal to ε, so that the Hosios condition holds in a steady state with zero wage inflation. The exogenous separation rate between firms and workers, λ, is 6 percent, as reported in Campolmi and Faia (2011). To pin down exogenous producer exit, δ, we target the portion of worker separation due to plant exit. This number ranges between 25 and 55 percent in EMU members (see Haltiwanger, Scarpetta, and Schweiger, 2008). We choose a midpoint of these estimates so that the exit of plants accounts for 40 percent of overall job destruction. This yields a value for δ (0.026) that is very close to the calibration in BGM (0.025).

Two labor market parameters are left for calibration: the scale parameter for the cost of vacancy posting, κ, and the matching efficiency parameter, $\varkappa$. As common practice in the literature, we calibrate these parameters to match the steady-state average job finding probability and the probability of filling a vacancy across EMU countries. The former is 45 percent (Hobijn and Şahin, 2009), while the latter is 70 percent, in line with estimates reported by ECB (2002) and Weber (2000). With this calibration, the model generates a 12 percent steady-state unemployment rate, which is not distant from the EMU average of 9.8 percent plus a plausible adjustment for job searchers not included in unemployment rate statistics.

For the bivariate productivity process, we set persistence and spillover parameters consistent with Baxter (1995) and Baxter and Farr (2005), implying zero spillovers across countries and persistence equal to 0.999. We refer to this as Baxter calibration below. We perform sensitivity analysis by considering also values in Backus, Kehoe, and Kydland (1992, 1994), with lower persistence at 0.906 and positive spillovers at 0.088 (BKK calibration below). We set the standard deviation of productivity innovations at 0.0068 to match the absolute volatility of Euro Area GDP, but leave the covariance of innovations at the standard 0.19 percent of Baxter (1995) and Backus, Kehoe, and Kydland (1992, 1994).[46]

Finally, the parameter values in the historical rule for the ECB's interest rate setting are those estimated by Gerdesmeier and Roffia (2003). The inflation and GDP gap weights are 1.93 and 0.075, respectively, while the smoothing parameter is 0.87.

I. Model Properties

Impulse Responses

Figure A.1 (solid lines) shows impulse responses to a one-percent innovation to Home productivity under the historical rule for ECB interest rate setting.[47] Focus on the Home country first. Unemployment (U_t) does not respond on impact, but it falls in the periods after the shock. The higher expected return of a match induces domestic intermediate input producers to post more vacancies on impact,

[46] Using the 0.73 percent standard deviation of innovations in Baxter (1995) and Backus, Kehoe, and Kydland (1992, 1994) does not alter any of our main results. Only the absolute volatility of GDP is affected and, as a consequence, the absolute magnitude of welfare costs of business cycles (for given regulation level). We also experimented with the bivariate productivity process for the Euro Area in Canzoneri, Cumby, Diba, and Mykhaylova (2006), which is roughly similar to that estimated for France and Germany by Collard and Dellas (2002). The key difference is that this process features less persistent productivity (0.76). While the performance of the model remains quite good, this parametrization results in excessively smooth consumption relative to the data and a less satisfactory match of international correlations. Our own estimation of bivariate productivity processes for Germany versus different combinations of France, Italy, and Spain yielded results in between the Baxter and BKK calibrations. We settled on the Baxter calibration as benchmark given the stronger consensus for very persistent productivity processes in the literature on quantitative international business cycle models.

[47] Dashed lines show responses under the Ramsey-optimal policy (discussed below). For comparability, all responses in the figure are computed around the Ramsey-optimal steady state.

which results in higher employment in the following period. Firms and workers (costly) renegotiate nominal wages because of the higher surplus generated by existing matches, and wage inflation ($\pi_{w,t}$) increases. Wage adjustment costs make the effective firm's bargaining power procyclical, i.e., $\eta_{w,t}$ rises. To understand why this happens, recall equations (12), (13), and (15). Notice that $\partial J_t / \partial w_t$ is the change in firm surplus due to a change in nominal wages. The first term in the expression (12) for $\partial J_t / \partial w_t$ reflects the fact that, when the nominal wage increases by one dollar, the nominal surplus is reduced by the same amount (times the number of worked hours); the second term is the wage adjustment cost paid by the firm; and the last term represents the expected savings on future wage adjustments if wages are renegotiated today. When the first two effects are larger than the third one, the firm's bargaining share rises. Intuitively, $\eta_{w,t}$ shifts upward to ensure optimal sharing of the cost of adjusting wages between firms and workers. Other things equal, the increase in $\eta_{w,t}$ dampens the response of the renegotiated equilibrium wage, amplifying the response of job creation to the shock.

Employment and labor income rise in the more productive economy, boosting aggregate demand for final goods and household consumption (C_t). The larger present discounted value of future profits generates higher expected return to product creation, stimulating producer entry ($N_{E,t}$) and investment ($I_t \equiv N_{E,t} e_t$) at Home. Price stickiness and increased substitutability across a larger number of available domestic varieties result in mildly countercyclical final producer markups (μ_t).

Product creation falls temporarily in the Foreign country as resources are shifted to Home to finance increased entry in the more productive economy. Accordingly, Home runs a current account deficit in response to the shock (CA_t falls on impact), as Home households borrow from abroad to finance higher investment in new products. Although Foreign households cannot hold shares in the mutual portfolio of Home firms (since only bonds are traded across countries), the return on bond holdings is tied to the return on share holdings in Home firms by no-arbitrage between bonds and shares within each country. Therefore, Foreign households share the benefit of higher Home productivity by shifting resources to Home via lending. Moreover, Home's terms of trade ($TOT_t \equiv p_{x,t}/p^*_{x,t}$) depreciate, i.e., Home goods become relatively cheaper. This shifts world demand toward Home goods (expenditure switching), but also generates a positive wealth effect for Foreign households, whose consumption rises. In contrast to the results of standard international real business cycle (IRBC) models, the combination of expenditure switching and resource shifting is not sufficient to imply negative comovement of GDP (Y_t) and employment across countries. The increase in aggregate demand at Home (which falls on both domestic and imported goods) is strong enough to ensure that trade linkages generate positive comovement of GDP and labor market variables. Interestingly, the adjustment in the Foreign economy takes place mostly along the intensive margin, as the reduction in Foreign product creation is short-lived and followed by a very mild increase as demand stimulates some entry in the Foreign final sector.

The historical policy rule yields muted responses of Home and Foreign producer price inflation ($\pi_{d,t}$ and $\pi^*_{d,t}$) to the shock. In fact, the adjustment of the economy closely mimics that under a policy of zero deviations of area-wide producer price inflation from its long-run target.[48]

Second Moments

Table A.2 presents model-implied, HP-filtered second moments under the Baxter calibration of the bivariate productivity process (normal fonts) and the alternative BKK calibration (italics). Bold fonts denote data moments. Area-wide moments are computed from the AWM database; cross-country correlations are averages of bilateral correlations between the four largest Euro Area economies.

The model correctly reproduces the volatility of area-wide consumption, investment, and real wages relative to GDP and generates first-order autocorrelations in line with the data. It also correctly captures the cyclicality of employment and is not far from its persistence.[49] This successful performance

[48] Impulse responses for a policy of strict producer price stability are available upon request.

[49] The absolute volatility of GDP and unemployment is matched by construction. The close match between data- and

is a result of the model's strong propagation mechanism. Investment volatility is lowered relative to the excessive volatility generated by a standard IRBC framework because product creation requires hiring new workers. This process is time consuming due to search and matching frictions in the labor market, dampening investment dynamics. In contrast, consumption is more volatile than in traditional models as shocks induce larger and longer-lasting income effects.

With respect to the international dimension of the business cycle, the model successfully reproduces a ranking of cross-country correlations that is a challenge for standard IRBC models: Although lower than in the data, GDP correlation is larger than consumption correlation. This result depends both on model features and the parametrization of technology shocks. As shown in Figure 1, an increase in Home productivity generates Foreign expansion through trade linkages, as demand-side complementarities more than offset the effect of resource shifting to the more productive economy. Moreover, absent technology spillovers, Foreign consumers have weaker incentives to increase consumption on impact, which reduces cross-country consumption correlation.

As shown in Table A.2, results are largely unaffected under the BKK calibration of exogenous shocks. The only exception is the magnitude and ranking of cross-country GDP and consumption correlations: The correlation of consumption is now higher than that of GDP. This result is explained by the Foreign permanent income effect of productivity spillovers, which induces Foreign households to increase consumption on impact in anticipation of future higher domestic productivity.[50]

J. Welfare Computations

Long-Run Policy

We compare welfare under the continuation of historical policy from $t = 0$ on (which implies continuation of the historical steady state) to welfare under the optimal long-run policy from $t = 0$ on (which implies a transition between the initial implementation at $t = 0$ and the Ramsey steady state). We measure the long-run welfare gains of the Ramsey policy in the two countries (which are equal by symmetry) by computing the percentage increase Δ in consumption that would leave the household indifferent between policy regimes. In other words, Δ solves:

$$\sum_{t=0}^{\infty} \beta^t u\left(C_t^{Ramsey}, h_t^{Ramsey} l_t^{Ramsey}\right) = \frac{u\left[\left(1 + \frac{\Delta}{100}\right) C^{Hist}, h^{Hist} l^{Hist})\right]}{1 - \beta}.$$

As noted in the main text, we assume identical initial conditions for state variables (the steady-state levels under historical policy) across different monetary policy regimes and include transition dynamics in the computation to avoid spurious welfare reversals.

Policy over the Cycle

As for the long-run optimal policy, we compare policy regimes by computing the welfare gains for the two countries from optimal policy in the monetary union over the cycle. Specifically, we compute the percentage Δ of steady-state consumption that would make households indifferent between living in a world with uncertainty under monetary policy m, where $m = Ramsey$ or $Hist$, and living in a

model-implied real wage moments provides indirect support for our calibration of the nominal wage adjustment cost.

[50] Importantly, however, the model generates positive and sizable GDP comovement regardless of the productivity parametrization. Standard IRBC models predict negative or negligible cross-country GDP correlation under the BKK calibration. Resource-shifting and the permanent income hypothesis dominate dynamics in those models.

deterministic Ramsey world:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^m, h_t^m l_t^m) = \frac{u\left[\left(1+\frac{\Delta}{100}\right) C^{Ramsey}, h^{Ramsey} l^{Ramsey})\right]}{1-\beta}.$$

First-order approximation methods are not appropriate to compute the welfare associated with each monetary policy arrangement. The solution of the model implies that the expected value of each variable coincides with its non-stochastic steady state. However, in an economy with a distorted steady state, volatility affects both first and second moments of the variables that determine welfare. Hence, we compute welfare by resorting to a second-order approximation of the policy functions.

Deregulation and Welfare in the Long Run

To measure the desirability of reform we compute the percentage increase Δ in steady-state consumption relative to the status quo (no deregulation *and* historical policy) that leaves households indifferent between implementing the reform or not:

$$\sum_{t=0}^{\infty} \beta^t u(C_t^m, l_t^m, h_t^m) = \frac{u\left[\left(1+\frac{\Delta}{100}\right) C^{SQ}, h^{SQ} l^{SQ})\right]}{1-\beta},$$

where SQ stands for status quo and m denotes the monetary regime ($m = Ramsey$ or $Hist$).

K. The Business Cycle Effects of Market Reform

See tables A.3-A.5.

L. Sensitivity Analysis

We perform sensitivity analysis by considering alternative values for the parameters whose calibration is relatively controversial in the literature. For household preferences, we investigate the role of a unitary intertemporal elasticity of substitutions ($\gamma = 1$), a lower elasticity of substitution between Home and Foreign goods ($\phi = 1.5$), absence of home bias ($\alpha = 0.5$), and a higher Frisch elasticity ($1/\gamma_h = 4$, as typically assumed in the business cycle literature). We evaluate the importance of nominal rigidity by considering smaller values for the scale parameters of price and wage adjustment costs ($\nu = \vartheta = 20$). Finally, we consider an alternative value for the elasticity of the matching function ($\varepsilon = 0.4$, a mid-point of the estimates reported by Petrongolo and Pissarides, 2006). We consider the effect of changing one parameter value at a time relative to the benchmark calibration.

The main results of the paper are extremely robust to the alternative parameter values we consider.[51] The parameter value that affects our results most significantly is the elasticity of the matching function, ε. Specifically, for any given level of market regulation, a lower value of ε reduces the gap between Ramsey-optimal policy and historical policy both in the long run and over the business cycle (the differences between the two policy regimes, however, remain sizable in absolute terms). In the long run, a smaller value of ε lowers the optimal long-run inflation target. Intuitively, when the elasticity of the matching function is below the bargaining power of firms ($\varepsilon < \eta$), there is a stronger tension between using positive long-run inflation to increase the bargaining power of firms (which stimulates job creation) and the cost of this policy (which widens the departure from the Hosios condition introduced by setting $\varepsilon < \eta$). Over the business cycle, instead, the historical policy of (near) price stability is less costly because unemployment is less volatile when ε is smaller, i.e., the need to use inflation to

[51] Tables and figures are available on request.

stabilize unemployment is mitigated, and the Ramsey-optimal policy implies less volatile inflation for any level of regulation.

TABLE A.1: CALIBRATION

	Parameter	Value
Risk Aversion	$\gamma_C =$	2
Frisch Elasticity	$1/\gamma_h =$	0.2
Discount Factor	$\beta =$	0.99
Elasticity Matching Function	$\varepsilon =$	0.6
Flexible-Wage Firm Bargaining Power	$\eta =$	0.6
Unemployment Benefit	$b =$	0.38
Exogenous Worker Separation	$\lambda =$	0.06
Vacancy Cost	$k =$	0.28
Matching Efficiency	$\chi =$	0.58
Home and Foreign Goods Substitutability	$\phi =$	3.8
Home Bias	$\alpha =$	0.2
Translog Substitutability Parameter	$\sigma =$	0.62
Producer Exit	$\delta =$	0.026
Producer Entry Cost, Technology	$f_T =$	0.42
Producer Entry Cost, Regulation	$f_R =$	1.20
Price Adjustment Cost	$\nu =$	80
Wage Adjustment Cost	$\vartheta =$	60
Historical Policy, Interest Rate Smoothing	$\varrho_i =$	0.87
Historical Policy, Inflation Response	$\varrho_\pi =$	1.93
Historical Policy, GDP Gap Response	$\varrho_Y =$	0.075
Bond Adjustment Cost	$\tau =$	0.0025
Productivity Persistence	$\Phi_{11} = \Phi_{22} =$	0.999
Productivity Spillover	$\Phi_{12} = \Phi_{21} =$	0
Productivity Innovations, Standard Deviation		0.0068
Productivity Innovations, Correlation		0.253

TABLE A.2: BUSINESS CYCLE STATISTICS

Variable	$\sigma_{X_R^U}$			$\sigma_{X_R^U}/\sigma_{Y_R^U}$			1st Autocorr			$corr(X_{R,t}^U, Y_{R,t}^U)$		
Y_R^U	**1.32**	1.32	*1.30*	**1**	1	*1*	**0.91**	0.76	*0.74*	**1**	1	*1*
C_R^U	**0.68**	1.00	*0.76*	**0.51**	0.75	*0.58*	**0.89**	0.72	*0.72*	**0.87**	0.99	*0.88*
I_R^U	**3.30**	3.09	*4.13*	**2.50**	2.34	*3.18*	**0.89**	0.76	*0.76*	**0.94**	0.64	*0.71*
l^U	**0.50**	0.50	*0.46*	**0.38**	0.38	*0.35*	**0.92**	0.81	*0.81*	**0.88**	0.76	*0.73*
w_R^{Ur}	**0.50**	0.54	*0.49*	**0.38**	0.41	*0.38*	**0.85**	0.94	*0.91*	**0.16**	0.62	*0.71*
$corr(C_{R,t}, C_{R,t}^*)$	**0.55**	0.29	*0.97*									
$corr(Y_{R,t}, Y_{R,t}^*)$	**0.86**	0.36	*0.41*									

Bold fonts denote data moments, normal fonts denote moments for the Baxter calibration of productivity, and italics denote the BKK calibration.

TABLE A.3: VOLATILITY

	Historical Policy						
	Status Quo	Asymmetric PMR	Asymmetric LMR	Asymmetric JOINT	Symmetric PMR	Symmetric LMR	Symmetric JOINT
Y_R	1.32	1.28	1.21	1.20	1.27	1.21	1.19
C_R	1.00	0.95	0.89	0.88	0.95	0.89	0.88
I_R	3.09	3.17	2.60	2.77	3.17	2.60	2.77
l	0.50	0.44	0.30	0.29	0.43	0.30	0.29
Y_R^*	1.32	1.32	1.32	1.31	1.27	1.21	1.19
C_R^*	1.00	1.00	0.99	0.95	0.95	0.89	0.88
I_R^*	3.09	3.08	3.08	3.08	3.17	2.60	2.77
l^*	0.50	0.50	0.50	0.50	0.43	0.30	0.29
	Ramsey Policy						
	Status Quo	Asymmetric PMR	Asymmetric LMR	Asymmetric JOINT	Symmetric PMR	Symmetric LMR	Symmetric JOINT
Y_R	1.35	1.11	1.06	1.06	1.02	0.95	0.95
C_R	1.59	1.06	0.87	0.87	0.87	0.72	0.72
I_R	3.92	3.43	2.79	2.99	3.18	2.70	2.92
l	0.38	0.34	0.28	0.27	0.29	0.19	0.19
Y_R^*	1.35	1.09	0.97	0.96	1.02	0.95	0.95
C_R^*	1.59	1.09	0.90	0.89	0.87	0.72	0.72
I_R^*	3.92	3.23	2.80	2.87	3.18	2.70	2.92
l^*	0.38	0.31	0.24	0.23	0.29	0.19	0.19

TABLE A.4: PERSISTENCE

	Historical Policy						
	Status Quo	Asymmetric PMR	Asymmetric LMR	Asymmetric JOINT	Symmetric PMR	Symmetric LMR	Symmetric JOINT
Y_R	0.76	0.75	0.70	0.70	0.75	0.70	0.70
C_R	0.72	0.72	0.72	0.72	0.72	0.72	0.72
I_R	0.76	0.75	0.73	0.71	0.75	0.73	0.71
l	0.81	0.79	0.69	0.68	0.79	0.69	0.68
Y_R^*	0.76	0.76	0.76	0.76	0.75	0.70	0.70
C_R^*	0.72	0.72	0.72	0.72	0.72	0.72	0.72
I_R^*	0.76	0.77	0.76	0.77	0.75	0.73	0.71
l^*	0.81	0.81	0.81	0.81	0.79	0.69	0.68
	Ramsey Policy						
	Status Quo	Asymmetric PMR	Asymmetric LMR	Asymmetric JOINT	Symmetric PMR	Symmetric LMR	Symmetric JOINT
Y_R	0.18	0.50	0.64	0.65	0.58	0.66	0.67
C_R	-0.08	0.23	0.57	0.58	0.40	0.68	0.69
I_R	0.29	0.56	0.77	0.74	0.73	0.82	0.81
l	0.71	0.77	0.74	0.74	0.77	0.68	0.67
Y_R^*	0.18	0.39	0.49	0.48	0.58	0.66	0.67
C_R^*	-0.08	0.12	0.30	0.28	0.40	0.68	0.69
I_R^*	0.29	0.60	0.70	0.71	0.73	0.82	0.81
l^*	0.71	0.73	0.74	0.72	0.77	0.68	0.67

TABLE A.5: CROSS-COUNTRY CORRELATIONS

	Historical Policy						
	Status Quo	Asymmetric PMR	Asymmetric LMR	Asymmetric JOINT	Symmetric PMR	Symmetric LMR	Symmetric JOINT
$corr(C_{R,t}, C^*_{R,t})$	0.29	0.29	0.29	0.29	0.29	0.29	0.29
$corr(Y_{R,t}, Y^*_{R,t})$	0.36	0.36	0.36	0.35	0.35	0.36	0.35
	Ramsey Policy						
$corr(C_{R,t}, C^*_{R,t})$	0.72	0.42	0.19	0.21	0.16	-0.09	-0.07
$corr(Y_{R,t}, Y^*_{R,t})$	0.39	0.12	0.07	0.08	0.00	-0.02	0.01

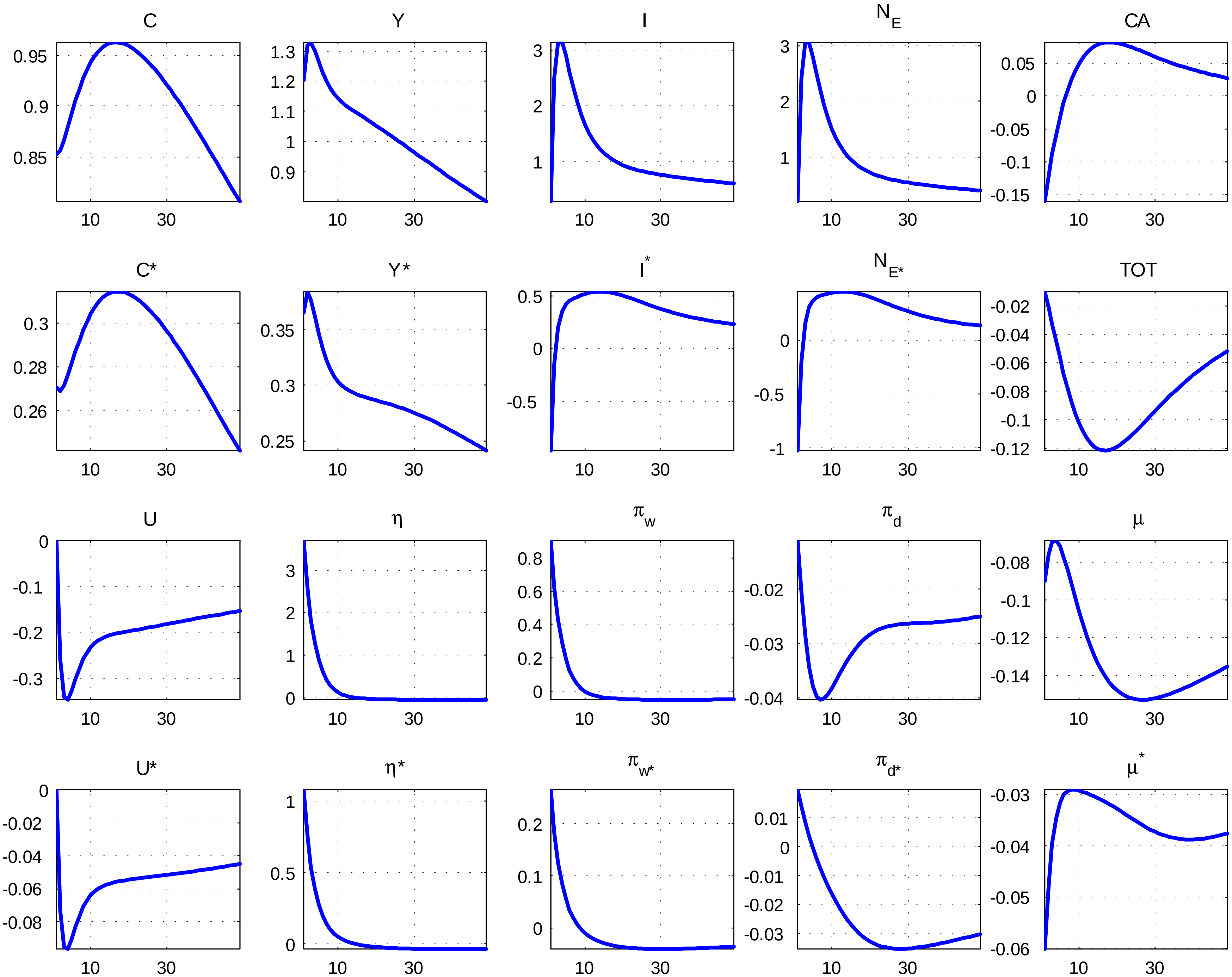

Figure A.1: Home Productivity Shock, High Regulation, Historical Policy.