# Market Deregulation and Optimal Monetary Policy in a Monetary Union*

Matteo Cacciatore†
*HEC Montréal*

Giuseppe Fiori‡
*North Carolina State University*

Fabio Ghironi§
*University of Washington, CEPR, EABCN, and NBER*

July 25, 2015

**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.

*JEL Codes*: E24; E32; E52; F41; J64; L51.
*Keywords*: Market deregulation; Monetary union; Optimal monetary policy.

*For helpful comments, we thank Giancarlo Corsetti, two anonymous referees, Javier Bianchi, Betty Daniel, Antonia Díaz, Andrea Ferrero, Francesco Giavazzi, Alexandre Jeanneret, Athanasios Orphanides, Paolo Pesenti, Alex Twist, and participants in seminars and conferences at Banco de España-Banque de France Conference on "Structural Reforms in the Wake of Recovery: Where Do We Stand?", Board of Governors of the Federal Reserve System, Boğaziçi University-CEE 2012 Annual Conference, CEPR ESSIM 2013, Deutsche Bundesbank, European Central Bank, Federal Reserve Bank of Boston, Florida State University, Johns Hopkins University-SAIS, Magyar Nemzeti Bank, NBER IFM November 2012, NBER SI 2013 "Macroeconomics Within and Across Borders," North Carolina State University, Rutgers University, SED 2012, Shanghai Macroeconomics Workshop 2014, Société Canadienne de Science Économique, University of Bonn, University of California-Riverside, University of Oxford, UQAM, University of Surrey, University of Virginia, University of Washington, and West Coast Workshop on International Finance and Open Economy Macroeconomics 2013. We are grateful to Jonathan Hoddenbagh and Tristan Potter for outstanding research assistance. Remaining errors are our responsibility. Ghironi thanks the NSF for financial support through a grant to the NBER. Work on this paper was done while Ghironi was a Visiting Scholar at the Federal Reserve Bank of Boston. The support of this institution is also acknowledged with gratitude. The views expressed in this paper are those of the authors and do not necessarily reflect those of the CEPR, the NBER, the Federal Reserve Bank of Boston, or Federal Reserve policy.

†Institute of Applied Economics, HEC Montréal, 3000, chemin de la Côte-Sainte-Catherine, Montréal (Québec), Canada. E-mail: matteo.cacciatore@hec.ca. URL: http://www.hec.ca/en/profs/matteo.cacciatore.html

‡Department of Economics, North Carolina State University, 2801 Founders Drive, 4102 Nelson Hall, Box 8110, Raleigh, NC 27695-8110, U.S.A. E-mail: gfiori@ncsu.edu. URL: http://www.giuseppefiori.net.

§Department of Economics, University of Washington, Savery Hall, Box 353330, Seattle, WA 98195, U.S.A. E-mail: ghiro@uw.edu. URL: http://faculty.washington.edu/ghiro.

"I would argue that our current monetary stance in fact makes *accelerating* structural reforms desirable, because it brings forward their positive demand effects." Mario Draghi, "Structural Reforms, Inflation and Monetary Policy," Sintra, May 22, 2015.

## 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] Important questions remain open for researchers and policymakers: What is the optimal macroeconomic policy response to the dynamics triggered by goods and labor market reform? How does deregulation affect the tradeoffs facing policymakers in the long-run and over 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 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

[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, then European Central Bank President Jean-Claude Trichet and President-to-be Mario Draghi took the then 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. Calls for structural reforms have since become a constant in President Draghi's press conferences and speeches, in those of many other policymakers, and in commentary in the media. Structural reforms are part of the conditionality imposed on Greece by its creditors in the Greek debt crisis. In the United States, Lawrence Summers called for "bold reform" of the U.S. economy as a key remedy to "secular stagnation" ("Bold Reform Is the Only Answer to Secular Stagnation," *Financial Times*, September 8, 2014).

[2] See, for instance, Blanchard and Giavazzi (2003), Cacciatore and Fiori (2010), Dawson and Seater (2011), Fiori, Nicoletti, Scarpetta, and Schiantarelli (2012), Griffith, Harrison, and Macartney (2007), and Messina and Vallanti (2007).

features of product and labor market regulation and reform as well as the narrative by policymakers. 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 find that regulation in goods and labor markets has significant effects on optimal monetary policy. In the presence of high market regulation, it is optimal to deviate from price stability in the long run and over the business cycle. Structural reforms that make product and/or labor markets more flexible have three consequences for policy: First, the optimal response to deregulation is expansionary, with a beneficial effect on welfare during the transition relative to the historical policy behavior (which, in turn, approximates a policy of price stability). Second, when the effects of deregulation are fully materialized, price stability is more desirable both in the long run (a lower optimal inflation target) and over the business cycle (smaller optimal deviations of inflation from target). Third, international synchronization of market reforms is beneficial, as it removes additional policy tradeoffs induced by heterogeneous market regulation in the monetary union.

The intuition for our results is straightforward. The initial steady state with high regulation in goods and labor markets is characterized by too high markups and too low job creation. Moreover, regulation makes cyclical unemployment fluctuations too volatile, which amplifies their welfare cost. The Ramsey policymaker uses positive long-run inflation (in the ECB's current target range) 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). 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.

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.[3] Once the beneficial effects of reforms have fully materialized, there is less need of

[3] In the case of joint product and labor market deregulation in one country, the welfare gain from the Ramsey-optimal policy (relative to historical policy) over a three-year horizon is 0.4 percent of annual pre-deregulation steady-state consumption in the country that deregulates and 0.75 percent in the other.

positive long-run inflation to close inefficiency gaps, and price stability over the cycle is less costly for economies that deregulated their markets. 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. The welfare cost of this additional tradeoff is not negligible: Ramsey-optimal cooperative monetary policies for national central banks operating under a flexible exchange rate improve welfare by 0.14 percent of steady-state consumption relative to the Ramsey-optimal policy in the monetary union with asymmetric market characteristics. 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, and the benefit increases if reforms are synchronized.

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 many ECB actions during Europe's sovereign debt crisis.[4] Moreover, 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 effects of market deregulation, including transition dynamics and business cycle implications of reforms.

[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.

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

Our closest antecedent in this vein of work is Cacciatore and Fiori (2010), who study, both theoretically and empirically, the dynamic consequences of market deregulation in a real business cycle model with search and matching frictions and endogenous product creation. 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.[6]

Explicit modeling of product and labor market dynamics differentiates our exercise from some recent analyses of the interaction between structural reforms and monetary policy. Eggertsson, Ferrero, and Raffo (2014) argue that the deflationary effects of product and labor market reforms can exacerbate the zero-lower-bound problem.[7] Andrés, Arce, and Thomas (2014) study the consequences of market reforms in an environment of debt deleveraging All 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 "automatically" have deflationary consequences. Gerali, Notarpietro, and Pisani (2015) show that investment dynamics affect the response of inflation to exogenous markup reductions. 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.

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 (2014), Cacciatore and Ghironi (2012), Faia (2012), and Lewis (2013) analyze optimal monetary policy in models with endogenous producer entry, while Chugh and Ghironi (2015) 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.

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.[8] 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

[6] 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). Thomas and Zanetti (2009) focus on the positive implications of labor market regulation for inflation volatility. On the consequences of labor market regulation for business cycle volatility in a model with nominal rigidity, see also Zanetti (2011).

[7] See also Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2011).

[8] Notice that our results imply that the classic Friedman rule—setting nominal interest rates to zero at all times and under all circumstances—is never optimal. We share this result with the vast majority of the New Keynesian literature with nominal rigidity. In the benchmark New Keynesian model with price stickiness as in Calvo (1983) and Yun (1996) or Rotemberg (1982), the Friedman rule is inefficient because price stickiness in itself implies the optimality of zero inflation under commitment (which in turn implies equality of real and nominal interest rates). In our model, the balance of distortions facing the Ramsey central bank implies departure from the Friedman rule in the form of an optimal, positive inflation rate.

product creation under flexible prices, as in Bilbiie, Fujiwara, and Ghironi (2014). 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).[9] Our work adds to this literature along two dimensions. First, we show that market regulation constitutes a hitherto mostly 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.[10] 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.[11] Finally, 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. Section 4 discusses the distortions and inefficiency wedges that characterize the market economy and presents intuitions on policy tradeoffs and optimal policy. Section 5 studies the consequences of market regulation and reform for the optimal inflation target and the optimal monetary policy response to market deregulation. Section 6 addresses the consequences of deregulation for the conduct of monetary policy over the business cycle. Section 7 concludes.

[9] 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).

[10] 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. Bilbiie, Fujiwara, and Ghironi (2014) discuss the consequences of product market regulation for optimal inflation, but price stability is (nearly) optimal over the business cycle in their model.

[11] 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 $\phi > 0$: $C_t = \left[(1-\alpha)^{\frac{1}{\phi}} C_{d,t}^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} C_{x,t}^{*\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$, where $0 < \alpha < 1$. 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. Therefore, 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 $\alpha$ 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 $\Omega_d$ and $\Omega_x^*$ 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 (2010), lower entry barriers in production of goods result in increased entry, a larger number of available goods, and—by inducing higher substitutability—lower markups.[12,13]

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 $\omega$ produced and sold at Home, and $p^*_{x,t}(\omega^*)$ the price of a variety $\omega^*$ produced in the Foreign country and exported to Home. The unit expenditure function on the basket of domestic goods $C_{d,t}$ is given by:

$$\begin{aligned}\ln P_{d,t} &= \frac{1}{2\sigma}\left(\frac{1}{N_t}-\frac{1}{\tilde{N}}\right)+\frac{1}{N_t}\int\limits_{\omega\in\Omega_{d,t}}\ln p_{d,t}(\omega)d\omega \\ &\quad +\frac{\sigma}{2N_t}\int\limits_{\omega\in\Omega_{d,t}}\int\limits_{\omega'\in\Omega_{d,t}}\ln p_{d,t}(\omega)(\ln p_{d,t}(\omega)-\ln p_{d,t}(\omega'))d\omega d\omega',\end{aligned}$$

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

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

where $N^*_t$ is the total number of Foreign products available at time $t$, and $\tilde{N}^*$ is the mass of $\Omega^*_x$.[14]

[12] 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.

[13] 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).

[14] Since we will abstract from producer heterogeneity and endogenous determination of the range of traded consumption varieties, 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 $mass(\Omega_d) = mass(\Omega_x)$, $mass(\Omega_{d,t}) = mass(\Omega_{x,t})$,

### 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 new workers, firms need to post vacancies, incurring a cost of $\kappa$ units of consumption per vacancy posted. 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 $\upsilon_t$ 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 $\lambda \in (0, 1)$.[15] 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. We present an alternative version of the model which allows for nominal wage

$mass(\Omega_d^*) = mass(\Omega_x^*)$, 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.

[15] 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 (2010). 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 and recent reforms (for instance, in Italy), we conjecture based on Cacciatore and Fiori's results that the additional complication would not alter our main messages.

indexation in an Online Appendix—henceforth, referred to simply as Appendix.[16]

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 $\epsilon_t$ ($\epsilon_t^*$). The diagonal elements of the autoregressive matrix $\Phi$, $\Phi_{11}$ and $\Phi_{22}$, measure the persistence of exogenous productivity and are strictly between 0 and 1, and the off-diagonal elements $\Phi_{12}$ and $\Phi_{21}$ measure productivity spillovers. The productivity innovations $\epsilon_t$ and $\epsilon_t^*$ 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 $\varphi_t$ in units of consumption. Intermediate producers choose the number of vacancies, $v_t$, and employment, $l_t$, to maximize the expected present discounted value of their profit stream:

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

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:

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

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,

[16] Available at http://faculty.washington.edu/ghiro.

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 the 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 $\eta$ 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:

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

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 $\iota_t$ 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 $\eta$—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). When wages are sticky, 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.[17] Final goods are produced using domestic intermediate inputs, and they are sold domestically and abroad.[18]

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 $\bar{p}_{x,t} = \bar{p}_{d,t}$, where $\bar{p}_{d,t}$ and $\bar{p}_{x,t}$ are the maximum prices that Home producer $\omega$ can charge in the Home and Foreign markets while still having positive market share. 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.[19] 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.

As shown in the Appendix, total demand for final Home producer $\omega$ can be written as:

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

where $Y_t^C$ and $Y_t^{C*}$ denote aggregate demand of the final consumption basket at Home and abroad, recognizing that aggregate 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.

We introduce price stickiness by following Rotemberg (1982) and assuming that final producers must pay a quadratic price adjustment cost $\Gamma_t(\omega) \equiv \nu \pi_{d,t}^2(\omega) p_{d,t}(\omega)(y_{d,t}(\omega) + y_{x,t}(\omega))/2$, where

[17] 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).

[18] We do not assume separate productivity shocks in the final production sector, which implies that marginal production cost in this sector is simply $\varphi_t$. 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.

[19] 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.

$\nu \geq 0$ determines the size of the adjustment cost (prices are flexible if $\nu = 0$) and $\pi_{d,t}(\omega) \equiv (p_{d,t}(\omega)/p_{d,t-1}(\omega)) - 1$.[20] (In the Appendix, we also consider the case of price indexation.) 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 setting the price for the first time) must buy the bundle of goods $\Gamma_t(\omega)/P_t$ when implementing a price decision.[21]

Total real profits are given by $d_t(\omega) = \left[p_{d,t}(\omega)\left(1 - \nu\pi_{d,t}^2(\omega)/2\right)/P_t - \varphi_t\right](y_{d,t}(\omega) + y_{x,t}(\omega))$. 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 $\varphi_t$: $\rho_{d,t}(\omega) = \mu_t(\omega)\varphi_t$. 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 $\omega$, and:

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

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 $\omega$ increases when the number of

[20] 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.

[21] 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.

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 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.[22] 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 $\delta$ of incurring an exit-inducing shock at the end of each period. Following BGM and Ghironi and Melitz (2005), we introduce a time-to-build lag in the model and assume that entrants at time $t$ will start producing only at $t + 1$. 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 $e_t = \varphi_t f_{E,t}$.[23] 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.[24] Investment in the mutual fund of final-sector firms in the stock market is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. Since there is no entry in the intermediate sector (and, therefore, no need to channel resources from households for the financing of such entry), we do not model trade in intermediate-

[22] 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.

[23] This condition holds as equality in each period as long as the mass of new entrants $N_{E,t}$ is always positive. We verified that this is the case in our exercises.

[24] For simplicity, we assume extreme home bias in equity holdings and rule out international trade in firm shares. See Hamano (2015) for a version of the Ghironi-Melitz (2005) model with international trade in equities.

sector equity explicitly, but simply assume that the profits of intermediate sector firms are rebated to households in lump-sum fashion.[25]

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 $\delta$ at the end of period $t$, it finances the continuing operation of all pre-existing firms and all new entrants during period $t$. The date $t$ price of a claim to the future profit stream of the mutual fund of $N_t + N_{E,t}$ firms is equal to the nominal price of claims to future profits of Home firms, $P_t e_t$.

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:

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

where $i_t$ is the nominal interest rate on the internationally traded bond, $T_t^G$ is a lump-sum transfer (or tax) from the government, $T_t^F$ is the lump-sum rebate of the cost of adjusting bond holdings from the financial intermediaries, and $T_t^I$ is the lump-sum rebate of profits from intermediate goods producers.[26] 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 $t$.

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

[26] In equilibrium,

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

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

$$1 + \tau a_{t+1} = (1 + i_{t+1}) E_t \left[\beta_{t,t+1}(1 + \pi_{C,t+1})^{-1}\right] \quad \text{and} \quad e_t = (1 - \delta) E_t \left[\beta_{t,t+1} (d_{t+1} + e_{t+1})\right],$$

where $\pi_{C,t} \equiv (P_t/P_{t-1}) - 1$ 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.[27] 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:

$$a_{t+1} = (1 + r_t) a_t + N_t \rho_{d,t} y_{x,t} - N^*_t Q_t \rho^*_{d,t} y^*_{x,t},$$

where$1 + r_t \equiv (1 + i_t) / (1 + \pi_{C,t})$ denotes the real interest rate. 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

We compare the Ramsey-optimal conduct of monetary policy to a representation of historical behavior for the central bank of our model EMU, captured by a standard rule for interest rate setting in the spirit of Taylor (1993), Woodford (2003), and much other literature.

### Data-Consistent Variables and Historical Monetary Policy

The ECB 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, we specify historical interest rate setting for our model ECB as a rule in which policy responds to movements in a country-weighted average of CPI inflation and GDP gaps relative to the equilibrium with flexible wages and prices.

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

In the presence of endogenous producer entry and preferences that exhibit "love for variety," an issue concerns the empirically relevant variables that enter the theoretical representation of historical policy. As highlighted by Ghironi and Melitz (2005) and BGM, 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.[28] To resolve this issue, we follow Ghironi and Melitz (2005) and BGM and introduce the data-consistent price index $\tilde{P}_t \equiv \Omega_t^{1/(\phi-1)} P_t$, where $\Omega_t$ 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. Multiplication of the welfare-consistent price index by $\Omega_t^{1/(\phi-1)}$ removes unmeasured, pure variety effects and delivers a price index that is closer to available CPI data.[29] Given any variable $X_t$ in units of consumption, we then construct its data-consistent counterpart as $X_{R,t} \equiv X_t / \Omega_t^{\frac{1}{\phi-1}}$. (Additional details are in the Appendix.)

Given data-consistent price indexes and GDPs for Home and Foreign, we assume the following interest rate rule to describe historical policy:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[ (1+i)\left(1 + \tilde{\pi}_{C,t}^U\right)^{\varrho_\pi} \left(\tilde{Y}_{g,t}^U\right)^{\varrho_Y} \right]^{1-\varrho_i}, \tag{3}$$

where $\tilde{\pi}_{C,t}^U \equiv \tilde{\pi}_{C,t}^{\gamma_\pi} \tilde{\pi}_{C,t}^{*1-\gamma_\pi}$ is data-consistent, union-wide CPI inflation, and $\tilde{Y}_{g,t}^U \equiv \tilde{Y}_{g,t}^{\gamma_{\tilde{Y}}} \tilde{Y}_{g,t}^{*1-\gamma_{\tilde{Y}}}$ is the data-consistent, union-wide GDP gap. Since Home and Foreign have identical size, we set $\gamma_\pi = \gamma_{\tilde{Y}} = 0.5$.[30]

Table 1 summarizes the key equilibrium conditions of the model, including the policy rule (3). We rearranged some equations appropriately for transparency of comparison to the planner's optimum described below, which we will use to build intuition for the tradeoffs facing the Ramsey policymaker.

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

[29] See also Feenstra (1994).

[30] Benigno (2004) shows that the optimal inflation target for the central bank of a monetary union should attach a larger weight to inflation in the country where nominal rigidity is more pervasive. We abstract from differences in nominal rigidity across countries in our exercise, which is consistent with setting $\gamma_\pi = 0.5$ in the absence of asymmetries. We explore below the consequences of optimally determining $\gamma_\pi$ and $\gamma_{\tilde{Y}}$ in the presence of asymmetries in market regulation.

**Ramsey-Optimal Monetary Policy**

The Ramsey central bank maximizes aggregate welfare under the constraints of the competitive economy. Let $\Lambda_{1,t}, ..., \Lambda_{20,t}$ be the Lagrange multipliers associated with the equilibrium conditions in Table 1 (excluding the interest rate rule).[31] The Ramsey problem consists of choosing $\{\Lambda_{1,t}, ..., \Lambda_{20,t}\}_{t=0}^{\infty}$ and

$$\{\pi_{C,t}, \pi_{C,t}^{*}, \pi_{w,t}, \pi_{w,t}^{*}, C_t, C_t^{*}, l_t, l_t^{*}, V_t, V_t^{*}, J_t, J_t^{*}, h_t, h_t^{*}, \rho_{d,t}, \rho_{d,t}^{*}, N_{t+1}, N_{t+1}^{*}, Q_t, i_{t+1}, a_{t+1}\}_{t=0}^{\infty},$$

to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{1}{2} \left( u\left(C_t\right) - l_t v\left(h_t\right)\right) + \frac{1}{2} \left( u\left(C_t^{*}\right) - l_t^{*} v\left(h_t^{*}\right)\right)\right] \tag{4}$$

subject to the constraints in Table 1 (excluding the interest rate rule).[32]

As common practice in the literature, we write the original non-stationary Ramsey problem in 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.

## 4 Inefficiency Wedges and Policy Tradeoffs

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 the 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.

We relegate the details of the planning problem and the analytical derivation of the inefficiency wedges to the Appendix. Table 2 summarizes the equilibrium conditions for the efficient allocation, and Table 3 summarizes the distortions that characterize the decentralized economy.

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

[32] 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.

**Inefficiency Wedges**

Our model features several sources of distortion: Some are familiar ingredients in New Keynesian 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:** Several distortions impinge on the product creation margin in each country. 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 $\Upsilon_{\mu,t} \equiv \left(\mu_{t-1}/\mu_t\right) - 1$. 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 $\Upsilon_{N,t} \equiv \mu_{t-1}\left(1 - 1/\mu_t - \nu\pi^2_{d,t}/2\right) - 1/(2\sigma N_t)$. These distortions are at work in Bilbiie, Fujiwara, and Ghironi (2014)—BFG below. 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 $\Upsilon_{R,t} \equiv f_{R,t}$.[33] The distortions $\Upsilon_{\mu,t}$, $\Upsilon_{N,t}$, $\Upsilon_{R,t}$ combine into a wedge $\Sigma_{PC,t}$ that differentiates the Euler equation for product creation in the market economy from the corresponding equation in the planner's optimum.

**Job creation margin:** A wedge $\Sigma_{JC,t}$ similarly results from several distortions that affect each economy's job creation margin. 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 of the matching function is necessary for efficiency in the absence of other distortions) is an additional distortion in this margin, measured by $\Upsilon_{\eta,t} \equiv \eta_{w,t} - \varepsilon$.[34] The distortion $\Upsilon_{\eta,t}$ is affected both by the flexible-wage value of the bargaining share ($\eta$, which can be different from $\varepsilon$) and the presence of wage stickiness, which makes the equilibrium bargaining share endogenous to inflation. Moreover, sticky wages distort job creation also by affecting the outside option of firms through the additional term $\Upsilon_{\pi_w,t} \equiv \vartheta\pi^2_{w,t}/2$. Finally, unemployment benefits increase the workers' outside option above its efficient level: $\Upsilon_{b,t} \equiv b$.

[33] Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2015) consider the case $f_{R,t} = -\tau^E_t f_{T,t}$ and discuss the determination of optimal product creation subsidies $\tau^E_t$ 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).

[34] In the presence of other distortions, the basic, flexible-wage Hosios condition $\eta = \varepsilon$ must be adjusted to include an appropriate additional term in order to deliver efficiency in job creation. We are grateful to Sanjay Chugh and Guillaume Rocheteau for clarifying this point. For simplicity of exposition and consistency with much literature (for instance, Arseneau and Chugh, 2012), we simply refer to the condition $\eta = \varepsilon$ as the Hosios condition below.

**Labor supply margin:** With endogenous labor supply, monopoly power in product markets induces a misalignment of relative prices between consumption goods and leisure, resulting in the wedge $\Sigma_{h,t} \equiv \Upsilon_{\varphi,t} + 1$, which is time-varying because of translog preferences and sticky prices. Except for translog preferences, this is the distortion that characterizes standard New Keynesian models with monopolistic competition, which typically assume C.E.S. Dixit-Stiglitz (1977) preferences. This distortion is at work also in BFG. 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 departures from efficient risk sharing across countries resulting in the wedge $\Sigma_{RS,t} \equiv (u_{C^*,t}/u_{C,t})/Q_t$. This wedge is affected also by the costs of adjusting bond holdings, which introduce 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.[35]

**International relative price margin:** As long as the model does not satisfy the conditions such that a fixed exchange rate is optimal, monetary union distorts real exchange rate dynamics by removing adjustment through the nominal exchange rate: $Q_t/Q_{t-1} = \left(1 + \pi^*_{C,t}\right) / (1 + \pi_{C,t})$.[36] This distortion cannot be summarized into an analytically defined wedge because the planned economy does not feature nominal rigidity. (As a consequence, Table 3 does not include an expression for this distortion.)

**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 $\Upsilon_{R,t}$ combining into a wedge $\Sigma_{Y^C,t}$.

The market allocation is efficient if and only if all the distortions are eliminated and the associated inefficiency wedges are closed at all points in time.[37]

### Tradeoffs and Intuitions for Optimal Policy

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. Although

[35] The standard risk sharing condition under complete markets implies $u_{C^*,t}/u_{C,t} = \varkappa Q_t$, where $\varkappa$ is a constant of proportionality that captures asymmetries in the initial steady-state position of the two economies. Under assumption of zero initial net foreign assets and symmetric countries, it is $\varkappa = 1$, implying the expression we are assuming for the risk sharing wedge.

[36] With flexible exchange rates, it would be $Q_t/Q_{t-1} = \left(1 + \pi^*_{C,t}\right) S_t / \left[(1 + \pi_{C,t}) S_{t-1}\right]$, where $S_t$ is the nominal exchange rate (units of Home currency per unit of Foreign currency).

[37] Given our definitions of distortions and wedges, this implies $\Sigma_{PC,t} = \Sigma_{JC,t} = \Sigma_{h,t} = \Sigma_{RS,t} = 1$ and $\Sigma_{Y^C,t} = 0$.

the model features multiple distortions, several of them have the same qualitative implications for optimal policy. Therefore, for any given level of market regulation, the Ramsey central bank actually faces a small number of policy tradeoffs—with intuitive implications for optimal policy—both in the long run and over the business cycle.

*Optimal Monetary Policy in the Long Run*

It is immediate to verify that long-run inflation in product-level and consumption prices 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, the steady-state Euler equations of households, and the expressions of price indexes: $1 + \pi_d = 1 + \pi_C = \beta(1 + i) = 1 + \pi_C^* = 1 + \pi_d^*$. Moreover, wage inflation is always equal to producer price inflation: $\pi_d = \pi_{w.}$

To begin understanding policy incentives in the long run, notice that a symmetric long-run equilibrium with constant endogenous variables eliminates some distortions: A constant markup removes the markup variation distortion from the product creation margin ($\Upsilon_\mu = 0$); The risk-sharing distortion of incomplete markets is eliminated in the deterministic steady state, and constant, zero net foreign assets eliminate the effect of bond adjustment costs, so that $\Sigma_{RS} = 1$; Finally, symmetry also eliminates the international relative price distortion of monetary union by implying $Q = 1$.

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 $\varepsilon$), increasing the bargaining power of firms. Compared to the zero inflation outcome, a positive long-run inflation rate can reduce the inefficiency wedges in product creation ($\Sigma_{PC}$), job creation ($\Sigma_{JC}$), and labor supply ($\Sigma_h$). 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.[38]

## 5 Optimal Inflation and the Monetary Policy Response to 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. 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

[38] 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.

monetary union, raising the question of desirability of coordinated reforms.

In this Section, we study the optimal monetary policy response to market deregulation during the transition dynamics and in the long run. In the next Section, we consider monetary policy over the business cycle. We use numerical illustrations to substantiate the general intuitions presented in the previous Section. We calibrate the model to match quarterly Euro Area macroeconomic data from 1995:Q1 to 2013:Q1. In the Appendix, we present a detailed description of our calibration, which is assumed symmetric across countries. Following standard practice, we set parameter values so that the model replicates long-run features of the data in the zero-inflation steady state. We show in the Appendix 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 also presents 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.

In our exercises, we assume that both countries start at high levels of regulation and consider a joint reduction in goods and labor market regulation. (The cases of separate product and labor market reforms are presented in the Appendix. Many results are qualitatively similar to the case of comprehensive product and labor market reform we focus on here.) We study both symmetric and asymmetric reforms across the two members of the monetary union.[39] Product market deregulation is modeled 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.[40] Market reforms change the levels of the relevant parameters from the initial Euro-Area-based calibration to the levels for the U.S. economy, a standard benchmark for flexible markets. Details are in the Appendix.[41]

[39] It could be argued that the scenario in which both countries start at high levels of regulation and one of them deregulates captures features of the dynamics after Germany's labor market 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 also 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.

[40] 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. We present results on anticipated deregulations in the Appendix.

[41] Notice that there is no presumption that the U.S. market regulation levels we use should be *optimal* for the Euro Area (or for the United States, for that matter). The optimal design of product and labor market regulation and reform is a first-order issue, which also raises the question of strategic interactions between government (regulators) and the

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). 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.

**Asymmetric Market Deregulation**

As shown in Table 4, the optimal long-run target for net inflation under the high regulation scenario of our historical calibration is indeed positive and equal to 1.15 percent—in the range of the ECB's mandate. (Inflation results in Table 4 are annualized.) Table 5 shows that the welfare gains from implementing the Ramsey-optimal inflation target in the high-regulation steady state amount to approximately 0.35 percent of steady-state consumption.[42]

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.[43] Importantly, the result of a positive Ramsey inflation target is not an "automatic" consequence of assuming a form of nominal rigidity that implies long-run non-neutrality of money. As shown in BFG, the same form of price stickiness implies a zero Ramsey-optimal inflation target in the sticky-price BGM model if preferences take the C.E.S. Dixit-Stiglitz (1977) form that is common in the New Keynesian literature. The additional distortions introduced in our model imply the optimality of positive long-run inflation. Moreover, consistent with results in BFG, Table 4 shows that the optimal long-run inflation target increases up to 2.31 percent in the presence of both price and wage indexation as commonly introduced in the literature. The reasons for this result are twofold: First, indexation lowers the welfare cost associated with a given long-run inflation rate (steady-state adjustment costs are decreasing in indexation rates). Second, indexation

central bank. We leave this issue for future research. Results in Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2015) provide initial insights into optimal product market policy in the BGM model.

[42] We measure the welfare gains from the Ramsey policy by computing the percentage increase in consumption that would leave households indifferent between policy regimes. Implementing the optimal policy implies transition dynamics as the Home and Foreign economies adjust to the new steady state with a positive inflation target. Welfare under the optimal policy accounts also for these transition dynamics. There are no transition dynamics under the historical policy as there is no change in steady-state inflation from the initial level of zero. Note that our results are not sensitive to the choice of (identical) initial conditions for the state variables. Additional details on our welfare computations are in the Appendix.

[43] 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.

requires larger inflation to achieve a given change in long-run markup and bargaining power of firms.[44]

Consider now a joint reduction in barriers to firm entry, unemployment benefits, and worker bargaining power in the Home economy. To understand the optimal monetary policy response to Home deregulation, it is useful first to inspect the dynamic adjustment and new long-run equilibrium under historical policy. We present impulse responses for selected variables in Figure 1, where solid lines show the responses for the historical policy case.[45] The reduction in barriers to entry at Home boosts product creation and results in increased investment.[46] Under financial autarky, this would require households to cut consumption and increase savings to finance the expansion in entry: Since we are holding exogenous productivity constant, 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 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.[47] 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 as increased business creation in the downstream sector translates into higher labor demand in intermediate input production. Lower unemployment benefits and worker bargaining have a moderating effect on wage dynamics, further increasing firms' vacancy posting and employment.

In contrast to models where product and labor market reform takes the form of exogenous markup cuts without underlying micro-level dynamics, Home deregulation has an inflationary effect, which erodes markups on impact. Financial and trade linkages imply significant spillovers to the Foreign economy along the transition. As Foreign consumers invest at Home, Foreign consumption falls, and unemployment rises. The dynamics of relative production costs generated by relative firm entry and job creation imply that 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.[48]

In the second part of the transition, the larger number of available domestic products lowers

[44] The 2.31 percent inflation target refers to the case in which the degree of price and wage indexation is set equal to 0.5, consistent with the empirical evidence discussed in the Appendix. Notice that, while indexation tends to increase the optimal inflation rate, the relationship is not monotonic. For instance, with full price indexation but no wage indexation, the optimal inflation target is 1.19 percent. The optimal target is similar when considering full wage indexation without price indexation. Intuitively, the equalization of price and wage inflation in steady state dampens the incentive of the Ramsey authority to increase inflation in the presence of asymmetric degrees of indexation between product prices and nominal wages.

[45] Responses of variables we mention but do not show, as well as responses of other variables, are available on request.

[46] The measure of investment in our model is $I_t \equiv N_{E,t}e_t$.

[47] The current account initially deteriorates across all asymmetric deregulation scenarios we consider. Policymakers 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.

[48] Home terms of trade appreciation also conflicts with the implications of exogenous markup cuts.

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? The optimal policy case is represented by the dashed lines in Figure 1. The responses of inflation rates show that the Ramsey policy is more expansionary than the ECB's historical behavior, though inflation rates remain well within reasonable limits. More aggressive monetary policy expansion 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 and incumbents are too small (in the notation introduced for distortions above, $\Upsilon_N > 0$ and $\Upsilon_\varphi > 0$). However, the Ramsey planner anticipates that the new long-run equilibrium will feature lower markups, a larger number of producers of more significant size, and higher aggregate employment. Therefore, the optimal policy reduces markups, boosts incumbent firm size, and increases employment at Home in anticipation of these long-run effects. Consistent with Draghi (2015), monetary policy that is more expansionary than historical "brings forward" key beneficial effects of market reforms. 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. By contrast, the product creation wedge $\Sigma_{PC,t}$, is temporarily widened.[49] The widening of $\Sigma_{PC,t}$ happens because the short-run increase in inflation reduces the incentive of prospective entrants to take advantage of lower non-technological barriers to entry.[50]

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. The product creation wedge falls on impact, but then increases, associated with lower product creation in the relatively less attractive business environment during much of 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

[49] The impulse responses of inefficiency wedges show the percent variations of the wedge deviations from efficiency. For a given wedge $\Sigma_{i,t}$ with efficient level equal to 1, we plot the response of $(|\Sigma_{i,t} - 1| - |\Sigma_i - 1|) / (|\Sigma_i - 1|)$. We consider absolute values because what matters is the deviation from efficiency (be it positive or negative).

[50] Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2015) show that it is optimal to tax entry in the benchmark BGM model with translog preferences. However, this does not imply that a reduction in entry should reduce the inefficiency wedge in product creation in our scenario of multiple distortions and a non-optimized change in entry barriers.

deregulating economy. In the long run, Home 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, implying $\Upsilon_\mu = 0$. Moreover, under the assumption of long-run zero net inflation, $\Upsilon_{\pi_w} = \Upsilon_{\pi_d} = 0$, and the Hosios condition implied by our calibration of the initial, historical position ensures that $\eta_w = \eta = \varepsilon$, so that $\Upsilon_\eta = 0$. Finally, product market regulation does not change the value of unemployment benefits, leaving $\Upsilon_b$ unaffected. The zero-inflation steady state features two additional distortions that are affected by regulation and inflation: the misalignment between the consumers' benefit from variety and the profit incentives for new entrants, $\Upsilon_N = (\mu - 1) - 1/(2\sigma N)$, and the monopoly power distortion in labor supply and job creation, $\Upsilon_\varphi = (1/\mu) - 1$.[51]

As barriers to entry fall, the steady-state number of products in the economy increases. With zero net inflation, the fall in markups due to higher substitutability is larger than the reduction in the consumers' incremental 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 $\Upsilon_\varphi$,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 become closer to the respective efficient levels.

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 $\eta$ is now greater than the elasticity of matches to vacancies, $\varepsilon$, a departure from the Hosios condition. In our second best environment, the rigid, distorted steady state features suboptimally low job creation: The increase in $\eta$ brings employment closer to the social optimum. Thus, the job creation wedge is smaller even if the Hosios condition is violated post-deregulation.[52]

The combination of these product and labor market effects of reform reduces the need for positive

[51] Notice that a long-run widening of $\Sigma_{RS,t}$ relative to the initial level of 1 does not imply that there is a larger incomplete markets distortion in the new steady state (which features zero net foreign assets like the initial one). Asymmetric deregulation introduces a long-run structural asymmetry between Home and Foreign. This implies that the risk sharing wedge around the new steady state should be redefined as $\Sigma_{RS,t} \equiv \left(u_{C^*,t}/u_{C,t}\right)/\left(\varkappa Q_t\right)$, where $\varkappa$ reflects the effect of the long-run asymmetry between the two economies. But the new, post-deregulation steady state remains efficient along the risk sharing margin because of the absence of any uncertainty in steady state.

[52] Put differently, the economy is getting closer to the job creation outcome under the adjusted Hosios condition for a distorted economy mentioned above.

long-run inflation to bring the economy closer to the efficient outcome. Long-run responses under the Ramsey-optimal policy are very similar to those under the historical rule because the reduction in product and job creation wedges dominates the Ramsey central bank's incentives and results in such lower steady-state optimal inflation. As shown in Table 4, the optimal inflation target falls to 0.97 percent. With both price and wage indexation, the reduction in the optimal inflation target implied by structural reform is even larger, as optimal long-run inflation falls from 2.31 to 1.94 percent.

Table 5 shows that market reform is highly beneficial for the deregulating country already under the historical policy, as welfare gains amount to 7.40 percent of steady-state consumption at Home. There is a modest prosper-thy-neighbor effect, as welfare rises by approximately 0.45 percent of steady-state consumption in Foreign.[53] While the welfare gains from implementing the optimal inflation target under high regulation are sizable, the gains from implementing the optimal policy response to deregulation are positive but not large for the reforming country (the relative gain is approximately 0.05 percent of steady-state consumption). In other words, welfare gains from optimal policy along the transition and in the new steady state have little impact on the lifetime effect of the reform on Home welfare, which is dominated by the reduction of long-run inefficiency wedges generated by the deregulation. The welfare gain from the Ramsey response to reform is small also in Foreign, but more significant than in Home: Market distortions are still in place in the rigid economy, and welfare gains from optimal policy along the transition and non-zero long-run inflation are more significant at 0.25 percent of steady-state consumption. These results are consistent with the fact that a policy of near price stability is relatively more desirable for more flexible economies.[54]

### International Synchronization of Reforms

Since long-run inflation rates are equalized across countries, the Ramsey authority can choose only one steady-state inflation target for both countries in the monetary union. Thus, with asymmetric deregulation, optimal monetary policy must trade off asymmetric desirability of inflation across countries associated with cross-country heterogeneity in real rigidities: While flexible product and labor markets at Home call for less inflation, the rigid member of the monetary union still benefits from a relatively higher long-run inflation target. To investigate this issue further, we consider an alternative

[53] Market deregulation improves welfare at Home and abroad across all the exercises we perform. However, it is important to notice that 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.

[54] As we show in the Appendix, joint reform of product and labor markets is more beneficial than deregulation of individual markets, even if there is some substitutability across reforms, since the welfare gain is smaller than the sum of the gains from individual reforms. This result is consistent with the empirical evidence in Fiori, Nicoletti, Scarpetta, and Schiantarelli (2012).

monetary policy arrangement between Home and Foreign: a flexible exchange rate with independent monetary policies. (The details of this alternative model are presented in the Appendix.) We then compute the Ramsey-optimal equilibrium with cooperative monetary policies, which, in contrast to the monetary union scenario, features two policy instruments—one for each economy—and allows for long-run differences in inflation rates. As shown in Table 4, the optimal policy results in optimal inflation differentials between Home and Foreign when regulation is asymmetric.[55] In the benchmark case of no price and wage indexation, the optimal inflation target is 0.76 percent at Home (the flexible economy), and 1.14 percent in Foreign. Relative to the Ramsey central bank of the monetary union, Ramsey-optimal cooperative policies increase welfare by an additional 0.06 percent of steady-state consumption.[56,57]

Symmetric market deregulation across countries could therefore further improve policy tradeoffs for the central bank of the monetary union. To address this issue, we consider the scenario in which both countries undertake deregulation of goods and labor markets. Tables 5 summarizes the results. The reduction in optimal long-run inflation is larger with symmetric deregulation—the optimal inflation target falls to 0.75 percent (1.51 percent with price and wage indexation). 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.

## 6 Market 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.

Figure 2 (dashed lines) shows impulse responses to a one percent Home productivity increase under the Ramsey-optimal policy in the presence of high regulation in Home and Foreign. Solid lines present the responses under the historical policy, explained in detail in the Appendix.[58]

[55] By contrast, when the steady state is symmetric, there is no difference between the optimal inflation target in the currency union and the optimal inflation target implied by the Ramsey-cooperative policies under flexible exchange rates. This is the case since, as discussed above, symmetric regulation implies identical real rigidities in Home and Foreign.

[56] For additional comparison, the Appendix presents also results on the welfare effects of reform under a policy of strict price stability (around the optimal target).

[57] The welfare calculations include transitions dynamics following the asymmetric Home deregulation. We do not report impulse responses for brevity. They are available upon request.

[58] The shock has persistence 0.999 and zero cross-country spillover as in the benchmark calibration described in the

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). 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. Opposite responses of employment across countries under the optimal policy are consistent with a standard efficiency incentive to shift production to the more 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. 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.[59]

### Asymmetric Market Deregulation

Figure 3 contrasts the effects of a one percent Home productivity shock before and after Home product and labor 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. In addition, 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.

These effects imply that the employment response to shocks is also muted. 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.[60] (See the Appendix for details.)

---

Appendix. The same assumptions on shock size, persistence, and spillover apply also to Figures 3 and 4 below.

[59] 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.

[60] Cacciatore, Ghironi, and Stebunovs (2015) and Stebunovs (2008) find that bank market integration has business cycle volatility consequences similar to those of product market deregulation by lowering financial barriers to producer

The welfare cost of business cycles falls significantly in the more flexible economy—by approximately 30 percent (Table 5)—while it falls only slightly in the rigid country. This is explained by the 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 4 shows that the Ramsey authority becomes less aggressive, as deregulation—even asymmetric—ameliorates domestic and international policy tradeoffs. At Home, more flexible product and labor markets dampen 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 shifting effect of Ramsey policy is mitigated.[61]

Table 5 shows that deregulation narrows the welfare gap between historical and Ramsey-optimal policy at Home. The welfare gain from Ramsey policy increases slightly in the country that remains rigid.[62] The intuition is straightforward: The flexible economy has less need of an active policy that addresses distortions. The focus of Ramsey-optimal activism correspondingly shifts toward the rigid country, which therefore gains more from optimal policy. To substantiate this intuition, we consider a constrained Ramsey problem in which the monetary authority maximizes the welfare of agents subject to the constraints represented by the competitive economy relations and the historical rule for interest rate setting. Our interest is in determining the optimal weights $\gamma_\pi$ and $\gamma_{\tilde{Y}}$ that define the relative focus of the monetary authority in stabilizing Home inflation and output gap relative to Foreign—recall that the union-wide CPI inflation and GDP gap that appear in the historical interest rate rule are given by: $\tilde{\pi}^U_{C,t} \equiv \tilde{\pi}^{\gamma_\pi}_{C,t}\tilde{\pi}^{*1-\gamma_\pi}_{C,t}$ and $\tilde{Y}^U_{g,t} \equiv \tilde{Y}^{\gamma_{\tilde{Y}}}_{g,t}\tilde{Y}^{*1-\gamma_{\tilde{Y}}}_{g,t}$. Concerning the response coefficients that also appear in the historical rule—$\varrho_i$, $\varrho_\pi$, and $\varrho_Y$—we consider two scenarios: In the first one, we keep $\varrho_i$, $\varrho_\pi$, and $\varrho_Y$ at their calibrated values. In the second one, we determine $\varrho_i$, $\varrho_\pi$, and $\varrho_Y$ optimally jointly with the weights $\gamma_\pi$ and $\gamma_{\tilde{Y}}$.[63] In both scenarios, the optimized rule features a more aggressive response to Foreign output gap fluctuations (which reduces the inefficient volatility of

entry.

[61] The 0.5 percent approximate increase in welfare from implementing optimal monetary policy under high regulation reported in the Introduction is the sum of the long-run welfare gain (0.35) and the gain from reduction in business cycle volatility (0.17, obtained as the difference between the cost of business cycles under historical policy, 0.94, and the cost of business cycles under optimal policy, 0.77).

[62] In the Appendix, we show that deregulation of product or labor market alone has similar implications. However, deregulation of both markets accomplishes the most significant moderation of Home's aggregate fluctuations, and the welfare cost of business cycles under the historical policy is lowest. 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.

[63] We search across a grid of parameter values for the values that minimize the welfare cost of business cycles in (4). We perform the search over the range [0, 10] for each parameter, with fineness equal to 0.01.

Foreign unemployment) and to deviations of Home inflation from trend (which reduces the inefficient volatility of Home markups).[64] Importantly, when the weights $\gamma_\pi$ and $\gamma_{\tilde{Y}}$ and the response coefficients $\varrho_i$, $\varrho_\pi$, and $\varrho_Y$ are jointly optimized, the welfare cost of business cycles is very similar to that implied by the Ramsey-optimal policy.

### Stabilization Policy and International Coordination of Reforms

To what extent can coordination (i.e., synchronization) of market reforms improve policy tradeoffs over the business cycle? 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. To address this issue, we consider again the flexible-exchange rate model discussed in the previous Section and compute the welfare cost of business cycles implied by Ramsey-optimal cooperative monetary policies. Consistent with the intuition above, Table 5 shows that the welfare cost of business cycle falls in both Home and Foreign relative to the optimal policy in the monetary union scenario: Ramsey-optimal cooperative policies with a flexible exchange rate yield an additional welfare gain of 0.08 percent of steady-state consumption (the sum of the gains in Home and Foreign).[65] The flexible Home economy benefits relatively more. This happens because, as discussed above, asymmetric regulation shifts the focus of Ramsey-optimal activism toward the rigid country in the monetary union. Other things equal, this results in inefficient stabilization in the flexible economy. The existence of two optimally designed policy instruments removes this tradeoff.

Our analysis thus suggests that the requirement of convergence toward flexible regulation of product and labor markets across countries should be part of the criteria to be met to join (or form) a currency union. Importantly, symmetric levels of regulation are not sufficient per se. The requirement is that market regulation be symmetric *and* flexible across members of the currency union. This is the case since, as noted above, both countries need monetary policy activism to stabilize unemployment fluctuations when regulation is symmetric and rigid. Since there is a tension between stabilizing the Home and Foreign economies in response to asymmetric shocks, the availability of a single monetary policy instrument results in negative cross-country spillovers over the cycle.[66]

[64] Specifically, in the first case, we find $\gamma_\pi = 1$ and $\gamma_{\tilde{Y}} = 0.25$. In the second scenario, we find $\gamma_\pi = 1$ and $\gamma_{\tilde{Y}} = 0.25$, together with $\varrho_i = 0$, $\varrho_Y = 2.5$, and $\varrho_\pi = 0.5$.

[65] For brevity, we do not present impulse responses. They are available upon request.

[66] As shown in Table 5, when regulation is symmetric and rigid, the optimal cooperative policy under flexible exchange rates results in an additional welfare gain equal to 0.1 percent of steady-state consumption (relative to the Ramsey-optimal policy in the monetary union). The gain falls to 0.06 percent of steady-state consumption when both countries have deregulated their markets.

To conclude, 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.

## 7 Conclusions

We studied the implications of structural reforms 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. Expansionary monetary policy can reduce transition costs and front-load the benefits of reforms by generating lower markups and stimulating job creation in the aftermath of deregulation. This finding provides support for the narrative of policymakers (Draghi, 2015, among others) and for the recurrent argument in policy discussions that supply-side policies should be accompanied by active policies supporting aggregate demand (see, for instance, Barkbu, Rahman, Valdés, and Staff, 2012). 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. There is an important 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.

From a methodological standpoint, a contribution of this paper was to clarify the importance of explicitly modeling micro-level product and labor market dynamics in analyses of the macroeconomic and policy implications of structural reforms.

## References

[1] Adão, B., I. Correia, and P. Teles (2003): "Gaps and Triangles," *Review of Economic Studies* 70: 699-713.

[2] Alessandria, G., and A. Delacroix (2008): "Trade and the (Dis)Incentive to Reform Labor Markets: The Case of Reform in the European Union," *Journal of International Economics* 75: 151-166.

[3] Andolfatto, D. (1996): "Business Cycles and Labor-Market Search," *American Economic Review* 86: 112-132.

[4] Andrés, J., Ó. Arce, and C. Thomas (2014): "Structural Reforms in a Debt Overhang," mimeo, University of Valencia and Banco de España.

[5] Aoki, K. (2001): "Optimal Monetary Policy Responses to Relative Price Changes," *Journal of Monetary Economics* 48: 55-80.

[6] Arsenau, D. M., and S. K. Chugh (2012): "Tax Smoothing in Frictional Labor Markets," *Journal of Political Economy* 120: 926-985.

[7] Arsenau, D. M., and S. K. Chugh (2008): "Optimal Fiscal and Monetary Policy with Costly Wage Bargaining," *Journal of Monetary Economics* 55: 1401-1414.

[8] Ascari, G., N. Branzoli, and E. Castelnuovo (2011): "Trend Inflation, Wage Indexation, and Determinacy in the U.S.," Quaderni di Dipartimento #276 (10-11), University of Pavia.

[9] Backus, D. K., P. J. Kehoe, and F. E. Kydland (1992): "International Real Business Cycles," *Journal of Political Economy* 100: 745-775.

[10] Backus, D. K., P. J. Kehoe, and F. E. Kydland (1994): "Dynamics of the Trade Balance and the Terms of Trade: The J Curve?" *American Economic Review* 84: 84-103.

[11] Barkbu, B., J. Rahman, R. Valdés, and Staff (2012): "Fostering Growth in Europe Now," IMF Staff Discussion Note 12/07.

[12] Barseghyan, L., and R. DiCecio (2011): "Entry Costs, Industry Structure, and Cross-Country Income and TFP Differences," *Journal of Economic Theory* 106: 1828-1851.

[13] Baxter, M. (1995): "International Trade and Business Cycles," in Grossman, G. M., and K. Rogoff, eds., *Handbook of International Economics*, vol. 3, Elsevier, Amsterdam, pp. 1801-1864.

[14] Baxter, M., and D. D. Farr (2005): "Variable Factor Utilization and International Business Cycles," *Journal of International Economics* 65: 335-347.

[15] Benigno, P. (2004): "Optimal Monetary Policy in a Currency Area," *Journal of International Economics* 63: 293-320.

[16] Benigno, P. (2009): "Price Stability with Imperfect Financial Integration," *Journal of Money, Credit and Banking* 41: 121-149.

[17] Benigno, P., and M. Woodford (2005): "Inflation Stabilization and Welfare: The Case of a Distorted Steady State," *Journal of the European Economic Association* 3: 1185-1236.

[18] Bergin, P. R., and G. Corsetti (2008): "The Extensive Margin and Monetary Policy," *Journal of Monetary Economics* 55: 1222-1237.

[19] Bergin, P. R., and G. Corsetti (2013): "International Competitiveness and Monetary Policy: Strategic Policy and Coordination with a Production Relocation Externality," *mimeo*, University of California, Davis and Cambridge University.

[20] Bergin, P. R., and R. C. Feenstra (2000): "Staggered Price Setting and Endogenous Persistence," *Journal of Monetary Economics* 45: 657-680.

[21] Bergin, P. R., and R. C. Feenstra (2001): "Pricing-to-Market, Staggered Contracts, and Real Exchange Rate Persistence," *Journal of International Economics* 54: 333-359.

[22] Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003): "Plants and Productivity in International Trade," *American Economic Review* 93: 1268-1290.

[23] Bernard, A. B., S. J. Redding, and P. K. Schott (2010): "Multi-Product Firms and Product Switching," *American Economic Review* 100: 70-97.

[24] Bilbiie, F. O., I. Fujiwara, and F. Ghironi (2014): "Optimal Monetary Policy with Endogenous Entry and Product Variety," *Journal of Monetary Economics* 64: 1-20.

[25] Bilbiie, F. O., F. Ghironi, and M. J. Melitz (2012): "Endogenous Entry, Product Variety and Business Cycles," *Journal of Political Economy* 120: 304-345.

[26] Bilbiie, F. O., F. Ghironi, and M. J. Melitz (2008a): "Monetary Policy and Business Cycles with Endogenous Entry and Product Variety," in Acemoglu, D., K. S. Rogoff, and M. Woodford, eds., *NBER Macroeconomics Annual 2007*, University of Chicago Press, Chicago, IL, pp. 299-353.

[27] Bilbiie, F. O., F. Ghironi, and M. J. Melitz (2008b). "Monopoly Power and Endogenous Product Variety: Distortions and Remedies." NBER WP 14383.

[28] Blanchard, O. J., and P. A. Diamond (1989): "The Beveridge Curve," *Brookings Papers on Economic Activity* 20: 1-76.

[29] Blanchard, O. J., and F. Giavazzi (2003): "Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets," *Quarterly Journal of Economics* CXVIII: 879-907.

[30] Blanchard, O. J., and J. Galí (2010): "Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment," *American Economic Journal: Macroeconomics* 2: 1-30.

[31] Broda, C., and D. E. Weinstein (2010): "Product Creation and Destruction: Evidence and Price Implications," *American Economic Review* 100: 691-723.

[32] Cacciatore, M. (2014): "International Trade and Macroeconomic Dynamics with Labor Market Frictions," *Journal of International Economics* 93: 17-30.

[33] Cacciatore, M., and G. Fiori (2010): "The Macroeconomic Effects of Goods and Labor Markets Deregulation," *mimeo*, HEC Montréal and North Carolina State University.

[34] Cacciatore, M., and F. Ghironi (2012): "Trade, Unemployment, and Monetary Policy," *mimeo*, HEC Montréal and Boston College.

[35] Cacciatore, M., F. Ghironi, and V. Stebunovs (2015): "The Domestic and International Effects of Interstate U.S. Banking," *Journal of International Economics* 95: 171-187.

[36] Calvo, G. A. (1983): "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics* 12: 383-398.

[37] Card, D.(1994): "Intertemporal Labor Supply: An Assessment," in Sims, C., ed., *Advances in Econometrics*, Sixth World Congress, Cambridge University Press, New York, NY.

[38] Chugh, S. K., and F. Ghironi (2015): "Optimal Fiscal Policy with Endogenous Product Variety," CEPR DP 10674.

[39] Collard, F., and H. Dellas (2002): "Exchange Rate Systems and Macroeconomic Stability," *Journal of Monetary Economics* 49: 571-599.

[40] Corsetti, G., L. Dedola, and S. Leduc (2010): "Optimal Monetary Policy in Open Economies," in Friedman, B., and M. Woodford, eds., *Handbook of Monetary Economics*, vol. 3B, Elsevier, Amsterdam, pp. 861-933.

[41] Corsetti, G., P. Martin, and P. Pesenti (2013): "Varieties and the Transfer Problem," *Journal of International Economics* 89: 1-12.

[42] Dawson, J. W., and J. J. Seater (2011): "Federal Regulation and Aggregate Economic Growth," *mimeo*, Appalachian State University and North Carolina State University.

[43] Diamond, P. A. (1982a): "Wage Determination and Efficiency in Search Equilibrium," *Review of Economic Studies* 49: 217-227.

[44] Diamond, P. A. (1982b): "Aggregate Demand Management in Search Equilibrium," *Journal of Political Economy* 90: 881-894.

[45] Dixit, A. K., and J. E. Stiglitz (1977): "Monopolistic Competition and Optimum Product Diversity," *American Economic Review* 67: 297-308.

[46] Draghi, M. (2015): "Structural Reforms, Inflation and Monetary Policy," Introductory Speech, ECB Forum on Central Banking, Sintra, May 22, 2015.

[47] Ebell, M., and C. Haefke (2009): "Product Market Deregulation and the U.S. Employment Miracle," *Review of Economic Dynamics* 12: 479-504.

[48] ECB (2002): "Labor Market Mismatches in the Euro Area," European Central Bank.

[49] Eggertsson, G., A. Ferrero, and A. Raffo (2014): "Can Structural Reforms Help Europe?" *Journal of Monetary Economics* 61: 2-22.

[50] Erceg, C. J., D. W. Henderson, and A. T. Levin (2000): "Optimal Monetary Policy with Staggered Wage and Price Contracts," *Journal of Monetary Economics* 46: 281-313.

[51] Faia, E. (2009): "Ramsey Monetary Policy with Labor Market Frictions," *Journal of Monetary Economics* 56: 570-581.

[52] Faia, E. (2012): "Oligopolistic Competition and Optimal Monetary Policy," *Journal of Economic Dynamics and Control* 36: 1760-1774.

[53] Feenstra, R. C. (1994): "New Product Varieties and the Measurement of International Prices," *American Economic Review* 84: 157-177.

[54] Feenstra, R. C. (2003a): "A Homothetic Utility Function for Monopolistic Competition Models, without Constant Price Elasticity," *Economics Letters* 78: 79-86.

[55] Feenstra, R. C. (2003b): *Advanced International Trade: Theory and Evidence*, Princeton University Press, Princeton, NJ.

[56] Felbermayr, G., and J. Prat (2011): "Product Market Regulation, Firm Selection, and Unemployment," *Journal of the European Economic Association* 9: 278-317.

[57] Fernández-Villaverde, J., P. A. Guerrón-Quintana, and J. Rubio-Ramírez (2011): "Supply-Side Policies and the Zero Lower Bound," NBER WP 17543.

[58] Fiori, G., G. Nicoletti, S. Scarpetta, and F. Schiantarelli (2012): "Employment Outcomes and the Interaction between Product and Labor Market Deregulation: Are They Substitutes or Complements?" *Economic Journal* 122: F79-F104.

[59] Flinn, C. J. (2006): "Minimum Wage Effects on Labor Market Outcomes under Search, Bargaining, and Endogenous Contact Rates," *Econometrica* 74: 1013-1062.

[60] Gerali, A., A. Notarpietro, and M. Pisani (2015): "Structural Reforms and Zero Lower Bound in a Monetary Union," Temi di Discussione 1002, Bank of Italy.

[61] Gerdesmeier, D., and B. Roffia (2003): "Empirical Estimates of Reaction Functions for the Euro Area," ECB WP 206.

[62] Gertler, M., L. Sala, and A. Trigari (2008): "An Estimated Monetary DSGE Model with Unemployment and Staggered Nominal Wage Bargaining," *Journal of Money, Credit and Banking* 40: 1713-1764.

[63] Gertler, M., and A. Trigari (2009): "Unemployment Fluctuations with Staggered Nash Wage Bargaining," *Journal of Political Economy* 117: 38-86.

[64] Ghironi, F., and M. J. Melitz (2005): "International Trade and Macroeconomic Dynamics with Heterogeneous Firms," *Quarterly Journal of Economics* CXX: 865-915.

[65] Griffith, R., R. Harrison, and G. Maccartney (2007): "Product Market Reforms, Labour Market Institutions and Unemployment," *Economic Journal* 117: 142-166.

[66] Haltiwanger, J., S. Scarpetta, and H. Schweiger (2008): "Assessing Job Flows Across Countries: The Role of Industry, Firm Size and Regulations," NBER WP 13920.

[67] Hamano, M. (2015): "International Equity and Bond Positions in a DSGE Model with Variety Risk in Consumption," *Journal of International Economics* 96: 212-226.

[68] Hobijn, B., and A. Şahin (2009): "Job-Finding and Separation Rates in the OECD," *Economics Letters* 104: 107-111.

[69] Hopenhayn, H. and R. Rogerson (1993): "Job Turnover and Policy Evaluation: A General Equilibrium Analysis," *Journal of Political Economy* 5: 915-38.

[70] Juillard, M. (1996): "Dynare: A Program for the Resolution and Simulation of Dynamic Models with Forward Variables through the Use of a Relaxation Algorithm," CEPREMAP WP 9602.

[71] Khan, A., R. G. King, and A. L. Wolman (2003): "Optimal Monetary Policy," *Review of Economic Studies* 70: 825-860.

[72] Krause, M. U., and T. A. Lubik (2007): "The (Ir)Relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions," *Journal of Monetary Economics* 54: 706-727.

[73] Laffargue, J.-P. (1990): "Résolution d'un Modèle Macroéconomique avec Anticipations Rationnelles," *Annales d'Economie et de Statistique* 17.

[74] Lewis, V. (2013): "Optimal Monetary Policy and Firm Entry," *Macroeconomic Dynamics* 17: 1687-1710.

[75] Lucas, R. E. Jr., and N. L. Stokey (1983): "Optimal Fiscal and Monetary Policy in an Economy Without Capital," *Journal of Monetary Economics* 12: 55-93.

[76] Martin, J., and I. Méjean (2013): "Price Dispersion and the Euro: Micro Heterogeneity and Macro Implications," *International Review of Economics and Finance* 26: 70-86.

[77] Messina, J., and G. Vallanti (2007): "Job Flow Dynamics and Firing Restrictions: Evidence from Europe," *Economic Journal* 117: 279-301.

[78] Merz, M. (1995): "Search in the Labor Market and the Real Business Cycle," *Journal of Monetary Economics* 36: 269-300.

[79] Mortensen, D. T., and C. A. Pissarides (1994): "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies* 61: 397-415.

[80] Obstfeld, M., and K. Rogoff (1995): "Exchange Rate Dynamics Redux," *Journal of Political Economy* 103: 624-660.

[81] OECD (2004): *Employment Outloook*, Organisation for Economic Co-operation and Development.

[82] Petrongolo, B., and C. A. Pissarides (2006): "Scale Effects in Markets with Search," *Economic Journal* 116: 21-44.

[83] Pissarides, C. A. (2003): "Company Startup Costs and Employment," in Aghion, P., R. Frydman, J. Stiglitz, and M. Woodford, eds., *Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps*, Princeton University Press, Princeton, NJ, pp. 479-504.

[84] Rotemberg, J. J. (1982): "Monopolistic Price Adjustment and Aggregate Output," *Review of Economic Studies* 49: 517-531.

[85] Sibert, A., and A. Sutherland (2000): "Monetary Union and Labor Market Reform," *Journal of International Economics* 51: 421-435.

[86] Stebunovs, V. (2008): "Finance as a Barrier to Entry: U.S. Bank Deregulation and Business Cycles," *mimeo*, Board of Governors of the Federal Reserve System.

[87] Taylor, J. B. (1993): "Discretion vs. Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.

[88] Thomas, C. (2008): "Search and Matching Frictions and Optimal Monetary Policy," *Journal of Monetary Economics* 55: 936-956.

[89] Thomas, C. and F. Zanetti (2009): "Labor Market Reform and Price Stability: An Application to the Euro Area," *Journal of Monetary Economics* 56: 885-899.

[90] Trigari, A. (2009): "Equilibrium Unemployment, Job flows and Inflation Dynamics," *Journal of Money, Credit and Banking* 41: 1-33.

[91] Turnovsky, S. J. (1985): "Domestic and Foreign Disturbances in an Optimizing Model of Exchange Rate Determination," *Journal of International Money and Finance* 4: 151-171.

[92] Weber, A. (2000): "Vacancy Durations—A Model for Employer's Search," *Applied Economics* 32: 1069-1075.

[93] Woodford, M. (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, Princeton, NJ.

[94] Yun, T. (1996): "Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles," *Journal of Monetary Economics* 37: 345-370.

[95] Zanetti, F. (2011): "Labor Market Institutions and Aggregate Fluctuations in a Search and Matching Model," *European Economic Review* 55: 644-658.

0.5

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) |
| $\frac{w_t}{P_t}h_t=\eta_{w,t}\left(\frac{v(h_t)}{u_{C,t}}+b\right)+(1-\eta_{w,t})\left(\varphi_tZ_th_t-\frac{\vartheta}{2}\pi^2_{w,t}\right)$ <br> $+E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_{w,t})-(1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\}$ | (11) |
| $\frac{w^*_t}{P^*_t}h^*_t=\eta^*_{w,t}\left(\frac{v(h^*_t)}{u_{C^*,t}}+b^*\right)+(1-\eta^*_{w,t})\left(\varphi^*_tZ^*_th^*_t-\frac{\vartheta}{2}\pi^{*2}_{w,t}\right)$ <br> $+E_t\left\{\beta^*_{t,t+1}J^*_{t+1}\left[(1-\lambda)(1-\eta^*_{w,t})-(1-\lambda-\iota^*_t)(1-\eta^*_{w,t+1})\frac{\eta^*_{w,t}}{\eta^*_{w,t+1}}\right]\right\}$ | (12) |
| $v_{h,t}/u_{C,t}=\varphi_tZ_t$ | (13) |
| $v_{h^*,t}/u_{C^*,t}=\varphi^*_tZ^*_t$ | (14) |
| $(1+\pi_{w,t})=\frac{w_t/P_t}{w_{t-1}/P_{t-1}}(1+\pi_{C,t})$ | (15) |
| $\left(1+\pi^*_{w,t}\right)=\frac{w^*_t/P^*_t}{w^*_{t-1}/P^*_{t-1}}\left(1+\pi^*_{C,t}\right)$ | (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) |
| $1+\tau a_{t+1}=(1+i_{t+1})E_t\left(\beta_{t,t+1}\frac{1}{1+\pi_{C,t+1}}\right)$ | (18) |
| $1-\tau Q_ta_{t+1}=(1+i_{t+1})E_t\left(\beta^*_{t,t+1}\frac{1}{1+\pi^*_{C,t+1}}\right)$ | (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: OPTIMAL LONG-RUN INFLATION

| | Trend Inflation | | | | | |
|---|---|---|---|---|---|---|
| | *Status Quo* | | *Asymmetric* | | *Symmetric* | |
| | Home | Foreign | Home | Foreign | Home | Foreign |
| *No Indexation* | | | | | | |
| Ramsey MU | 1.15 | 1.15 | 0.97 | 0.97 | 0.75 | 0.75 |
| Ramsey Coop | 1.15 | 1.15 | 0.76 | 1.14 | 0.75 | 0.75 |
| *Price Indexation* ($\iota_p = 1$) | | | | | | |
| Ramsey MU | 1.19 | 1.19 | 0.97 | 0.97 | 0.71 | 0.71 |
| Ramsey Coop | 1.19 | 1.19 | 0.72 | 1.17 | 0.71 | 0.71 |
| *Wage Indexation* ($\iota_w = 1$) | | | | | | |
| Ramsey MU | 1.10 | 1.10 | 1.01 | 1.01 | 0.91 | 0.91 |
| Ramsey Coop | 1.10 | 1.10 | 0.92 | 1.09 | 0.91 | 0.91 |
| *Price and Wage Indexation* ($\iota_p = \iota_w = 0.5$) | | | | | | |
| Ramsey MU | 2.31 | 2.31 | 1.94 | 1.94 | 1.51 | 1.51 |
| Ramsey Coop | 2.31 | 2.31 | 1.53 | 2.29 | 1.51 | 1.51 |

Note: Ramsey MU ≡ Optimal Policy in the Monetary Union;

Ramsey Coop ≡ Optimal Cooperative Policy With A Flexible Exchange Rate;

Asymmetric ≡ Home Country Product and Labor Market Reform;

Symmetric ≡ Home and Foreign Country Product and Labor Market Reform.

Table 5: WELFARE EFFECTS OF REFORMS

| Market Reform | ΔWelfare | | | | | |
|---|---|---|---|---|---|---|
| | *Hist* | | *Ramsey MU* | | *Ramsey Coop* | |
| | Home | Foreign | Home | Foreign | Home | Foreign |
| *Status Quo* | | | 0.35 | 0.35 | 0.35 | 0.35 |
| *Asymmetric* | 7.40 | 0.45 | 7.45 | 0.70 | 7.49 | 0.72 |
| *Symmetric* | 7.78 | 7.78 | 7.83 | 7.83 | 7.83 | 7.83 |
| | Welfare Cost of Business Cycles | | | | | |
| | *Hist* | | *Ramsey MU* | | *Ramsey Coop* | |
| | Home | Foreign | Home | Foreign | Home | Foreign |
| *Status Quo* | 0.94 | 0.94 | 0.77 | 0.77 | 0.72 | 0.72 |
| *Asymmetric* | 0.62 | 0.93 | 0.54 | 0.74 | 0.49 | 0.71 |
| *Symmetric* | 0.62 | 0.62 | 0.52 | 0.52 | 0.49 | 0.49 |

Note: Hist ≡ Historical Monetary Policy;

Ramsey MU ≡ Ramsey-Optimal Policy in the Monetary Union;

Ramsey Coop ≡ Ramsey-Optimal Cooperative Policy With Flexible Exchange Rate;

Asymmetric ≡ Home Country Product and Labor Market Reform;

Symmetric ≡ Home and Foreign Country Product and Labor Market Reform;

ΔWelfare ≡ Welfare change.

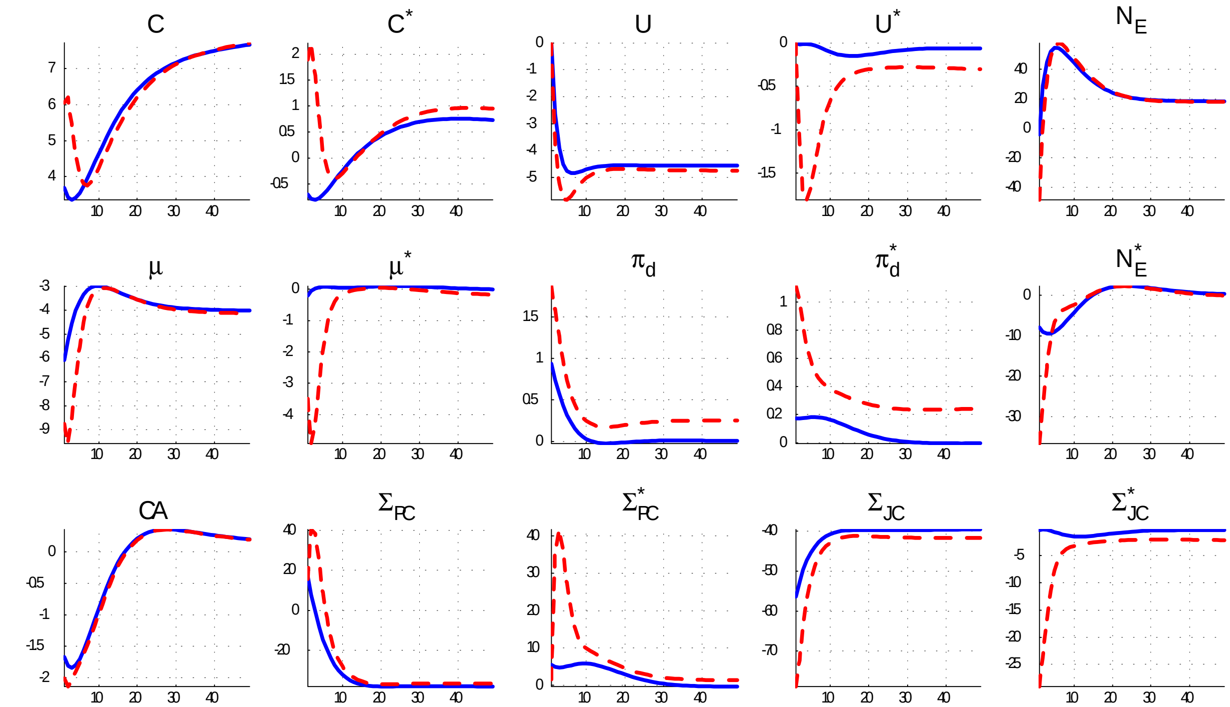


Figure 1. Home product and labor market reform, historical policy (continuous lines) versus Ramsey-optimal policy (dashed lines). Responses show percentage deviations from the high-regulation steady state under historical policy (zero steady-state inflation). Unemployment and inflation are in deviations from the steady state.

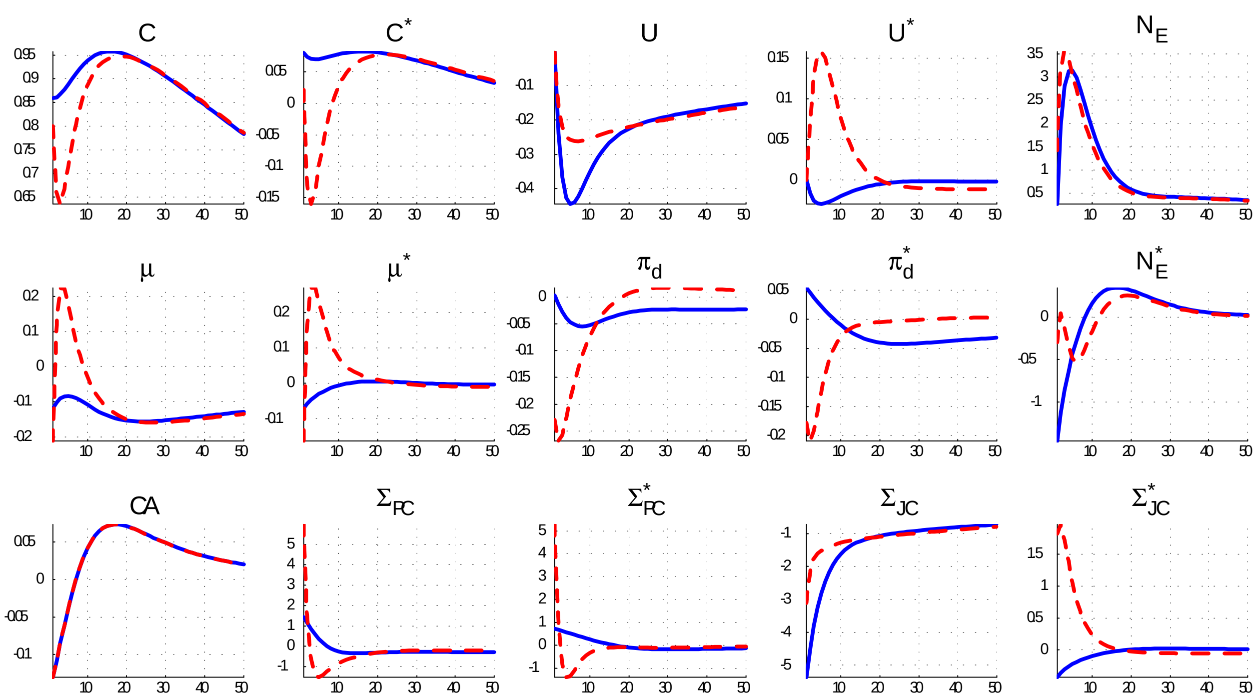


Figure 2. Home productivity shock with high regulation, historical policy (continuous lines) versus Ramsey-optimal policy (dashed lines). Responses show percentage deviations from the respective steady state. Unemployment and inflation are in deviations from the steady state.

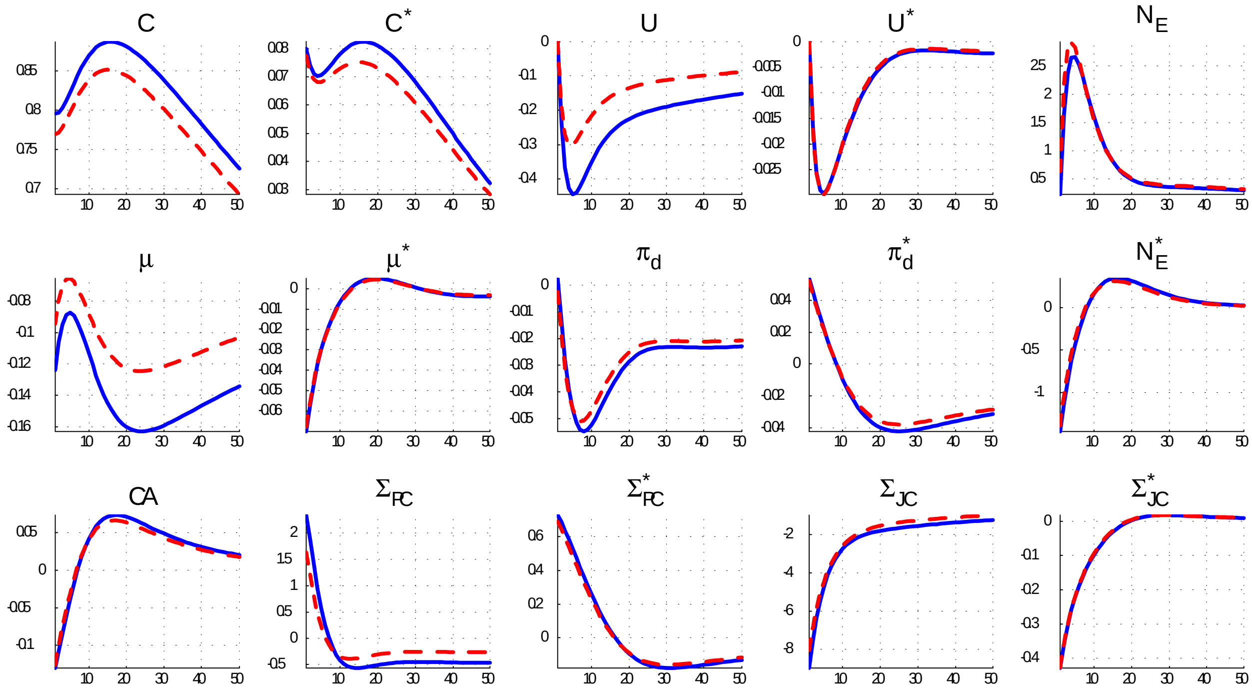


Figure 3. Home productivity shock, historical policy with high regulation (continuous lines) versus low regulation (dashed lines). Responses show percentage deviations from the zero-inflation steady state. Unemployment and inflation are in deviations from the steady state.

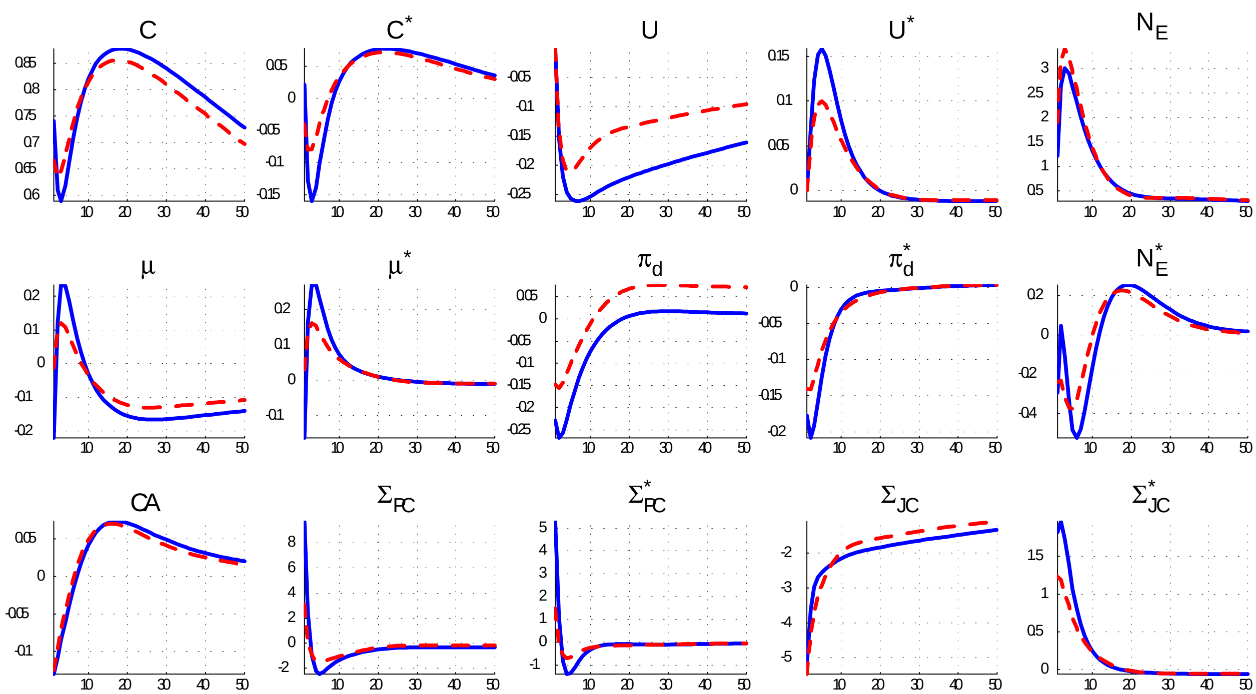


Figure 4. Home productivity shock, Ramsey-optimal policy with high regulation (continuous lines) versus low regulation (dashed lines). Responses show percentage deviations from the Ramsey steady state. Unemployment and inflation are in deviations from the steady state.