The Domestic and International Effects of Euro Area Market Reforms*

Matteo Cacciatore† HEC Montréal

Giuseppe Fiori‡ North Carolina State University

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

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Abstract

What will be the internal and external effects of euro area market reforms? Will increased market flexibility in Europe affect incentives for the conduct of macroeconomic policy by European policymakers and their partners? We address these questions in a two-country model with heterogeneous plants, endogenous producer entry, and labor market frictions. We interpret the two countries in our model as the euro area and the United States. We find that market reforms in the euro area will result in increased producer entry and lower unemployment on both sides of the Atlantic, but a worse European external balance, at least for some time. With high market regulation in the euro area, optimal monetary policy requires significant departures from price stability both in the long run and over the business cycle, and a higher inflation target in the euro area than in the U.S. The adjustment to market reforms requires expansionary monetary policy, and more expansion in reforming Europe than in the already flexible U.S. However, deregulation reduces static and dynamic inefficiencies, making price stability more desirable everywhere once the transition is complete.

JEL Codes: E24; E32; E52; F41; J64; L51.

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†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.

1 Introduction

It is frequently argued in policy circles that market reforms—or "structural" reforms—that facilitate product creation and enhance labor market flexibility would be beneficial for rigid economies, such as those of poorly performing euro area countries. The spotlight has been shining particularly bright on this argument since 2008, with the beginning of a wave of crises that rocked the world economy.[1] The argument is that more flexible markets would foster a more rapid recovery from recessions and, in general, would result in better economic performance. Deregulation of product markets would accomplish this by 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.[2]

In this paper, we make a start at exploring the implications of changes in the market structure of large economies, such as the euro area, for the global economy. The issue is intuitively relevant, as the implementation of market reforms that will alter important characteristics of a wide set of European countries will have effects that extend beyond the boundaries of Europe. For instance, if the euro area becomes a more favorable environment for business creation, how will this affect incentives for this activity not just in Europe, but also in its partners? What will happen to relative prices and imbalances between the euro area and the rest of the world? Moreover, if reforms in Europe have significant international effects, in addition to domestic ones, they will have consequences for the conduct of macroeconomic policy in Europe and outside. How will increased European flexibility affect macroeconomic policy incentives of European policymakers and their partners?

We address these questions by studying the consequences of market reforms in a two-country, New Keynesian model with heterogeneous firms, endogenous producer entry, and labor market frictions. The model is developed in detail in Cacciatore and Ghironi (2012). It builds on Ghironi and Melitz's (2005) model of international trade and macroeconomic dynamics with heterogeneous firms and Cacciatore's (2014) extension to incorporate search-and-matching labor market frictions as in Diamond (1982a,b) and Mortensen and Pissarides (1994)—henceforth, DMP. Cacciatore and Ghironi (2012) augment the framework by introducing sticky prices and wages—and a role for

[1] One only needs to read the statements by European Central Bank President Mario Draghi since 2011 for confirmation that calls for deregulation of product and labor markets have become a mantra at the highest levels of policymaking.

[2] In the recent literature, see, for instance, Bertinelli, Cardi, and Sen (2013), Blanchard and Giavazzi (2003), Cacciatore and Fiori (2010), Dawson and Seater (2011), Ebell and Haefke (2009), Felbermayr and Prat (2011), Fiori et al. (2012), Griffith, Harrison, and Macartney (2007), and Messina and Vallanti (2007).

monetary policy—to study the consequences of trade integration for monetary policymaking. Here, we focus on market reforms.

We interpret the countries in our model as the euro area and the United States, and we show that market reforms in Europe result in increased producer entry and lower unemployment on both sides of the Atlantic, but a worse European external balance, at least for some time. By putting upward pressure on labor costs, producer entry in Europe implies stronger terms of trade during much of the transition. A joint reform of both product and labor markets in the euro area causes the unemployment rate to fall on both sides of the Atlantic, but more so in Europe, and it has reallocation effects across euro area producers in line with arguments in the policy discussions: The reform implies an increase in average export productivity and a decrease in employment at less productive, non-exporting firms. Conversely, average export productivity falls in the U.S., as rising euro area imports imply that less efficient U.S. firms begin exporting, and average employment rises in the short and medium term at U.S. firms that sell only domestically.

When European markets are rigid, optimal policy requires significant departures from price stability both in the long run and over the business cycle—and more active policy and a higher inflation target in the euro area than in the U.S. The adjustment to market reforms requires expansionary policy to reduce transition costs and front-load long-run gains. Optimal policy is expansionary on both sides of the Atlantic, but more so in the euro area. Importantly, deregulation reduces static and dynamic inefficiencies in the euro area, and this makes price stability more desirable in both Europe and the United States once the transition is complete. Ramsey-optimal cooperative monetary policy—the model's rendering of monetary coordination between the European Central Bank (ECB) and the Federal Reserve—maximizes the benefits of European market reforms globally, with non-negligible welfare gains relative to historical monetary policy behavior.[3]

These results can be understood by considering the distortions that characterize the market world economy of our model relative to the social optimum. Optimal policy uses inflation to narrow inefficiency wedges relative to the efficient allocation along the economies' distorted margins of adjustment: product creation, job creation, labor supply, and risk sharing. For instance, positive long-run inflation pushes job creation closer to the efficient level by eroding markups and reducing worker bargaining power in the presence of sticky wages. Market reform reduces the need for inflation to accomplish this. Over time, reforms result in an endogenous increase in both the

[3] We follow Sims (2007) in considering historical behavior a more realistic benchmark for comparison than optimal, non-cooperative policies.

number of producers and average productivity in the euro area. Even if, depending on the type of reform, employment by the average producer may fall as more productive incumbents require less labor to produce the same amount of output, increased labor demand from a larger number of new entrants and expansion in the total number of producers imply lower aggregate unemployment. Employment is pushed toward the efficient level, and this reduces the need for average inflation to accomplish this goal.[4] The incentive to use inflation over the business cycle is similarly determined by the tradeoffs across domestic and international distortions (which imply more active monetary policy in the relatively more distorted economy).

The paper contributes to the literature on the consequences of market reforms by bringing an explicit international perspective to the topic and by studying the implications of reforms for monetary policy. The literature on the effects of deregulating product and/or labor markets has focused so far on closed-economy environments.[5] The connection between supply-side policies—such as market reforms—and demand-side macro policy is a novel topic of exploration in policy and academic circles.[6] In an IMF Staff Discussion Note, Barkbu et al. (2012) discuss the effects of market reforms in Europe and argue for these supply-side policies to be accompanied by active policies supporting aggregate demand. Cacciatore, Fiori, and Ghironi (2013) study the consequences of deregulating product and labor markets for optimal monetary policy in a two-country monetary-union model that does not feature producer heterogeneity, endogenous determination of the trade pattern, and the reallocation effects across producers that are present in this paper. Eggertsson, Ferrero, and Raffo (2014) and Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez (2011) focus on the consequences of the zero lower bound on interest rates for monetary policy in the aftermath of market reforms.[7] We expand this literature to the more general scenario of two countries that are not constrained to sharing the same currency, and whose trade pattern is determined endogenously. By highlighting the reallocation and productivity effects of reforms, we connect the literature on market reforms and macroeconomic policy to a vast literature on resource allocation

[4] See Pissarides and Vallanti (2007) for evidence that higher productivity is associated with lower unemployment in the long run.

[5] Cacciatore, Ghironi, and Stebunovs (2015) study the domestic and international effects of reforms in the structure of U.S. banking, highlighting the consequences that these reforms had by creating a more favorable environment for business creation in the U.S.

[6] To appreciate the importance of this topic for policymakers, one only needs to read Draghi (2015).

[7] Both these papers do not feature producer entry dynamics and search-and-matching labor market frictions. They treat reforms as exogenous reductions in price and wage markups, which have deflationary consequences and automatically cause terms of trade depreciation and external surplus. By contrast, product and labor market reforms have inflationary effects in Cacciatore, Fiori, and Ghironi (2013), as increased business creation and higher labor demand put upward pressure on wages. These mechanisms generate terms of trade appreciation and external deficit.

and productivity, much of which focuses on taxes as a key source of inefficiency.[8]

The paper also contributes to the literature on optimal monetary policy in models with endogenous producer entry and product creation. In addition to Cacciatore, Fiori, and Ghironi (2013), examples of this literature include Bergin and Corsetti (2008, 2014), Bilbiie, Fujiwara, and Ghironi (2014), Etro and Rossi (2015), Faia (2012), and Lewis (2013). Most of these papers focus on closed-economy models.[9] Besides our own work, Bergin and Corsetti (2014) is a notable exception. They focus on the role of a "production relocation externality" in shaping incentives for monetary policymaking in a two-country model with two consumption sectors in each country. Their key result is that optimal monetary policy, while helping differentiated good producers set low prices for competitive purposes (the standard argument for monetary expansion in response to recessions in open economies) also results in appreciation of the country's effective terms of trade as a consequence of production relocation across countries and sectors. Our model does not feature this channel and places more attention on relocation across heterogeneous producers within the final consumption sector—a channel that is absent from Bergin and Corsetti's analysis.[10,11]

Finally, the paper is related to the vast literature on monetary transmission and optimal monetary policy in New Keynesian macroeconomic models.[12] In particular, we contribute to the strand of this literature that incorporates labor market frictions, such as Arseneau and Chugh (2008), Faia (2009), and Thomas (2008), and to the literature on price stability in open economies (Benigno and Benigno, 2003 and 2006, Catão and Chang, 2012, Dmitriev and Hoddenbagh, 2012, Galí and Monacelli, 2005, and many others) by studying hitherto unexplored mechanisms that affect monetary policy incentives in the international economy.

The rest of the paper is organized as follows. Section 2 presents the model and the scenarios we consider for monetary policy. Section 3 discusses the sources of inefficiency that characterize our model world economy. Section 4 presents the calibration of the model and its properties in relation

[8] See Restuccia and Rogerson (2013) and references therein. Fattal Jaef (2014) is a recent contribution to this literature that focuses on the consequences of taxes and subsidies. See also Gopinath et al. (2015).

[9] Auray and Eyquem (2011) and Cavallari (2013) study the role of monetary policy for shock transmission in two-country versions of the model in Bilbiie, Ghironi, and Melitz (2008a), but they do not analyze optimal monetary policy.

[10] While productivity is the source of heterogeneity across producers in our model, Cavallari and D'Addona (2015) extend Cavallari (2013) to incorporate heterogeneous trade costs as in Bergin and Glick (2009) and to model endogenous selection of firms into exporting through this channel. The extended model is used to explain the evidence of a significant role of the extensive margin of export in the adjustment to shocks.

[11] A growing literature has also begun studying fiscal policy in models with endogenous producer entry. Examples include Bilbiie, Ghironi, and Melitz (2008b), Chugh and Ghironi (2015), Colciago (2015), Devereux, Head, and Lapham (1996), and Lewis and Winkler (2015a,b).

[12] See Corsetti, Dedola, and Leduc (2010), Galí (2008), Schmitt-Grohé and Uribe (2010), Walsh (2010), Woodford (2003), and references therein.

to standard international business cycle moments. Section 5 studies the domestic and international effects of market reforms and their implications for monetary policy. Section 6 concludes.

2 The Model

The results in this paper are obtained using the model developed in Cacciatore and Ghironi (2012). We describe the model below, but we refer readers to that paper for details and derivations that we omit.

The model features two countries, Home and Foreign. In the equations we present below, we denote foreign variables with a superscript star. We focus on the Home economy in our description, with the understanding that everything is similar in Foreign.

Households and Preferences

Each country is populated by a unit mass of atomistic households. In turn, each household has a continuum of members on the unit interval. In equilibrium, some members are unemployed, while others are employed. As common in the literature on search-and-matching frictions in labor markets, we assume perfect insurance within the household, so that there is no *ex post* heterogeneity across members.

The representative Home household maximizes the expected intertemporal utility function

$$E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \left[u(C_s) - l_s v(h_s) \right] \right\}, \tag{1}$$

where $\beta \in (0,1)$, C_t is consumption of a basket of goods, h_t is labor effort, and l_t is the number of employed household members. The functions $u(\cdot)$ and $v(\cdot)$ satisfy the standard assumptions. Although nominal rigidity will imply that there is a role for monetary policy in our model, we abstract from assumptions—such as money in the utility functions—that would motivate a demand for cash currency in each country, and we resort to a cashless economy.

The consumption basket C_t aggregates Home and Foreign sectoral consumption outputs $C_t(n)$ in continuous Dixit-Stiglitz (1977) fashion with elasticity of substitution $\phi > 1$. Given the nominal price index $P_t(n)$ for sector n (expressed in Home currency), this implies the standard consumption-based price index $P_t = \left[\int_0^1 P_t(n)^{1-\phi} dn \right]^{\frac{1}{1-\phi}}$.

Production

Production occurs in two vertically integrated production sectors in each country. In the upstream sector, perfectly competitive firms use labor to produce a non-tradable intermediate input. In the downstream sector, each consumption-producing sector n is populated by a representative monopolistically competitive, multi-product firm that purchases the intermediate input and produces its sectoral output. This consists of a bundle of differentiated product varieties—or product features. In equilibrium, some of these varieties are exported while the others are sold only domestically.

Intermediate Sector

There is a unit mass of intermediate producers in each country. The representative firm in this sector produces output according to the function

$$y_t^I = Z_t l_t h_t, \tag{2}$$

where Z_t is exogenous aggregate productivity. Home productivity and its Foreign counterpart, Z_t^*, follow a bivariate $AR(1)$ process in logs, with autoregressive parameter matrix Φ and variance-covariance Σ_Z of normally distributed innovations. The firm sells its output to final good producers at the price φ_t (in units of consumption).

Each firm employs the continuum l_t 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 κ units of consumption per vacancy posted. The probability of finding a worker depends on a constant-returns-to-scale matching technology, which converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches:

$$M_t = \chi U_t^{1-\varepsilon} V_t^{\varepsilon}, \tag{3}$$

where $\chi > 0$ and $0 < \varepsilon < 1$. Each firm meets unemployed workers at a rate $q_t \equiv M_t/V_t$. Newly created matches become productive only in the next period. For an individual firm, the inflow of productive new hires in $t+1$ is therefore $q_t \upsilon_t$, where υ_t is the number of vacancies posted by the firm in period t. (In equilibrium, $\upsilon_t = V_t$.) Firms and workers who were productive in the previous period can separate exogenously with probability $\lambda \in (0,1)$. As a result of these assumptions firm-level employment obeys the law of motion $l_t = (1-\lambda)l_{t-1} + q_{t-1}\upsilon_{t-1}$.

Nominal rigidity is introduced in the form of sticky prices (discussed below) and wages. Intermediate-sector firms face a quadratic cost of adjusting the nominal wage rate, w_t. For each worker, the real cost of changing the nominal wage between period $t-1$ and t is $\vartheta\pi_{w,t}^2/2$, 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.[13]

Intermediate producers choose the number of vacancies, υ_t, and employment, l_t, to maximize the expected present discounted value of profits:

$$E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}\frac{u_{C,s}}{u_{C,t}}\left(\varphi_s Z_s l_s h_s - \frac{w_s}{P_s}l_s h_s - \kappa\upsilon_s - \frac{\vartheta}{2}\pi_{w,s}^2 l_s\right)\right], \tag{4}$$

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.

Profit maximization yields the job creation equation:

$$\frac{\kappa}{q_t} = E_t\left\{\beta_{t,t+1}\left[\varphi_{t+1}Z_{t+1}h_{t+1} - \frac{w_{t+1}}{P_{t+1}}h_{t+1} - \frac{\vartheta}{2}\pi_{w,t+1}^2 + (1-\lambda)\frac{\kappa}{q_{t+1}}\right]\right\}, \tag{5}$$

where $\beta_{t,t+1} \equiv \beta u_{C,t+1}/u_{C,t}$ is the one-period-ahead stochastic discount factor. Profit maximizing job creation requires the vacancy creation cost incurred by the firm per current match to be equal to the expected discounted profit that the time-t match will generate at $t+1$ (the future marginal revenue product from the match and its wage cost, including wage adjustment costs) plus the expected discounted saving on future vacancy creation costs, further discounted by the probability of current match survival $1-\lambda$.

The wage is determined by individual Nash bargaining over the nominal wage, and the wage payment divides the match surplus between workers and firms. The equilibrium sharing rule that determines the bargained wage can be written as $\eta_{w,t}H_t = (1-\eta_{w,t})J_t$, where $\eta_{w,t}$ is the bargaining share of firms, H_t is worker surplus , and J_t is firm surplus. Worker surplus is the difference between the value to the worker of being employed (the real wage bill plus the discounted, expected continuation value of the match next period) and the value of unemployment to the worker (the outside option—the utility value of leisure $v(h_t)/u_{C,t}$ plus an unemployment benefit b—and the

[13] We are constrained by tractability in our choice of a quadratic cost of wage adjustment along the lines of Rotemberg's (1982) model of price stickiness over the alternative Calvo (1983)-Yun (1996) model of nominal rigidity. Introducing the Calvo-Yun model in a framework along the lines of Gertler and Trigari (2009) such as ours admits tractable aggregation only at the first order of approximation, but we use second-order approximation in our policy analysis below.

expected discounted continuation value of unemployment status). Firm surplus is the per period marginal revenue product of the match, $\varphi_t Z_t h_t$, net of the wage bill and costs incurred to adjust wages, plus the expected discounted continuation value of the match to the firm in the next period.[14]

The bargained wage satisfies:

$$\begin{aligned}\frac{w_t}{P_t}h_t &= \eta_{w,t}\left(\frac{v(h_t)}{u_{C,t}}+b\right)+(1-\eta_{w,t})\left(\varphi_t Z_t h_t-\frac{\vartheta}{2}\pi_{w,t}^2\right)\\ &\quad +E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_{w,t})-(1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\},\end{aligned} \tag{6}$$

where ι_t is the probability of becoming employed at time t, defined by $\iota_t \equiv M_t/U_t$. With flexible wages ($\vartheta = 0$), the third term in the right-hand side of this equation reduces to $(1-\eta)\,\iota_t E_t\left(\beta_{t,t+1}J_{t+1}\right)$, or, in equilibrium, $\kappa\,(1-\eta)\,\iota_t/q_t$. In this case, the real wage bill per worker is a linear combination—determined by the constant bargaining parameter η—of worker's outside option and the marginal revenue product generated by the worker plus the expected discounted continuation value of the match to the firm (adjusted for the probability of worker employment). When wages are sticky, bargaining shares are endogenous, and so is the distribution of surplus between workers and firms. Moreover, the current wage bill reflects also expected changes in bargaining shares.

As common practice in the literature we assume that hours per worker are determined by firms and workers in a privately efficient way, i.e., so as to maximize the joint surplus of their employment relation.[15] The joint surplus is the sum of the firm's surplus and the worker's surplus, i.e., $J_t + H_t$. 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 consumption sector n, the representative, monopolistically competitive producer n produces the sectoral output bundle $Y_t(n)$, sold to consumers in Home and Foreign. Producer n is a multi-product firm that produces a set of differentiated product varieties, indexed by ω and defined over a continuum Ω: $Y_t(n) = \left(\int_{\omega\in\Omega}^{\infty} y_t(\omega,n)^{\frac{\theta-1}{\theta}}d\omega\right)^{\frac{\theta}{\theta-1}}$, with $\theta > 1$.[16] We assume monopolistic

[14] As in Gertler and Trigari (2009), the equilibrium bargaining share is time-varying due to the presence of wage adjustment costs. Absent these costs, we would have a time-invariant bargaining share $\eta_{w,t} = \eta$, where η is the weight of firm surplus in the Nash bargaining problem.

[15] See, among others, Thomas (2008) and Trigari (2009).

[16] Sectors (and sector-representative firms) are of measure zero relative to the aggregate size of the economy. Notice that $Y_t(n)$ can also be interpreted as a bundle of product features that characterize the final product n.

competition among a continuum of firms as this simplifies the analysis considerably by abstracting from strategic interactions. We conjecture that our assumptions on price setting below and symmetry across the multi-product firms we model would make it possible to consider the consequences of firms of non-negligible size and alternative forms of competition (such as Bertrand or Cournot) even in the environment of plant-level heterogeneity that we describe below. However, we chose to abstract from the complications that this would introduce in the analysis of optimal policy for ease of comparison with the existing New Keynesian literature that employs monopolistic competition under continuity. A cost of this choice is that we cannot explore pro-competitive effects of changes in product market regulation that affect strategic interactions as in the arguments put forth, for instance, by Brander and Spencer (1985) and Horstmann and Markusen (1992).[17] Studying the issues explored in this paper in an environment of strategic interactions is an important, empirically relevant extension of our exercise that we leave for future work.

Each product variety $y_t(\omega, n)$ in the bundle $Y_t(n)$ is created and developed by the representative final producer n. Since consumption-producing sectors are symmetric in the economy, from now on we omit the index n to simplify notation. The cost of producing the bundle Y_t, denoted with P_t^y, is $P_t^y = \left(\int_{\omega\in\Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}$, where $p_t^y(\omega)$ is the nominal marginal cost of producing variety ω.

The number of products created and commercialized by each final producer is endogenous. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. To create a new product, the final producer must undertake a sunk investment, $f_{e,t}$, in units of intermediate input. Product creation requires each final producer to create a new plant that will be producing the new variety (a technological requirement with cost $f_{T,t}$) and to incur non-technological entry costs related to bureaucratic requirements for business creation ($f_{R,t}$, "red tape"). Thus, $f_{e,t} \equiv f_{T,t} + f_{R,t}$.[18]

Plants produce with different technologies indexed by relative productivity z. To save notation, we identify a variety with the corresponding plant productivity z, omitting ω. Upon product creation, the productivity level of the new plant z is drawn from a common distribution $G(z)$ with

[17] Colciago and Etro (2010) and Etro (2009) pioneered the introduction of strategic interactions in the modeling framework we build on. Extensions to closed-economy, sticky-price environments without heterogeneity are in Etro and Rossi (2015) and Faia (2012). Cacciatore, Ghironi, and Stebunovs (2015) build on Stebunovs (2008) to develop a flexible-price model in which strategic behavior by financial intermediaries that can be reinterpreted as firm headquarters has a negative effect on product creation.

[18] Though we do not model an equity market explicitly below, we implicitly assume that firms finance product creation costs by selling shares to domestic households as in Bilbiie, Ghironi, and Melitz (2012) and Ghironi and Melitz (2005). For analyses of the role of financial intermediaries in producer entry in this class of models, see Bergin, Feng, and Lin (2014), Cacciatore, Ghironi, and Stebunovs (2015), Notz (2012), Poutineau and Vermandel (2015), and Stebunovs (2008).

support on $[z_{\min}, \infty)$. Foreign plants draw productivity levels from an identical distribution. This relative productivity level remains fixed thereafter. Each plant uses intermediate input to produce its differentiated product variety, with real marginal cost $\varphi_{z,t} \equiv p_t^y(z)/P_t = \varphi_t/z$.

At time t, each final Home producer commercializes $N_{d,t}$ varieties and creates $N_{e,t}$ new products that will be available for sale at time $t+1$. New and incumbent plants can be hit by a "death" shock with probability $\delta \in (0,1)$ at the end of each period. Therefore, the law of motion for the stock of producing plants is $N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t})$.

When serving the Foreign market, each final producer faces per-unit iceberg trade costs, $\tau_t > 1$, and fixed export costs, $f_{x,t}$. Fixed export costs are denominated in units of intermediate input and paid for each exported product variety. Thus, the total fixed cost is $F_{x,t} \equiv N_{x,t} f_{x,t}$, where $N_{x,t}$ denotes the number of product varieties exported to Foreign. Absent fixed export costs, each producer would find it optimal to sell all its product varieties in both countries. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cutoff level $z_{x,t}$ determined by a zero-export-profit condition below) are exported. The share of exporting plants is given by $N_{x,t} = [1 - G(z_{x,t})]\, N_{d,t}$.

Define two special "average" productivity levels (weighted by relative output shares): an average $\tilde{z}_d$ for all producing plants and an average $\tilde{z}_{x,t}$ for all plants that export:

$$\tilde{z}_d \equiv \left[\int_{z_{\min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}, \qquad \tilde{z}_{x,t} \equiv \left[\frac{1}{1-G(z_{x,t})}\right] \left[\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}. \tag{7}$$

These averages summarize all the information on the productivity distributions relevant for all macroeconomic variables. Assume that $G(\cdot)$ is Pareto with shape parameter $k_p > \theta - 1$. As a result, $\tilde{z}_d = \alpha^{1/(\theta-1)} z_{\min}$ and $\tilde{z}_{x,t} = \alpha^{1/(\theta-1)} z_{x,t}$, where $\alpha \equiv k_p/\left(k_p - \theta + 1\right)$. The share of exporting plants is given by:

$$N_{x,t} = [1 - G(z_{x,t})]\, N_{d,t} = \left(\frac{z_{\min}}{\tilde{z}_{x,t}}\right)^{k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t} = \left(\frac{z_{\min}}{z_{x,t}}\right)^{k_p} N_{d,t} \tag{8}$$

Output bundles for domestic and export sale, and associated unit costs, are:

$$Y_{d,t} = \left[\int_{z_{\min}}^{\infty} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}}, \qquad Y_{x,t} = \left[\int_{z_{x,t}}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}}, \tag{9}$$

$$P_{d,t}^{y}=\left[\int_{z_{\min}}^{\infty}p_{t}^{y}(z)^{1-\theta}dG(z)\right]^{\frac{1}{1-\theta}},\qquad P_{x,t}^{y}=\left[\int_{z_{x,t}}^{\infty}p_{t}^{y}(z)^{\frac{\theta-1}{\theta}}dG(z)\right]^{\frac{1}{1-\theta}}. \tag{10}$$

In deciding how many products to create and which ones to export, the firm chooses the sequences $\{N_{d,s+1}\}_{s=t}^{\infty}$ and $\{z_{x,s}\}_{s=t}^{\infty}$ to minimize the intertemporal cost function:

$$E_t\left\{\sum_{s=t}^{\infty}\beta_{t,s}\left[\frac{P_{d,s}^{y}}{P_s}Y_{d,s}+\tau_s\frac{P_{x,s}^{y}}{P_s}Y_{x,s}+\left(\frac{N_{d,s+1}}{1-\delta}-N_{d,s}\right)f_{e,s}\varphi_s+N_{x,s}f_{x,s}\varphi_s\right]\right\}, \tag{11}$$

taking into account that $N_{x,t}=(z_{\min}/z_{x,t})^{k_p}N_{d,t}$, $P_{d,t}^{y}/P_t=N_{d,t}^{\frac{1}{1-\theta}}\varphi_t/\tilde{z}_d$, $P_{x,t}^{y}/P_t=N_{x,t}^{\frac{1}{1-\theta}}\varphi_t/\tilde{z}_{x,t}$, and $\tilde{z}_{x,t}=\alpha^{1/(\theta-1)}z_{x,t}$. The first-order condition with respect to $N_{d,t+1}$ yields the Euler equation for product creation:

$$\varphi_t f_{e,t}=E_t\left\{(1-\delta)\beta_{t,t+1}\left[\begin{array}{c}\frac{1}{\theta-1}\left(\frac{P_{d,t+1}^{y}Y_{d,t+1}}{P_{t+1}N_{d,t+1}}+\frac{P_{x,t+1}^{y}Y_{x,t+1}}{P_{t+1}N_{x,t+1}}\frac{N_{x,t+1}}{N_{d,t+1}}\tau_{t+1}\right)\\-\frac{N_{x,t+1}}{N_{d,t+1}}\varphi_{t+1}f_{x,t+1}+\varphi_{t+1}f_{e,t+1}\end{array}\right]\right\}. \tag{12}$$

At the optimum, the cost of producing an additional variety (in units of consumption), $\varphi_t f_{e,t}$, must be equal to its expected benefit: the expected discounted marginal revenue from commercializing the variety, net of export costs if it is exported, and the expected saving on future product creation costs.

The first-order condition with respect to $z_{x,t}$ yields:

$$\frac{k_p-(\theta-1)}{(\theta-1)k_p}\frac{P_{x,t}^{y}}{P_t}\frac{Y_{x,t}}{N_{x,t}}\tau_t=f_{x,t}\varphi_t. \tag{13}$$

At the optimum, the marginal revenue from adding a variety with productivity $z_{x,t}$ to the export bundle must be equal to the fixed export cost. Thus, varieties produced by plants with productivity below $z_{x,t}$ are distributed only in the domestic market.

We are now left with the determination of domestic and export prices. Price setting happens at the level of the bundles $Y_{d,t}$ and $Y_{x,t}$ rather than the level of individual varieties (or product features). As shown in Cacciatore and Ghironi (2012), this preserves the aggregation properties of the Melitz (2003) trade model in an environment of sticky prices.

Denote with $P_{d,t}$ the price (in Home currency) of the product bundle $Y_{d,t}$ and let $P_{x,t}$ be the price (in Foreign currency) of the exported bundle $Y_{x,t}$. Each final producer faces the following domestic and foreign demand for its product bundles: $Y_{d,t}=(P_{d,t}/P_t)^{-\phi}Y_t^{C}$ and $Y_{x,t}=(P_{x,t}/P_t^{*})^{-\phi}Y_t^{C*}$, where Y_t^C and Y_t^{C*} are aggregate demands of the consumption baskets in Home and Foreign. Aggregate demand in each country includes sources other than household consumption, but it takes the same form as the consumption basket, with the same elasticity of substitution $\phi > 1$ across sectoral bundles. This ensures that the consumption price index for the consumption aggregator is also the price index for aggregate demand of the basket.

We assume producer currency pricing (PCP): Each final producer sets $P_{d,t}$ and the domestic currency price of the export bundle, $P_{x,t}^d$, letting the price in the foreign market be $P_{x,t} = \tau_t P_{x,t}^d / S_t$, where S_t is the nominal exchange rate (units of Home currency per unit of Foreign). Absent fixed export costs, the producer would set a single price $P_{d,t}$, and the law of one price (adjusted for the presence of iceberg trade costs) would determine the export price as $P_{x,t} = \tau_t P_{d,t}/S_t$. With fixed export costs, however, the composition of domestic and export bundles is different, and the marginal costs of producing these bundles are not equal. Therefore, final producers choose two different prices for the Home and Foreign markets even under PCP.

We assume that prices in the final sector are sticky: Final producers must pay quadratic price adjustment costs as in Rotemberg (1982) when changing domestic and export prices. The nominal costs of adjusting domestic and export price are, respectively, $\Gamma_{d,t} \equiv \nu \pi_{d,t}^2 P_{d,t} Y_{d,t}/2$, and $\Gamma_{x,t}^d \equiv \nu \pi_{x,t}^{d2} P_{x,t}^d Y_{x,t}/2$, where $\nu \geq 0$ determines the size of the adjustment costs (domestic and export prices are flexible if $\nu = 0$), $\pi_{d,t} = (P_{d,t}/P_{d,t-1}) - 1$ and $\pi_{x,t}^d = \left(P_{x,t}^d / P_{x,t-1}^d\right) - 1$. In Bilbiie, Ghironi, and Melitz (2008a), where price rigidity is at the level of individual product varieties, the Rotemberg model of price stickiness simplifies the analysis considerably relative to the Calvo (1983)-Yun (1996) approach.[19] Since we impose price rigidity at the bundle level, using the Calvo-Yun model would not imply the intractability that would arise from trying to use it at the variety level in an environment with heterogeneity. However, we use the Rotemberg model of price stickiness for consistency with the form of nominal rigidity we introduced in wage setting, where we were constrained by tractability, and to facilitate comparison of results and intuitions with other work on optimal monetary policy in this class of models that uses the same setup.[20]

When choosing $P_{d,t}$ and $P_{x,t}^d$, the firm maximizes:

[19] Cavallari (2013) uses the Calvo-Yun model in her two-country version of Bilbiie-Ghironi-Melitz. Etro and Rossi (2015) use Calvo-Yun in a version of Bilbiie-Ghironi-Melitz with Bertrand competition.

[20] This work includes Bergin and Corsetti (2014), Faia (2012), and our own work in Bilbiie, Fujiwara, and Ghironi (2014), Cacciatore and Ghironi (2012), and Cacciatore, Fiori, and Ghironi (2013). Much New Keynesian literature on Ramsey-optimal monetary policy in models without producer entry builds on the Rotemberg model of nominal rigidity in wages and/or prices. For instance, Arseneau and Chugh (2008), Chugh (2006), and Schmitt-Grohé and Uribe (2004).

$$E_t \left\{ \sum_{s=t}^{\infty} \beta_{t,s} \left[\left(\frac{P_{d,s}}{P_s} - \frac{P_{d,s}^y}{P_s} \right) Y_{d,s} - \left(\frac{P_{x,s}^d}{P_s} - \frac{P_{x,s}^y}{P_s} \tau_s \right) Y_{x,s} - \frac{\Gamma_{d,s}}{P_s} - \frac{\Gamma_{x,s}^d}{P_s} \right] \right\}, \tag{14}$$

subject to the demand schedules $Y_{d,t} = (P_{d,t}/P_t)^{-\phi} Y_t^C$ and $Y_{x,t} = \left[P_{x,t}^d / (Q_t P_t)\right]^{-\phi} Y_t^{C*}$, where $Q_t \equiv S_t P_t^* / P_t$ is the consumption-based real exchange rate (units of Home consumption per unit of Foreign).

The profit-maximizing real price of Home output for domestic sale is given by:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{(\phi - 1)\, \Xi_{d,t}} \frac{P_{d,t}^y}{P_t}, \tag{15}$$

where $\Xi_{d,t}$ is given by:

$$\Xi_{d,t} \equiv 1 - \frac{\nu}{2} \pi_{d,t}^2 + \frac{\nu}{(\phi - 1)} \left\{ \pi_{d,t} (1 + \pi_{d,t}) - E_t \left[\beta_{t,t+1} \pi_{d,t+1} \frac{(1 + \pi_{d,t+1})^2}{1 + \pi_{t+1}^C} \frac{Y_{d,t+1}}{Y_{d,t}} \right] \right\}. \tag{16}$$

Price stickiness introduces endogenous markup variation. 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 ($\nu = 0$), the markup is constant and equal to $\phi/(\phi - 1)$.[21]

The real price (relative to the Foreign price index) of Home export output implied by the optimal choice of $P_{x,t}^d$ is equal to:

$$\frac{P_{x,t}}{P_t^*} = \frac{\phi}{(\phi - 1)\, \Xi_{x,t}^d} \frac{\tau_t P_{x,t}^y}{Q_t P_t}, \tag{17}$$

where:

$$\Xi_{x,t}^d \equiv 1 - \frac{\nu}{2} \pi_{x,t}^{d^2} + \frac{\nu}{(\phi - 1)} \left\{ \pi_{x,t}^d \left(1 + \pi_{x,t}^d\right) - E_t \left[\beta_{t,t+1} \pi_{x,t+1}^d \frac{\left(1 + \pi_{x,t+1}^d\right)^2}{1 + \pi_{t+1}^C} \frac{Y_{x,t+1}}{Y_{x,t}} \right] \right\}. \tag{18}$$

Absent fixed export costs $z_{x,t} = z_{\min}$ and $\Xi_{x,t}^d = \Xi_{d,t}$.

As noted above, the assumption of price rigidity at the level of the sectoral output bundles $Y_{d,t}$ and $Y_{x,t}$ rather than the individual product varieties $y_{d,t}(z)$ and $y_{x,t}(z)$ allows us to introduce price stickiness in the Ghironi-Melitz (2005) framework while still preserving the aggregation properties

[21] The assumption of C.E.S. preferences over a continuum of products implies that the model does not capture pro-competitive effects of product market reforms via flexible-price markup variation. See Cacciatore and Fiori (2010) and Cacciatore, Fiori, and Ghironi (2013) for models that incorporate such mechanism by assuming a translog expenditure function.

of the Melitz (2003) model. In essence, the model is isomorphic to one where the final sector firm has $N_{d,t}$ plants with productivity level $\tilde{z}_d$ that produce $\tilde{y}_{d,t} \equiv y_{d,t}(\tilde{z}_d)$ units of variety output in the Home country and sell it domestically for the real price $\tilde{\rho}_{d,t} = \mu_{d,t}\varphi_t/\tilde{z}_d$, and $N_{x,t}$ plants with productivity level $\tilde{z}_{x,t}$ that export $\tilde{y}_{x,t} \equiv y_{x,t}(\tilde{z}_{x,t})$ units of variety output to the Foreign market for the price $\tilde{\rho}_{x,t} = \mu_{x,t}(\tau_t\varphi_t)/(\tilde{z}_{x,t}Q_t)$, where $\mu_{d,t} \equiv \phi/[(\phi-1)\Xi_{d,t}]$ and $\mu_{x,t} \equiv \phi/\left[(\phi-1)\Xi^d_{x,t}\right]$.[22]

Household Budget Constraint and Intertemporal Decisions

The representative household can invest in non-contingent nominal bonds that are traded domestically and internationally. International assets markets are incomplete as only these bonds are traded across countries. Home bonds, issued by Home households, are denominated in Home currency. Foreign bonds, issued by Foreign households, are denominated in Foreign currency. We assume standard quadratic costs of adjusting bond holdings to ensure uniqueness of the deterministic steady state and stationary model responses to temporary shocks. The cost of adjusting holdings of Home bonds entering $t+1$ (A_{t+1}) is $\psi(A_{t+1}/P_t)^2/2$, while the cost of adjusting holdings of Foreign bonds ($A_{*,t+1}$) is $\psi(A_{*,t+1}/P^*_t)^2/2$, with $\psi > 0$. These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion in equilibrium.

The Home household's period budget constraint is:

$$\begin{aligned} & A_{t+1} + S_t A_{*,t+1} + \frac{\psi}{2}P_t\left(\frac{A_{t+1}}{P_t}\right)^2 + \frac{\psi}{2}S_t P^*_t\left(\frac{A_{*,t+1}}{P^*_t}\right)^2 + P_t C_t \\ = \quad & (1+i_t)A_t + (1+i^*_t)A_{*,t}S_t + w_t L_t + P_t b(1-l_t) + T^G_t + T^A_t + T^I_t + T^F_t, \end{aligned} \tag{19}$$

where i_t and i^*_t are, respectively, the nominal interest rates on Home and Foreign bond holdings between $t-1$ and t, known with certainty as of $t-1$; T^G_t is a lump-sum transfer (or tax) from the government; T^A_t is a lump-sum rebate of the cost of adjusting bond holdings from the intermediaries to which it is paid; and T^I_t and T^F_t are lump-sum rebates of profits from intermediate and final goods producers.[23]

[22] The expressions for the prices $\tilde{\rho}_{d,t}$ and $\tilde{\rho}_{x,t}$ use the fact that, as noted above, the real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ can be rewritten as $P^y_{d,t}/P_t = N_{d,t}^{\frac{1}{1-\theta}}\varphi_t/\tilde{z}_d$ and $P^y_{x,t}/P_t = N_{x,t}^{\frac{1}{1-\theta}}\varphi_t/\tilde{z}_{x,t}$. Note also that $\tilde{y}_{d,t} \equiv \tilde{\rho}_{d,t}^{-\phi}N_{d,t}^{\frac{\theta-\phi}{1-\theta}}Y^C_t$ and $\tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi}N_{x,t}^{\frac{\theta-\phi}{1-\theta}}Y^{C*}_t$.

[23] In equilibrium,

$$T^G_t = -P_t b(1-l_t),$$

$$T^A_t = P_t\frac{\psi}{2}\left(\frac{A_{t+1}}{P_t}\right)^2 + S_t P_t\frac{\psi}{2}\left(\frac{A_{*,t+1}}{P^*_t}\right)^2,$$

Let $a_{t+1} \equiv A_{t+1}/P_t$ denote real holdings of Home bonds (in units of Home consumption) and let $a_{*,t+1} \equiv A_{*,t+1}/P_t^*$ denote real holdings of Foreign bonds (in units of Foreign consumption). The Euler equations for bond holdings are:

$$1+\psi a_{t+1} = (1+i_{t+1})\, E_t \left(\frac{\beta_{t,t+1}}{1+\pi_{C,t+1}} \right), \tag{20}$$

$$1+\psi a_{*t+1} = \left(1+i^*_{t+1}\right) E_t \left[\beta_{t,t+1} \frac{Q_{t+1}}{Q_t \left(1+\pi^*_{C,t+1}\right)} \right], \tag{21}$$

where $\pi_{C,t} \equiv (P_t/P_{t-1}) - 1$ and $\pi^*_{C,t+1} \equiv \left(P_t^*/P_{t-1}^*\right) - 1$.

Details of the equilibrium of our model economy are in Cacciatore and Ghironi (2012). 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 conditions $a_{t+1} + a^*_{t+1} = 0$ and $a^*_{*,t+1} + a_{*,t+1} = 0$ in all periods. Cacciatore and Ghironi (2012) show that imposing equilibrium conditions on the budget constraints of the representative Home and Foreign households and subtracting the constraint for the Foreign household (expressed in units of Home consumption) from that for the Home household yields the following law of motion for Home net foreign assets:

$$a_{t+1} + Q_t a_{*,t+1} = \frac{1+i_t}{1+\pi_{C,t}} a_t + Q_t \frac{1+i^*_t}{1+\pi^*_{C,t}} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N^*_{x,t} \tilde{\rho}^*_{x,t} \tilde{y}^*_{x,t}. \tag{22}$$

In addition to equilibrium in bond markets, the budget constraints of Home and Foreign governments, and the rebates received by households, this equation accounts for the fact that demand for consumption output comes from several sources and for labor market equilibrium in each country. For instance, Home consumption demand aggregates household consumption, costs of vacancy posting in the labor market, costs of wage adjustment in the intermediate sector, and costs of price

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

$$T_t^F = \left(\frac{\mu_{d,t} - 1}{\mu_{d,t}} - \frac{\nu}{2} \pi^2_{d,t} \right) \tilde{\rho}_{d,t} N_{d,t} \tilde{y}_{d,t} + Q_t \left(\frac{\mu_{x,t} - 1}{\mu_{x,t}} - \frac{\nu}{2} \left(\pi^d_{x,t} \right)^2 \right) \tilde{\rho}_{x,t} N_{x,t} \tilde{y}_{x,t} - \varphi_t \left(N_{x,t} f_{x,t} + N_{e,t} f_{e,t} \right).$$

adjustment in the final sector:

$$Y_t^C = C_t + \kappa V_t + \frac{\vartheta}{2}\pi_{w,t}^2 l_t + \frac{\nu}{2}\pi_{d,t}^2 \tilde{\rho}_{d,t} N_{d,t} \tilde{y}_{d,t} + \frac{\nu}{2}\pi_{x,t}^{d^2} \tilde{\rho}_{x,t} N_{x,t} \tilde{y}_{x,t}. \tag{23}$$

Labor market equilibrium equates labor supply to the sum of labor used to produce intermediate input used in domestic sale production, labor used to produce intermediate input used in export production, labor used in creation of new products, and labor used for fixed export costs:

$$l_t h_t = N_{d,t} \frac{\tilde{y}_{d,t}}{Z_t \tilde{z}_d} + N_{x,t} \frac{\tilde{y}_{x,t}}{Z_t \tilde{z}_{x,t}} \tau_t + N_{e,t} \frac{f_{e,t}}{Z_t} + N_{x,t} \frac{f_{x,t}}{Z_t}. \tag{24}$$

As shown in Cacciatore and Ghironi (2012), equations (23) and (24) and their Foreign counterparts, as well as optimal price setting by final sector firms, are imposed in deriving equation (22).

Defining $1 + r_t \equiv (1 + i_t) / (1 + \pi_{C,t})$, we can rearrange (22) to show that the change in net foreign assets between t and $t + 1$ is determined by the current account:

$$(a_{t+1} - a_t) + Q_t (a_{*,t+1} - a_{*,t}) = CA_t \equiv r_t a_t + Q_t r_t^* a_{*,t} + TB_t, \tag{25}$$

where TB_t is the trade balance:

$$TB_t \equiv Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*. \tag{26}$$

The trade balance—and, therefore, the current account and the dynamics of net foreign assets—depends on the number of exported products versus the number of imported ones, in addition to prices and quantities of individual traded products.

Monetary Policy

To close the model, we must specify the behavior of monetary policy. In our benchmark exercises, we compare the Ramsey-optimal, cooperative conduct of monetary policy to a representation of historical central bank behavior under a flexible exchange rate, intended to capture key features of policymaking by the ECB and the Federal Reserve.[24] Historical policy is thus captured by standard rules for interest rate setting in the spirit of Taylor (1993) and Woodford (2003) for both central

[24] Since we do not focus on the recent crisis, we abstract from non-conventional monetary policy instruments. We also do not focus on the issue of the zero lower bound (ZLB) on interest rates. In contrast to analyses in which reforms are modeled as exogenous markup cuts, reforms are not necessarily deflationary in our framework, which ameliorates concerns from the ZLB issue.

banks in our model.

As discussed in Cacciatore and Ghironi (2012), the specification of historical policy rules for the central banks requires us to define data-consistent price and quantity variables in our model: Endogenous product creation and "love for variety" in preferences imply that variables measured in units of consumption do not have a direct counterpart in the data, i.e., they are not data-consistent. As the economy experiences entry of Home and Foreign products, 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.[25] We follow Ghironi and Melitz (2005) and construct an average price index $\tilde{P}_t \equiv \left(N_{d,t} + N^*_{x,t}\right)^{\frac{1}{\theta-1}} P_t$. The average price index $\tilde{P}_t$ is closer to the actual CPI data constructed by statistical agencies than the welfare-based index P_t, and, therefore, it is the data-consistent CPI implied by the model. In turn, given any variable X_t in units of consumption, its data-consistent counterpart can be obtained as $X_{R,t} \equiv X_t P_t / \tilde{P}_t$.

Under the historical characterization of policy, we assume that the exchange rate is flexible, and each country's central bank sets its interest rate to respond to data-consistent CPI inflation and GDP gap relative to the equilibrium with flexible prices and wages:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i)\,(1 + \tilde{\pi}_{C,t})^{\varrho_\pi} \left(\tilde{Y}^g_{R,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}, \quad 0 \leq \varrho_i \leq 1,\ \varrho_\pi > 0,\ \varrho_Y \geq 0, \tag{27}$$

where $\tilde{\pi}_{C,t}$ is the data-consistent CPI inflation and $\tilde{Y}^g_{R,t}$ is the data-consistent GDP gap.[26] A similar rule for interest rate setting applies to the Foreign central bank. We compare the properties of our model world economy under this international monetary regime to those generated by Ramsey-optimal, cooperative monetary policy chosen by a worldwide Ramsey authority that maximizes an equally weighted average of Home and Foreign welfare.[27]

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

[26] We define GDP, denoted with Y_t, as total income: the sum of labor income and profit income from final and intermediate producers. Formally, $Y_t \equiv (w_t/P_t)\, l_t + T^F_t + T^I_t$. We define the GDP gap as $\tilde{Y}^g_{R,t} \equiv Y_{R,t}/Y^{flex}_{R,t}$ where $Y^{flex}_{R,t}$ is data-consistent GDP under flexible prices and wages.

[27] See the Appendix for details. Cacciatore and Ghironi (2012) consider also the case in which Home and Foreign Ramsey-central banks act in non-cooperative fashion. With high trade integration, welfare gains from cooperation are small relative to non-cooperative Ramsey policies, but they are larger relative to historical policy, as trade amplifies spillovers from non-optimized policies. Following Sims (2007), we focus on historical behavior as the empirically relevant benchmark here. Results for the non-cooperative Ramsey scenario are available on request.

3 Sources of Inefficiency

The worldwide Ramsey planner that determines the optimal, cooperative monetary policy uses its policy instruments (the Home and Foreign interest rates) to address the consequences of a set of distortions that exist in the market economy of our model. To understand these distortions and the tradeoffs they create for policy, Cacciatore and Ghironi (2012) compare the equilibrium conditions of the market economy to those implied by the solution to the first-best, optimal planning problem. This makes it possible to define inefficiency wedges for the market economy (relative to the social planner's optimum) and describe Ramsey policy in terms of its implications for these wedges. In this section, we summarize the sources of inefficiency in our model with reference to the margins of economic adjustment on which they impinge. Specifically, price and wage stickiness, firm monopoly power, unemployment benefits, "red tape" regulation, trade costs, and incomplete markets affect five margins of adjustment and the resource constraint for consumption output in the market economy:

- **Product creation margin:** Sticky prices result in inefficient time-variation and lack of synchronization of domestic and export markups that introduce inefficiency in the product creation margin (described by the Euler equations for product creation at Home and abroad). Time variation and lack of synchronization of markups across markets imply inefficient deviations of the monopoly profit incentive for product creation (the markup) from the welfare benefit of product variety determined by the constant elasticity of substitution across products. Similarly, if steady-state inflation is not zero, sticky prices imply a departure from the balancing of product creation incentives and welfare benefit of variety implied by continuous Dixit-Stiglitz preferences under flexible prices. Finally, the product creation margin is affected by the presence of the non-technological entry costs $f_{R,t}$ and of any non-technological, inefficiently set component of trade costs that affects the role of expected export profits in product creation.[28] As shown in Cacciatore and Ghironi (2012), the Euler equations for domestic and foreign product creation coincide with those of the first-best environment when prices and wages are flexible, there is no "red tape," and trade costs are of purely technological nature.[29]

[28] Bilbiie, Ghironi, and Melitz (2008b) and Chugh and Ghironi (2015) consider the case $f_{R,t} = -\tau_t^e f_{T,t}$ and discuss the determination of optimal product creation subsidies τ_t^e in a first- or second-best environment, respectively. We will 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). In the continuous Dixit-Stiglitz environment of this paper, it would be optimal to set $\tau_t^e = 0$ in the absence of other distortions.

[29] Efficiency along the product creation margin in this case is a consequence of the assumption of a Dixit-Stiglitz continuum. This implies that the monopoly profit incentive for product creation is perfectly aligned with the welfare

- **Job creation margin:** This margin of adjustment is described by the Euler equations for job creation in the two countries. As product creation, also this margin is affected by several distortions: First, monopoly power in the final consumption sector distorts the job creation decision by inducing a suboptimally low return from vacancy posting in the intermediate sector. Price stickiness impacts this departure from efficiency by inducing endogenous markup variation. Second, 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) is an additional distortion in this margin.[30] This distortion is affected both by the flexible-wage value of the bargaining share (η, which can be different from ε) and the presence of wage stickiness, which induces time variation of $\eta_{w,t}$ (and a departure of its steady-state value from η if steady-state wage inflation is not zero). Sticky wages are sufficient to generate a wedge between private and social returns to vacancy posting. Third, sticky wages distort job creation also by affecting the outside option of firms through the term $\vartheta\pi_{w,t}^2/2$. Finally, unemployment benefits increase the workers' outside option above its efficient level. When $\mu_{d,t} = 1$, $\eta_{w,t} = \varepsilon$, and $b = \vartheta = 0$, there is no inefficiency in job creation.

- **Labor supply margin:** Endogenous supply of labor effort constitutes the third margin of adjustment for the economies in our model. With endogenous labor supply, monopoly power in product markets induces a misalignment of relative prices between consumption goods and leisure. This is the distortion that characterizes standard New Keynesian models without labor market frictions and endogenous product dynamics. Sticky prices induce time variation of this distortion, which disappears if $\mu_{d,t} = 1$.

- **International trade margin:** To the extent that fixed export costs and iceberg trade costs are not determined only by trade technology (which would constrain also a global planner), but they also reflect policies and regulations that are not set in a globally efficient manner, trade costs distort international trade along both its extensive and intensive margins (the number of traded products and the amount of trade in each of these products). The trade margin is efficient if trade costs are of purely technological nature.

benefit of a new product. This perfect alignment is broken when we deviate from the Dixit-Stiglitz continuum assumption. See Bilbiie, Ghironi, and Melitz (2008b) for more detail, and Bilbiie, Fujiwara, and Ghironi (2014) and Cacciatore, Fiori, and Ghironi (2013) for the monetary policy implications of such deviations.

[30] 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. 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.

- **International risk sharing margin:** The fifth margin of adjustment is also of international nature and pertains to the ability of households in Home and Foreign to insure against country-level, idiosyncratic uncertainty. Incomplete markets imply inefficient risk sharing between Home and Foreign households: The ratio of marginal utilities of consumption at Home and abroad, $u_{C^*,t}/u_{C,t}$, is not tied to the welfare-based real exchange rate, Q_t. The departure of consumption dynamics from the perfect risk sharing outcome is also affected by the costs of adjusting bond holdings. If asset markets were internationally complete and there were no costs of adjusting asset holdings, we would have $u_{C^*,t}/u_{C,t} = Q_t$.[31]

- **Resource constraint:** Finally, sticky prices and wages and the non-technological portion of product creation costs imply inefficient diversion of resources from consumption and creation of new products and vacancies.

The market allocation is efficient only if *all* the distortions are zero at all points in time, and the adjustment of the economy is efficient along all margins. Since we abstract from optimal fiscal policy with access to lump-sum instruments, worldwide-optimal market regulation, and we allow for asymmetric shocks, it follows that we work in a second-best environment in which the efficient allocation cannot be achieved.[32] To simplify the analysis, we assume below that trade costs are of purely technological nature, ensuring efficiency along the trade margin. In the second-best environment created by the remaining distortions, the worldwide Ramsey central bank optimally uses its leverage on the economies 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.

4 Calibration and Model Properties

We are interested in understanding the *external* effects of market reforms in the euro area, and the implications these reforms may have for monetary policy not just in the euro area but also outside.

[31] 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 $\varkappa = 1$. We adjust the risk sharing condition for $\varkappa \neq 1$ when appropriate below.

[32] We abstract from the question of optimal determination of market regulation and reforms below, simply assuming that euro area reforms adjust market characteristics to U.S. levels, without the presumption that these should be the optimal levels (for Europe or the U.S.). On one side, it is a very open question whether reforms in Europe are being designed according to any optimality criteria. On the other, the question of optimal regulation would require explicitly studying strategic interactions between policymakers (central banks and regulators) within and across countries. This is a very interesting issue that we leave for future research.

For this reason, we take the United States as reference point for our benchmark calibration, and for an initial investigation of our model's properties. We perform this investigation by calibrating both countries in our model symmetrically to U.S. targets, and studying the ability of the model to replicate standard moments of the U.S. business cycle and its international interdependence with foreign fluctuations.[33] To build intuition for the mechanisms at work, we discuss the responses to a Home productivity shock.

Calibration

Table 1 summarizes the calibration. (Variables without time indexes denote steady-state levels.) We interpret periods as quarters and set the discount factor β to 0.99, implying an annual real interest rate of 4 percent. The period utility function is given by $C_t^{1-\gamma_C}/(1-\gamma_C)-l_t h_t^{1+\gamma_h}/(1+\gamma_h)$. The risk aversion coefficient γ_C is equal to 1, while the Frisch elasticity of labor supply $1/\gamma_h$ is set to 0.3.[34] The elasticity of substitution across product varieties, θ is set to 3.8 following Bernard, Eaton, Jensen, and Kortum (2003), who find that this value fits U.S. plant and macro trade data. As Ghironi and Melitz (2005), we set the elasticity of substitution across Home and Foreign goods, ϕ, equal to θ. We follow Ghironi and Melitz (2005) also in setting the shape parameter k_p of the Pareto distribution that we assume for productivity draws to 3.4, normalizing $z_{\min}$ to 1, and calibrating the fixed export cost f_x so that the share of exporting plants is equal to 21 percent (as reported by Bernard, Eaton, Jensen, and Kortum, 2003). This requires $f_x = 0.003$. We set iceberg trade costs, τ, so that total trade (imports plus exports) over GDP is equal to 22 percent, the average value for the U.S. in the period 1980:Q1-2011:Q1. This requires setting $\tau = 1.51$.[35] We focus on the period since 1980 for our calibration as the implementation of European market reforms would happen in the environment of higher trade integration that prevailed since the 1980s.[36]

To ensure steady-state determinacy and stationarity of net foreign assets, we set the bond adjustment cost ψ to 0.0025 as in Ghironi and Melitz (2005). The scale parameter for the cost of

[33] Symmetric, U.S.-based calibration is common practice in the literature. For completeness of our exercise, we repeated it assuming a symmetric, euro-area-based calibration. Parameter values for this alternative and a summary table of model properties are in the Appendix.

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

[35] Anderson and van Wincoop (2004) estimate a value of 1.7 in their survey of trade cost measurement, though they focus on a different time period.

[36] Importantly, changing the reference period for the calibration does not affect our main policy results significantly.

adjusting prices, ν, is equal to 80, close to the value used in Bilbiie, Ghironi, and Melitz (2008a) and estimated for the U.S. by Ireland (2001). Parameter values in this range are consistent with the degree of price rigidity often assumed in models that adopt the framework of Calvo (1983) and Yun (1996). We choose ϑ, the scale parameter of nominal wage adjustment costs, so that the model reproduces the volatility of unemployment relative to GDP observed in the period 1980:Q1-2011:Q1 used to calibrate iceberg trade costs. This implies $\vartheta = 80$ too.[37] To calibrate the total entry costs, we follow Ebell and Haefke (2009) and set f_e so that entry costs amount to 5.2 months of per capita output. This implies $f_e = 0.58$.

We set unemployment benefits, b, to 0.19, so that the replacement rate, $b/(wh)$, is 0.55, as reported by OECD (2004).[38] The flexible-wage bargaining share of workers, $1 - \eta$, is equal to 0.4, as estimated by Flinn (2006). The elasticity of the matching function, ε, is equal to 0.6, as estimated by Blanchard and Diamond (1989) and such that the Hosios condition holds in a steady state with zero inflation. The exogenous separation rate between firms and workers, λ, is 10 percent, as reported by Shimer (2005). To pin down exogenous producer exit, δ, we target the 40-percent portion of worker separation due to plant exit documented by Haltiwanger, Scarpetta, and Schweiger (2008). This yields $\delta = 0.029$, a value very close to that in Ghironi and Melitz (2005).

Two labor market parameters are left for calibration: the scale parameter for the cost of vacancy posting, κ, and the matching efficiency parameter, χ. We calibrate these parameters to match the average probability of finding a job and the probability of filling a vacancy in the period 1980:Q1-2011:Q1. The former is 60 percent, while the latter is 70 percent, in line with Shimer (2005). This implies $\kappa = 0.10$ and $\chi = 0.73$.[39] With this calibration, the model generates an 11-percent steady-state unemployment rate, which is not distant from the U.S. average plus a plausible adjustment for job searchers not included in unemployment rate statistics.

For the bivariate productivity process in the intermediate sector, we set persistence and spillover parameters (respectively, the diagonal and off-diagonal parameters in the autoregressive matrix coefficient) consistent with evidence in Baxter (1995) and Baxter and Farr (2005), implying persistence equal to 0.999 and zero spillovers across countries. Moreover, we set the standard deviation

[37] Changing the reference period for the calibration of this parameter does not change the parameter value significantly, and the implied changes have very little effects on the properties of the model.

[38] Our calibration implies that the overall flow value of unemployment, $v(h)/u_C + b$, relative to the worker's compensation, wh, is 75 percent.

[39] As for the wage rigidity parameter, changing the reference period implies little changes in these values, and little effects on the properties of the model.

of productivity innovations at 0.008 to match the absolute volatility of U.S. GDP in the period 1980:Q1-2011:Q1, but we leave the correlation of innovations at the standard 0.258 of Baxter (1995) and Backus, Kehoe, and Kydland (1992, 1994).

Finally, the parameter values in the historical rule for interest rate setting by the Federal Reserve are those estimated by Clarida, Galí, and Gertler (2000). The inflation and GDP gap coefficients are 1.62 and 0.34, respectively, and the smoothing parameter is 0.71. These values are quite representative also of later literature that estimated interest rate reaction functions for the Federal Reserve (and the central banks of other low inflation countries) for the period since the early 1980s.

Impulse Responses

Figure 1 shows impulse responses to a one-percent positive innovation to Home productivity under historical interest rate setting for both central banks in the model. We assume shock persistence 0.9 for this figure as this facilitates the presentation of results relative to the extremely slow return to the steady state implied by persistence 0.999. Focus on the Home country first. Unemployment (U_t) does not respond on impact, but it falls in the periods after the shock. The higher expected return of a match induces domestic intermediate input producers to post more vacancies on impact, which results in higher employment in the following period. Firms and workers (costly) renegotiate nominal wages because of the higher surplus generated by existing matches, and wage inflation ($\pi_{w,t}$) increases.[40]

Employment and labor income rise in the more productive economy, boosting aggregate demand for final goods and household consumption (C_t). The larger present discounted value of future profits generates higher expected return to product creation, stimulating product creation ($N_{e,t}$) and investment ($I_t \equiv N_{e,t}\varphi_t f_{e,t}$, not shown) at Home. The number of domestic plants that produce for the export market also increases, since higher aggregate productivity reduces the export productivity cutoff $z_{x,t}$ (not shown).

Foreign households shift resources to Home to finance product creation in the more productive economy. Home initially runs a current account deficit to finance increased product creation (CA_t falls on impact), and Foreign households share the benefit of higher Home productivity by shifting resources to Home via lending. (Home's deficit becomes more persistent if we increase the

[40] Wage adjustment costs make the effective firm's bargaining power procyclical, i.e., $\eta_{w,t}$ (not shown) rises. Other things equal, the increase in $\eta_{w,t}$ dampens the response of the renegotiated equilibrium wage, amplifying the response of job creation to the shock.

persistence of the shock.) The trade balance behaves similarly to the current account and moves countercyclically, as in the data.

The Home currency appreciates in nominal terms, but it depreciates in consumption-based real terms, and Home's average terms of trade ($\tilde{TOT}_t \equiv \varepsilon_t \tilde{p}_{X,t}/\tilde{p}^*_{X,t}$) depreciate, i.e., Home goods become relatively cheaper. Terms of trade depreciation is milder than in standard models: The pressure from increased Home labor demand on relative wages and the responses of $z_{x,t}$ and its foreign counterpart counteract, other things equal, the effects of higher productivity on marginal costs, and domestic export prices fall by less compared to a model that abstracts from product entry and plant heterogeneity. In contrast to standard international real business cycle (IRBC) and New Keynesian models, our model predicts a positive comovement of GDP (Y_t), employment, and investment across countries. The increase in aggregate demand at Home (which falls on both domestic and imported goods), the moderate size of expenditure switching effects induced by terms of trade dynamics, and the combination of labor market frictions with slow dynamics of the number of plants ensure that demand-side effects prevail on resource shifting in generating positive comovement.

Second Moments

Table 2 presents model-generated, HP-filtered second moments (normal fonts) based on the calibration in Table 1 (i.e., with productivity persistence 0.999 consistent with much literature). Bold fonts denote data moments for the period 1980:Q1-2011:Q1, where cross-country correlations are averages of bilateral GDP and consumption correlations between the U.S. and its four largest trading partners in that period (Canada, Japan, Germany, and UK).[41]

The model generates too much volatility of consumption and investment, but it is quite successful at replicating the volatility of unemployment, real wages, and trade relative to GDP. Moreover, it generates a negatively-sloped Beveridge curve, and all the first-order autocorrelations are in line with the data.[42] On balance, we view the performance as a successful result of the model's strong propagation mechanism. Investment volatility, though higher than in the data, is lowered relative to the excessive volatility generated by a standard IRBC framework because product creation re-

[41] The data are from the Federal Reserve Economic Data—FRED—database maintained by the Federal Reserve Bank of St. Louis. We took logarithms and HP filtered the data with the conventional value of $1,600$ for the smoothing parameter.

[42] The close match between data- and model-implied real wage moments provides indirect support for our calibration of the nominal wage adjustment cost. Shifting the reference period for calibration in the past improves the model's performance on consumption and investment volatility. For instance, a calibration based on the period 1954:Q1-1980:Q1 yields relative consumption and investment volatilities at 0.88 and 5.34, with data counterparts at 0.64 and 3.20.

quires hiring new workers. This process is time consuming due to search and matching frictions in the labor market, dampening investment dynamics. In contrast, consumption is more volatile than the excessive smoothness of traditional models as shocks induce larger and longer-lasting income effects.

With respect to the international dimension of the business cycle, the model is quite successful in matching the cyclical properties of trade data: exports ($X_{R,t}$) and imports ($IM_{R,t}$) are more volatile than GDP, the trade balance is countercyclical, and its volatility is in line with the data. These stylized facts are not reproduced by standard IRBC models (see Engel and Wang, 20011) and many New Keynesian models. The model can also reproduce a ranking of cross-country correlations that is a challenge for standard IRBC models: GDP correlation across countries is larger than consumption correlation.[43] As shown in Figure 1, an increase in Home productivity generates Foreign expansion through trade linkages, as demand-side complementarities more than offset the effect of resource shifting to the more productive economy. (This is true also with higher shock persistence than for the example of Figure 1.) Moreover, absent technology spillovers, Foreign consumers have weaker incentives to increase consumption on impact, which reduces the cross-country consumption correlation.[44]

5 Market Reforms and Monetary Policy in the International Economy

Having established that the model successfully reproduces (qualitatively and/or quantitatively) several features of the international business cycle, we turn to our main exercise and study the domestic and international consequences of market reforms in one of the countries in our model, and how such reforms affect the conduct of optimal monetary policy.

We calibrated both countries in the model to U.S. targets to assess the model's properties. A goal of our exercise in this paper is to begin shedding light on how market reforms in Europe are likely to affect transatlantic interdependence and policy incentives for the Federal Reserve and the ECB. For this purpose, we isolate structural conditions of product and labor markets as the only source of asymmetry between the euro area and the United States in our model. We accomplish this by re-calibrating the parameters that capture Home market regulation (the entry cost in product

[43] A calibration based on the pre-globalization, 1954:Q1-1980:Q1, period matches the cross-country correlation of GDPs almost perfectly (a traditionally elusive result) while preserving the ranking of consumption and GDP correlations. Details are available on request.

[44] The very low correlation of consumption across countries in Table 2 is due to the combination of incomplete markets, bond adjustment costs (albeit small), and extremely persistent shocks. Reducing shock persistence facilitates risk sharing and increases consumption correlation, consistent with results in Baxter and Crucini (1995).

markets, f_e; unemployment benefits, b; and the flexible-wage bargaining power of workers, $1-\eta$, taken as a measure of employment protection) to European levels (see the Appendix for details).[45] This adjustment in parameter values allows us to treat the Home country as a model-euro area that differs from the U.S. only by featuring more rigid product and labor markets, and to isolate the consequences of this asymmetry and of reforms that align European market characteristics to U.S. levels.

Under the new calibration, we compute the welfare benefit of moving from the historical policy behavior of the calibration in Table 1 to the Ramsey-optimal cooperative monetary policy, as well as the cooperative, Ramsey-optimal, long-run inflation rates in the two countries. These results are reported in Table 3, in the "Status Quo" row. We then compute impulse responses to Home product market reform (Figure 2), Home labor market reform (Figure 3), and joint reform of both Home markets (Figure 4). Each Home market reform brings the relevant parameter value(s) to the flexible (U.S.) level used in the previous section. The parameter change is treated as a permanent shock, and the impulse responses trace the domestic and international effects of this change from the impact period to the long run, under historical policy or the cooperative, Ramsey-optimal policy.[46]

Since much of the policy debate on the benefits of market reforms focuses on the benefits they would generate by reallocating resources to more efficient uses, for each reform, we also present figures that make it possible to study such reallocation effects. Specifically, part b of Figures 2-4 shows the responses of three measures of productivity and employment across different uses of resources in production. In our model economy, it is possible to define the productivity of the average Home product-variety line, whose output is sold both domestically and abroad, as:

$$\tilde{z}_t = \left\{ \left[\tilde{z}_d^{\theta-1} + \left(\frac{\tilde{z}_{x,t}}{\tau} \right)^{\theta-1} \frac{N_{x,t}}{N_{d,t}} \right] \right\}^{\frac{1}{\theta-1}} . \tag{28}$$

[45] For our purposes, changing directly the value of f_e is sufficient to capture changes in product market regulation. The underlying assumption is that the change comes from a change in the "red tape" portion f_R of the overall entry cost rather than in the technological requirement f_T.

[46] In the Ramsey policy problem for this exercise, we assume that the initial conditions are given by the rigid steady state under the historical policy (which features zero inflation). In technical terms, we solve for the Ramsey-optimal policy in response to market deregulation assuming time-zero commitment to the optimal plan. An alternative approach would be to solve for the optimal response to reform assuming that the initial conditions are given by the optimal Ramsey steady state with high product and labor market regulation, i.e., from a timeless perspective. Our choice has the advantage of making the comparison between historical and Ramsey-optimal policy more transparent. (In the presence of different initial conditions associated to alternative monetary policy regimes, as implied by the alternative approach, it would be impossible to isolate the role of monetary policy for the transition dynamics following reforms.)

The first row of each b-figure shows the responses to reform of this average productivity, of the average productivity of product lines that are sold only domestically ($\tilde{z}_d$, which is constant by construction), and of the average productivity for export production ($\tilde{z}_{x,t}$; this is the average productivity of the export operation of product lines sold both domestically and abroad). We then exploit linearity of production of differentiated varieties in the non-traded intermediate input, and linearity of production of the latter in labor, to plot (in the second row of each b-figure) the responses of implicit employment in the average production line, $y_t\left(\tilde{z}_t\right)/\left(Z_t\tilde{z}_t\right) \equiv y_{d,t}\left(\tilde{z}_t\right)/\left(Z_t\tilde{z}_t\right) + y_{x,t}\left(\tilde{z}_t\right)/\left(Z_t\tilde{z}_t\right)$, employment in the average product variety line that is sold only domestically, $y_{d,t}\left(\tilde{z}_d\right)/\left(Z_t\tilde{z}_d\right)$, and employment in the average export operation of traded varieties, $y_{x,t}\left(\tilde{z}_{x,t}\right)/\left(Z_t\tilde{z}_{x,t}\right)$. These are implicit measures of employment in production of the differentiated varieties, as our model assumes that labor is used in production of the intermediate input. However, linearity of the production process from labor to final varieties makes it possible for us to characterize transparently the use of labor in variety production, and thus analyze the resource reallocation effects discussed by policymakers in the context of our model. (The bottom two rows in each b-figure show the same variables for the Foreign country, to investigate the external resource allocation consequences of Home market reforms.)

Finally, we address the welfare consequences of reforms in Tables 3 and 4. All welfare results are in percentage of steady-state consumption. Table 3 presents the changes in welfare directly implied by Home reforms under historical policy and the Ramsey-optimal policy.[47] Table 4 presents the effects of Home reforms on the welfare costs of business cycles.[48]

Optimal Policy in the Status Quo

As Table 3 shows, moving from historical policy to the Ramsey-optimal, cooperative policy increases welfare by 0.54 percent of steady-state consumption at Home and 0.27 percent in Foreign under the regulation status quo. The Ramsey-optimal policy implies a higher inflation rate in the Home

[47] Results for the case in which Home pegs the exchange rate of its currency against Foreign are available on request. We do not include them in the paper given the extremely low likelihood that the ECB would ever peg the euro to the dollar.

[48] When studying optimal policy over the business cycle, we follow standard practice in the literature and assume that the non-stochastic steady state is the same across the policy regimes we consider, and it is given by the Ramsey-optimal steady state (which features non-zero inflation). When computing the welfare costs of business cycles, we follow Schmitt-Grohé and Uribe (2007), and we focus on the conditional expected discounted utility of the representative agent (as opposed to the unconditional one) in order to account for the transitional effects from the deterministic to the stochastic steady state. Since the non-stochastic steady state is the same across the policy regimes we consider, our choice of computing expected welfare conditional on the initial state being the non-stochastic steady state ensures that the economy begins from the same initial point under all policies.

country than in Foreign. (In steady state, consumer and producer price inflation rates coincide, so we simply refer to inflation when talking about the long-run target.) This can be understood with reference to the distortions we discussed above: A long-run equilibrium with constant endogenous variables eliminates some of these distortions: A constant markup removes the markup variation distortion from the product creation margin; Constant consumption removes the risk-sharing distortion of incomplete markets, and constant, zero net foreign assets eliminate the effect of asset adjustment costs. Monopoly power of firms in the downstream sector, positive unemployment benefits, and a departure from the Hosios condition in Home imply suboptimally low job-creation. Since $\pi_C = \pi_d = \pi_w$, positive inflation raises firm bargaining power η_w, favoring vacancy posting by firms. The intuition for the positive relation between inflation and η_w is straightforward: Positive inflation is costly for firms, who bear the costs of wage adjustment. Suppose we want a firm to hire the same amount of labor in an environment of positive inflation as it would with zero inflation. For the firm to be willing to do that with positive wage adjustment costs, it must be compensated by the willingness of workers to accept a lower level of the bargained wage. For this to happen, the bargaining power of firms must rise.

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 Bilbiie, Fujiwara, and Ghironi (2014), the same form of price stickiness implies a zero Ramsey-optimal inflation target in the sticky-price model of Bilbiie, Ghironi, and Melitz (2008a)—regardless of labor supply elasticity—if preferences take the C.E.S. Dixit-Stiglitz (1977) form that is common in the New Keynesian literature. The reason is that continuous C.E.S. Dixit-Stiglitz preferences imply a perfect balancing of monopoly profit incentives for product creation and the welfare benefit of product variety to consumers in the flexible-price equilibrium of the model. In this case, the Ramsey policymaker refrains from using positive average inflation to address the effect of monopoly power on labor supply just as in the benchmark New Keynesian model without producer entry. The additional distortions introduced in our model imply the optimality of positive long-run inflation.[49]

Specifically, the Ramsey policymaker must trade the beneficial welfare effects of reducing these steady-state distortions against the costs of non-zero inflation implied by distorting the product creation margin, allocating resources to wage and price changes, and by the departure from the

[49] Bilbiie, Fujiwara, and Ghironi (2014) and Cacciatore, Fiori, and Ghironi (2013) find that the optimal inflation target rises in the presence of standard forms of price and wage indexation. The reason is that indexation lowers the welfare cost associated with a given long-run inflation rate, and it requires larger inflation to achieve a given change in long-run markup and bargaining power of firms.

Hosios condition that is induced also in Foreign by having positive inflation. Compared to the zero inflation outcome, the Ramsey authority reduces the inefficiency wedge in job creation implied by the distortions. The choice of a higher inflation rate for the Home country reflects its more distorted nature, and therefore the higher desirability of inflation to close inefficiency gaps in this country.[50]

The finding of optimal positive long-run inflation is in contrast with the prescription of zero (or near zero) target inflation delivered by the vast majority of New Keynesian models in closed and open economy. 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 labor markets. In particular, the prescription of an optimal positive long-run inflation stems from the presence of wage stickiness and search and matching frictions in the labor market. Wage stickiness allows the Ramsey authority optimally to manipulate bargaining power to reduce inefficiencies in job creation. Absent sticky wages, a policy of zero long-run inflation would be optimal also in our model, as positive inflation would no longer shift effective bargaining power in favor of firms, and zero inflation would preserve efficiency along the product creation margin, confirming the result in Bilbiie, Fujiwara, and Ghironi (2014).

Optimal, cooperative policy requires deviations from price stability also over the business cycle (these deviations are amplified if regulation is high in both countries). Historical policy approximates price stability in our model, while Ramsey-optimal policy lets price inflation move more significantly in response to shocks. (Figures are available on request.) Ramsey-optimal policy lowers the cost of the cycle more significantly for Home than for Foreign—again consistently with the fact that inflation is more desirable in the more rigid country.

The Dynamic Effects of Market Reforms and Monetary Policy During the Transition

We begin by discussing the effects of reforms under the historical policy (solid lines in the figures). Figure 2 shows that Home product market reform that induces more investment in business creation (increased producer entry) at Home causes lower domestic unemployment, but also an initial contraction of GDP, and a small decrease in consumption. Both GDP and consumption then rise above the initial steady state over time. Households initially save to increase investment in business creation in the more favorable environment, and the initial GDP effect of reform ends

[50] In Cacciatore, Fiori, and Ghironi (2013), the central bank of a monetary union is constrained to choosing a single long-run inflation target for the two countries in union. When these differ in the extent to which inflation is desirable, the central bank must trade off this difference between Home and Foreign in determining its policy. The worldwide Ramsey central bank of this paper does not face this constraint as a flexible exchange rate allows it to set different targets for the two countries even in the fully cooperative scenario we consider.

up being negative, but these negative effects are reversed in one to two years (approximately one for consumption, two for GDP) as the economy reaps the benefits of increased entry and lower unemployment. The effects of Home labor market reform in Figure 3 are broadly similar. The main differences are that there is an initial dip in producer entry at Home, as labor market reform favors the operations of incumbent producers, and there is no initial contraction of Home consumption and GDP. Not surprisingly, the responses to joint reform of both product and labor markets in Figure 4 display features in between Figures 2 and 3. Interestingly, Home reform has an initially positive effect on Foreign GDP, but it is also associated with less business creation in Foreign during the transition, and it has a more persistent negative effect on Foreign consumption, with little change in unemployment.

Reforms are associated with Home terms of trade improvement, welfare-consistent real appreciation, and current account deficit for much of the transition. Terms of trade appreciation is associated with lower Home exports and higher imports, a decrease in the number of Home exporters, and, conversely, an increase in the number of Foreign exporters. While arguments in policy circles and academic literature (for instance, Corsetti, Martin, and Pesenti, 2013) often refer to increased flexibility of product and labor markets as ways to boost competitiveness and rebalance weak external positions, our analysis (like that in Cacciatore, Fiori, and Ghironi, 2013) highlights that transition dynamics are likely to be characterized by worsening external balances in reforming countries, as they experience the analog to investment booms and the associated incentive to borrow. In turn, producer entry puts upward pressure on labor costs that ends up pushing the relative price of domestic products in the same direction, leading to an appreciation of the terms of trade that is a standard prediction of models with extensive margins.[51]

Resource reallocation effects of reforms in the b-Figures are intuitive: Consistent with the decrease (increase) in the number of Home (Foreign) exporters, Home (Foreign) average export productivity rises (falls) as less efficient Home (Foreign) exporters exit (enter) the export market. Average plant employment in export production is unchanged in both countries, but that unchanged amount of labor is used with higher (lower) productivity in Home (Foreign). Different reforms have different effects on average employment for domestic sale production: It is roughly unaffected abroad, but it falls at Home in response to product market reform and in the case of joint reform of both markets (except for an initial small increase), and it rises in the case of labor market reform.

All reforms cause an increase in overall average plant productivity at Home, where average plant

[51] See Bergin and Corsetti (2014) and Ghironi and Melitz (2005) for more discussion of these mechanisms.

employment falls after product or joint market reforms, but rises after labor market reform.[52] *Ceteris paribus*, higher average productivity increases the value of job matches to upstream producers inducing them to post more vacancies and hire more labor. In the case of labor market reforms, this effect determines an increase in average plant employment. Home reforms have a positive but small short-to-medium-run effect on average plant employment abroad, with a larger short-run effect in the case of joint product and labor market reform. The increase in average plant productivity at Home is driven by the increase in average export productivity (as the ratio between the number of exporters and the total number of plants is falling), while the opposite is true in Foreign, where average exporter efficiency is falling, but the number of exporters is rising—and this is also driving the difference in the response of average employment. These responses suggest that reforms in the euro area will indeed induce a more efficient use of resources in terms of productivity, but average employment per plant may fall (even if aggregate unemployment is lower) as a consequence of the external balance effects of reforms and their implications for the proportion of exporters in the total population of producers. From the perspective of the U.S., the implications of our exercise are that the implementation of reforms in the euro area would likely have an expansionary effect on U.S. GDP and employment, and it would improve the U.S. external balance during the transition. Reduced business creation would be compensated by expanded export participation, with employment gains for the average U.S. firm in the short to medium term.

Optimal monetary policy (dashes in the figures) has the main consequence of front-loading the gains from market reforms. As Figures 2-4 show, Ramsey-optimal policy is more expansionary than historical behavior during the transition dynamics generated by market reforms, as highlighted by the responses of producer price and wage inflation in both countries. This results in more significant employment gains at Home and abroad than under historical policy regardless of the reform considered. (Notice the insignificant deflation effects of reforms even under historical policy, confirming that deflation is not among the important consequences of market reform in our framework. Reforms are indeed inflationary even under historical policy for other calibrations we considered.) Even when it engineers a larger initial consumption decline to boost product creation at Home (when the product market is reformed) through increased Home household investment and Foreign lending, Ramsey policy is generally front-loading the anticipated long-run consumption gains of reforms for Home households—and, except for an initial dip at Home and abroad, it is generating higher consumption than under historical policy during the transition dynamics also

[52] The Appendix presents more details on the long-run average productivity effects of reforms.

in Foreign. Optimal policy accomplishes the front-loading of consumption gains also by affecting the resource-reallocation effects of reforms shown in the b-Figures. Focusing on the case of joint reform of product and labor markets, optimal policy dampens the early increase in average export productivity at Home, delays the employment loss in production for domestic sales (amplifying the initial gain), and results in a more favorable short-to-medium term employment outcome for the average plant than under historical policy. The effect on export productivity is consistent with the dynamics of the number of exporters and total exports: Both the number of Home exporters and total exports rise initially and are below the initial steady state for a shorter time before converging to their higher long-run levels. Optimal policy smooths the firm-level employment costs in the euro area that are associated with reform of the area's product and labor markets, and it generates a better performance of the reforming country's export activities.[53] The result that expansionary policy front-loads the long-run gains from market reforms is consistent with arguments in Draghi (2015).

From a welfare perspective, the results in Tables 3 and 4 show that Home stands to gain much more than Foreign from reforming its markets, and that the gain is larger under the cooperative, Ramsey-optimal policy. While the benefit of reform is much larger in Home, the welfare increment in Foreign is considerably larger under optimal policy than under historical policy behavior. Though with differences across countries that trace back to the differences in their underlying distortions, both Home and Foreign benefit from cooperative, optimal policymaking that allows both countries to obtain larger gains from euro area market reforms.

Optimal Policy in the Post-Reform Long Run

Market reform reduces static and dynamic inefficiencies, making price stability more desirable once the transition to the post-reform environment is complete. As shown in Table 3, the Ramsey-optimal inflation target falls as markets become more flexible. The optimal Home inflation rate coincides with that for Foreign after joint deregulation of product and labor markets makes Home symmetric to Foreign.

The result that the optimal inflation target is lower in the post-reform environment is explained by the effects of reforms on average productivity and the number of producers: Even if, depending on the type of reform, employment by the average producer may fall as more productive incumbents

[53] Note, however, that this does not imply better current account performance, as imports and the number of Foreign exporters rise too.

require less labor to produce the same amount of output, increased labor demand from a larger number of new entrants and expansion in the total number of producers imply lower aggregate unemployment. As a consequence, there is less need of positive inflation to boost aggregate job creation closer to the efficient outcome. Over the business cycle, market reforms also reduce the costs of historical policies of near price stability (Table 4).

Does Partner Regulation Matter?

In the Appendix, we re-calibrate product and labor market parameters for both Home and Foreign to European levels, and we consider the consequences of market reforms in just one country (Home, leaving Foreign markets rigid) or both (asymmetric versus symmetric, synchronized reform). The exercise provides additional information on the functioning of the model and the benefits of reforms. Specifically, in addition to the results above, it allows us to gauge whether and how regulation in a country's partners matters for the effects and policy implications of domestic market reform.[54]

Interestingly, our results show that the level of regulation of Home's trading partner is irrelevant for both transition dynamics and the long-run effects of market reforms, as well as for their business cycle implications. This is consistent with results in Cacciatore, Fiori, and Ghironi (2013). As in the case of a monetary union explored in that paper, there are gains from coordinating reforms across countries if both are initially rigid (synchronized reforms are more beneficial than asymmetric ones). However, the magnitude of these gains is smaller than in a monetary union because asymmetric reforms do not induce an additional tradeoff for the Ramsey authority, which is not constrained to choose only one monetary instrument for two asymmetric countries. The larger benefit from synchronized reforms simply reflects higher worldwide aggregate demand.

6 Conclusions

This paper assessed the domestic and international consequences of euro area market reforms and their implications for monetary policy by the ECB and its foreign counterparts. Except for an initial contraction in European GDP following product market reform or joint reform of both product and labor markets, our model predicts that structural reforms in the euro area will have positive effects on employment and GDP in Europe and abroad. Reforms will lead to appreciated

[54] We relegate the presentation of these results to the Appendix (where we omit the corresponding b-Figures, and we do not expand on comments) because we view the exercise we focus on in the main text as closer to the real world situation of a rigid euro area that adjusts its markets to flexible U.S. standards, and the possible consequences of this adjustment.

euro area terms of trade, and they will cause the euro area to run an external deficit, at least for some time. Changes in the structure of European product and labor markets have important implications for monetary policy, with sizable gains for trade partners from the implementation of optimal, cooperative policies relative to historical behavior. The benefits of market reforms in the euro area will be maximized, domestically and abroad, if policies are adjusted cooperatively to the new structural environment in which they will operate.

Appendix

A. Ramsey-Optimal, Cooperative Monetary Policy

The worldwide Ramsey authority maximizes aggregate welfare under the constraints of the competitive economy. Let $\{\Lambda_{1,t}, ..., \Lambda_{23,t}\}_{t=0}^{\infty}$ be the Lagrange multipliers associated with the equilibrium conditions in Table A.1 (excluding the two interest-rate setting rules).[55] The Ramsey problem consists of choosing:

$$\begin{aligned}\{C_t, C_t^*, \tilde{\rho}_{d,t}, \tilde{\rho}_{d,t}^*, l_t, l_t^*, h_t, h_t^*, V_t, V_t^*, N_{d,t}, N_{d,t}^*, J_t, J_t^*, \tilde{z}_{x,t}, \tilde{z}_{x,t}^*, \pi_{w,t}, \\ \pi_{w,t}^*, \pi_{C,t}, \pi_{C,t}^*, i_{t+1}, i_{t+1}^*, a_{t+1}, a_{*,t+1}^*, Q_t, \Lambda_{1,t}, ..., \Lambda_{23,t}\}_{t=0}^{\infty},\end{aligned} \tag{29}$$

to maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{2} \left[u(C_t) - l_t v(h_t) \right] + \frac{1}{2} \left[u(C_t^*) - l_t^* v(h_t^*) \right] \right\}, \tag{30}$$

subject to the constraints in Table A.1 (excluding the interest rate rules).[56]

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

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

[56] 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.

B. Euro Area Calibration

We calibrate the parameters that capture market regulation (the entry cost in product markets, f_e; unemployment benefits, b; and the flexible-wage bargaining power of workers, $1-\eta$) to European levels. To calibrate entry costs, f_e, we compute a weighted average of Pissarides's (2003) index of entry delay for countries belonging to the Euro Area, with weights equal to the contributions of individual countries' GDPs to euro area total GDP. The implied cost of regulation is 69 percent of quarterly steady-state output, such that $f_e = 0.61$. We set $b = 0.21$, so that the replacement rate, $b/(wh)$, is equal to 0.62, the average value for the euro area (OECD, 2004). To pin down the change in workers' bargaining power, $1-\eta$, we use the fact that U.S. employment protection legislation indexes reported by OECD (2004), adjusted for worker coverage by our own calculations, are approximately one third of those for European countries. This requires setting $1-\eta$ equal to 0.52 in the euro area.

C. Long-Run Average Productivity Effects of Reforms

See Table A.2.

D. The Consequences of Reforms with a Rigid Partner

Table A.3 presents the business cycle properties of the model when both countries feature rigid markets as in the euro area calibration.[57] Tables A.4-A.6 and Figures A.1-A.3 present results on market reforms in this environment. In the tables, we consider both the case in which only Home implements market reforms and the case in which both countries reform their markets.

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TABLE 1. CALIBRATION

Risk Aversion	$\gamma_C = 1$
Frisch Elasticity	$1/\gamma_h = 0.3$
Discount Factor	$\beta = 0.99$
Elasticity Matching Function	$\varepsilon = 0.6$
Flexible-Wage Firm Bargaining Power	$\eta = 0.6$
Unemployment Benefit	$b = 0.19$
Exogenous Worker Separation	$\lambda = 0.10$
Vacancy Cost	$\kappa = 0.10$
Matching Efficiency	$\chi = 0.73$
Elasticity of Substitution	$\theta = \phi = 3.8$
Plant Exit	$\delta = 0.029$
Pareto Shape	$k_p = 3.4$
Pareto Support	$z_{\min} = 1$
Sunk Entry Cost	$f_e = 0.58$
Fixed Export Costs	$f_x = 0.003$
Iceberg Trade Costs	$\tau = 1.51$
Wage Adjustment Cost	$\vartheta = 80$
Price Adjustment Cost	$\nu = 80$
Bond Adjustment Cost	$\psi = 0.0025$
Historical Policy, Interest Rate Smoothing	$\varrho_i = 0.71$
Historical Policy, Inflation	$\varrho_\pi = 1.62$
Historical Policy, GDP Gap	$\varrho_Y = 0.34$
Productivity Persistence	$\Phi_{11} = \Phi_{22} = 0.999$
Productivity Spillover	$\Phi_{12} = \Phi_{21} = 0$
Productivity Innovations, Standard Deviation	0.008
Productivity Innovations, Correlation	0.258

TABLE 2. BUSINESS CYCLE STATISTICS

Variable	$\sigma_{X_R^U}/\sigma_{Y_R^U}$		1st Autocorr.		$corr(X_{R,t}^U, Y_{R,t}^U)$	
Y_R	**1**	1	**0.86**	0.77	**1**	1
C_R	**0.63**	1.20	**0.73**	0.74	**0.68**	0.79
I_R	**3.22**	6.77	**0.91**	0.75	**0.89**	0.53
U	**8.73**	8.73	**0.78**	0.66	**-0.86**	-0.61
w_R	**0.52**	0.69	**0.91**	0.93	**0.56**	0.79
X_R	**2.79**	2.35	**0.63**	0.61	**0.34**	0.50
IM_R	**3.17**	2.08	**0.76**	0.61	**0.75**	0.45
$corr(C_{R,t}, C_{R,t}^*)$	**0.44**	0.15				
$corr(Y_{R,t}, Y_{R,t}^*)$	**0.51**	0.67				

Bold fonts denote U.S. data moments, normal fonts denote model-generated moments.

TABLE 3. WELFARE EFFECTS OF REFORMS, NON STOCHASTIC STEADY STATE

Market Reform	ΔWelfare (Historical)		ΔWelfare (Ramsey)		Ramsey Inflation	
	Home	Foreign	Home	Foreign	Home	Foreign
Status Quo (Flexible Foreign)	0%	0%	0.54%	0.27%	1.85%	1.38%
PMR	2.34%	0.04%	2.84%	0.31%	1.81%	1.37%
LMR	3.93%	0.17%	4.23%	0.43%	1.40%	1.36%
JOINT	6.10%	0.21%	6.37%	0.46%	1.36%	1.36%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform;

ΔWelfare (Historical) ≡ Welfare change under historical policy;

ΔWelfare (Ramsey) ≡ Welfare change under Ramsey policy.

TABLE 4. WELFARE EFFECTS OF REFORMS, STOCHASTIC STEADY STATE

Market Reform	Welfare Cost (Historical)		Welfare Cost (Ramsey)	
	Home	Foreign	Home	Foreign
Status Quo (Flexible Foreign)	2.57%	1.21%	2.20%	0.98%
PMR	2.23%	1.20%	1.88%	0.96%
LMR	1.29%	1.16%	1.04%	0.93%
JOINT	1.15%	1.15%	0.92%	0.92%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform;

Welfare Cost (Historical) ≡ Welfare cost of business cycles under historical policy;

Welfare Cost (Ramsey) ≡ Welfare cost of business cycles under Ramsey policy.

TABLE A.1. MODEL SUMMARY

$1=\tilde{\rho}_{d,t}^{1-\theta}N_{d,t}^{\frac{1-\phi}{1-\theta}}+\tilde{\rho}_{x,t}^{*1-\theta}N_{x,t}^{*\frac{1-\phi}{1-\theta}}$	(1)
$1=\tilde{\rho}_{d,t}^{*1-\theta}N_{d,t}^{\frac{1-\phi}{1-\theta}}+\tilde{\rho}_{x,t}^{1-\theta}N_{x,t}^{\frac{1-\phi}{1-\theta}}$	(2)
$\tilde{\rho}_{x,t}^{-\theta}N_{x,t}^{\frac{\theta-\phi}{1-\theta}}Y_t^{C*}=\frac{(\theta-1)}{k_p-(\theta-1)}\frac{\tilde{z}_{x,t}}{\tau_t}f_{x,t}$	(3)
$\tilde{\rho}_{x,t}^{*-\theta}N_{x,t}^{*\frac{\theta-\phi}{1-\theta}}Y_t^{C}=\frac{(\theta-1)}{k_p-(\theta-1)}\frac{\tilde{z}^*_{x,t}}{\tau^*_t}f^*_{x,t}$	(4)
$l_th_t=N_{d,t}\frac{\tilde{y}_{d,t}}{Z_t\tilde{z}_d}+N_{x,t}\frac{\tilde{y}_{x,t}}{Z_t\tilde{z}_{x,t}}\tau_t+N_{e,t}\frac{f_{e,t}}{Z_t}+N_{x,t}\frac{f_{x,t}}{Z_t}$	(5)
$l^*_th^*_t=N^*_{d,t}\frac{\tilde{y}^*_{d,t}}{Z^*_t\tilde{z}_d}+N^*_{x,t}\frac{\tilde{y}^*_{x,t}}{Z_t\tilde{z}^*_{x,t}}\tau_t+N^*_{e,t}\frac{f^*_{e,t}}{Z^*_t}+N^*_{x,t}\frac{f^*_{x,t}}{Z^*_t}$	(6)
$l_t=(1-\lambda)l_{t-1}+q_{t-1}V_{t-1}$	(7)
$l^*_t=(1-\lambda)l^*_{t-1}+q^*_{t-1}V^*_{t-1}$	(8)
$1=E_t\left\{\tilde{\beta}_{t,t+1}\frac{\tilde{\rho}_{d,t+1}}{\tilde{\rho}_{d,t}}\left[\begin{array}{c}\frac{\mu_{d,t}}{\mu_{d,t+1}}\left(\frac{f_{e,t+1}}{f_{e,t}}-\frac{N_{x,t+1}}{N_{d,t+1}}\frac{f_{x,t+1}}{f_{e,t}}\right)+\\ \frac{1}{(\theta-1)f_{e,t}}\left(\frac{\mu_{d,t}}{\mu_{d,t+1}}\tilde{y}_{d,t+1}+\frac{N_{x,t+1}}{N_{d,t+1}}\frac{Q_{t+1}\tilde{\rho}_{x,t+1}\tilde{z}_{x,t+1}}{\tilde{\rho}_{d,t+1}\tilde{z}_d}\frac{\mu_{d,t+1}}{\mu_{x,t+1}}\tilde{y}_{x,t+1}\right)\end{array}\right]\right\}$	(9)
$1=E_t\left\{\tilde{\beta}^*_{t,t+1}\frac{\tilde{\rho}^*_{d,t+1}}{\tilde{\rho}^*_{d,t}}\left[\begin{array}{c}\frac{\mu^*_{d,t}}{\mu^*_{d,t+1}}\left(\frac{f^*_{e,t+1}}{f^*_{e,t}}-\frac{N^*_{x,t+1}}{N^*_{d,t+1}}\frac{f^*_{x,t+1}}{f^*_{e,t}}\right)+\\ \frac{1}{(\theta-1)f^*_{e,t}}\left(\frac{\mu^*_{d,t}}{\mu^*_{d,t+1}}\tilde{y}^*_{d,t+1}+\frac{N^*_{x,t+1}}{N^*_{d,t+1}}\frac{\tilde{\rho}^*_{x,t+1}\tilde{z}^*_{x,t+1}}{Q_{t+1}\tilde{\rho}^*_{d,t+1}\tilde{z}_d}\frac{\mu^*_{d,t+1}}{\mu^*_{x,t+1}}\tilde{y}^*_{x,t+1}\right)\end{array}\right]\right\}$	(10)
$1=E_t\left\{\beta_{t,t+1}\left[(1-\lambda)\frac{q_t}{q_{t+1}}+\frac{q_t}{\kappa}\left(\varphi_{t+1}Z_{t+1}h_{t+1}-\frac{w_{t+1}}{P_{t+1}}h_{t+1}-\frac{\vartheta}{2}\pi^2_{w,t+1}\right)\right]\right\}$	(11)
$1=E_t\left\{\beta^*_{t,t+1}\left[(1-\lambda)\frac{q^*_t}{q^*_{t+1}}+\frac{q^*_t}{\kappa}\left(\varphi^*_{t+1}Z^*_{t+1}h^*_{t+1}-\frac{w^*_{t+1}}{P^*_{t+1}}h^*_{t+1}-\frac{\vartheta}{2}\pi^{*2}_{w,t+1}\right)\right]\right\}$	(12)
$v_{h,t}/u_{C,t}=\varphi_tZ_t$	(13)
$v^*_{h,t}/u^*_{C,t}=\varphi^*_tZ^*_t$	(14)
$\pi_{w,t}=\frac{w^r_t}{w^r_{t-1}}\pi_{C,t}$	(15)
$\pi^*_{w,t}=\frac{w^{r*}_t}{w^{r*}_{t-1}}\pi^*_{C,t}$	(16)
$\begin{aligned}&\frac{w_t}{P_t}h_t=\eta_t\left(\frac{v(h_t)}{u_{C,t}}+b\right)+(1-\eta_t)\left(\varphi_tZ_th_t-\frac{\vartheta}{2}\pi^2_{w,t}\right)\\ &+E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_t)-(1-\lambda-\iota_t)(1-\eta_{t+1})\frac{\eta_t}{\eta_{t+1}}\right]\right\}\end{aligned}$	(17)
$\begin{aligned}&\frac{w^*_t}{P^*_t}h^*_t=\eta^*_t\left(\frac{v(h^*_t)}{u_{C^*,t}}+b^*\right)+(1-\eta^*_t)\left(\varphi^*_tZ^*_th^*_t-\frac{\vartheta}{2}\pi^{*2}_{w,t}\right)\\ &+E_t\left\{\beta^*_{t,t+1}J^*_{t+1}\left[(1-\lambda)(1-\eta^*_t)-(1-\lambda-\iota^*_t)(1-\eta^*_{t+1})\frac{\eta^*_t}{\eta^*_{t+1}}\right]\right\}\end{aligned}$	(18)
$1+i_{t+1}=(1+i_t)^{\varrho_i}\left[(1+i)(1+\tilde{\pi}_{C,t})^{\varrho_\pi}\left(\tilde{Y}_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}$	(19)
$1+i^*_{t+1}=(1+i^*_t)^{\varrho_i}\left[(1+i^*)\left(1+\tilde{\pi}^*_{C,t}\right)^{\varrho_\pi}\left(\tilde{Y}^*_{g,t}\right)^{\varrho_Y}\right]^{1-\varrho_i}$	(20)
$1+\psi a_{t+1}=(1+i_{t+1})E_t\beta_{t,t+1}\left(\frac{1}{1+\pi_{C,t+1}}\right)$	(21)
$1-\psi a^*_{*,t+1}=\left(1+i^*_{t+1}\right)E_t\beta_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\frac{1}{1+\pi^*_{C,t+1}}\right)$	(22)
$1+\psi a^*_{*,t+1}=\left(1+i^*_{t+1}\right)E_t\beta^*_{t,t+1}\left(\frac{1}{1+\pi^*_{C,t+1}}\right)$	(23)
$1-\psi a_{t+1}=(1+i_{t+1})E_t\beta^*_{t,t+1}\left(\frac{Q_t}{Q_{t+1}}\frac{1}{1+\pi_{C,t+1}}\right)$	(24)
$a_{t+1}=\frac{1+i_t}{1+\pi_{C,t}}a_t-Q_t\frac{1+i^*_t}{1+\pi^*_{C,t}}a^*_{*,t}+N_{x,t}\tilde{\rho}_{d,t}\tilde{y}_{x,t}-N^*_{x,t}Q_t\tilde{\rho}^*_{d,t}\tilde{y}^*_{x,t}$	(25)

TABLE A.2. LONG-RUN AVERAGE PRODUCTIVITY

Market Reform	Δ Average Productivity (Historical)		Δ Average Productivity (Ramsey)	
	Home	Foreign	Home	Foreign
Status Quo (Flexible Foreign)	0%	0%	0%	0%
PMR	0.35%	-0.03%	0.37%	-0.03%
LMR	0.11%	-0.10%	0.11%	-0.10%
JOINT	0.46%	-0.13%	0.46%	-0.13%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform;

Δ Average Productivity (Historical) ≡ Average productivity change under historical policy;

Δ Average Productivity (Ramsey) ≡ Average productivity change under Ramsey policy;

TABLE A.3. BUSINESS CYCLE STATISTICS, EURO AREA CALIBRATION

Variable	$\sigma_{X_R^U}/\sigma_{Y_R^U}$		1st Autocorr.		$corr(X_{R,t}^U, Y_{R,t}^U)$	
Y_R	**1**	1	**0.91**	0.78	**1**	1
C_R	**0.51**	1.21	**0.89**	0.75	**0.87**	0.77
I_R	**2.50**	6.37	**0.89**	0.78	**0.94**	0.50
U	**5.40**	6.92	**0.89**	0.76	**-0.86**	-0.64
w_R	**0.50**	0.61	**0.85**	0.94	**0.56**	0.77
$corr(C_{R,t}, C_{R,t}^*)$	**0.55**	0.13				
$corr(Y_{R,t}, Y_{R,t}^*)$	**0.86**	0.68				

Bold fonts denote euro-area-wide data moments, normal fonts denote model-generated moments.

TABLE A.4. WELFARE EFFECTS OF REFORMS, NON STOCHASTIC STEADY STATE, EURO AREA CALIBRATION

Market Reform	ΔWelfare (Historical)		ΔWelfare (Ramsey)		Ramsey Inflation	
	Home	Foreign	Home	Foreign	Home	Foreign
Status Quo (Rigid Foreign)	0%	0%	0.57%	0.57%	1.87%	1.87%
Asymmetric PMR	2.57%	0.05%	3.10%	0.62%	1.82%	1.87%
Asymmetric LMR	4.20%	0.22%	4.51%	0.77%	1.39%	1.86%
Asymmetric JOINT	6.14%	0.24%	6.44%	0.79%	1.38%	1.85%
Symmetric PMR	2.62%	2.62%	3.15%	3.15%	1.82%	1.82%
Symmetric LMR	4.39%	4.39%	4.67%	4.67%	1.38%	1.38%
Symmetric JOINT	6.33%	6.33%	6.60%	6.60%	1.37%	1.37%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform; Asymmetric ≡ Home country reform;

Symmetric ≡ Home and Foreign country reform;

ΔWelfare (Historical) ≡ Welfare change under historical policy;

ΔWelfare (Ramsey) ≡ Welfare change under Ramsey policy.

TABLE A.5. WELFARE EFFECTS OF REFORMS, STOCHASTIC STEADY STATE, EURO AREA CALIBRATION

Market Reform	Welfare Cost (Historical)		Welfare Cost (Ramsey)	
	Home	Foreign	Home	Foreign
Status Quo (Rigid Foreign)	2.68%	2.68%	2.29%	2.29%
Asymmetric PMR	2.29%	2.65%	1.94%	2.26%
Asymmetric LMR	1.23%	2.58%	0.99%	2.20%
Asymmetric JOINT	1.21%	2.57%	0.98%	2.19%
Symmetric PMR	2.26%	2.26%	1.92%	1.92%
Symmetric LMR	1.17%	1.17%	0.94%	0.94%
Symmetric JOINT	1.16%	1.16%	0.93%	0.93%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform; Asymmetric ≡ Home country reform;

Symmetric ≡ Home and Foreign country reform;

Welfare Cost (Historical) ≡ Welfare cost of business cycles under historical policy;

Welfare Cost (Ramsey) ≡ Welfare cost of business cycles under Ramsey policy.

TABLE A.6. LONG-RUN AVERAGE PRODUCTIVITY, EURO AREA CALIBRATION

Market Reform	Δ Average Productivity (Historical)		Δ Average Productivity (Ramsey)	
	Home	Foreign	Home	Foreign
Status Quo (Rigid Foreign)	0%	0%	0%	0%
Asymmetric PMR	0.38%	-0.03%	0.38%	-0.03%
Asymmetric LMR	0.12%	-0.12%	0.11%	-0.11%
Asymmetric JOINT	0.44%	-0.14%	0.44%	-0.13%
Symmetric PMR	0.35%	0.35%	0.35%	0.35%
Symmetric LMR	0.00%	0.00%	0.00%	0.00%
Symmetric JOINT	0.32%	0.32%	0.32%	0.32%

Note: PMR ≡ Product Market Reform; LMR ≡ Labor Market Reform;

JOINT ≡ Product and Labor Market Reform; Asymmetric ≡ Home country reform;

Symmetric ≡ Home and Foreign country reform;

Δ Average Productivity (Historical) ≡ Average productivity change under historical policy;

Δ Average Productivity (Ramsey) ≡ Average productivity change under Ramsey policy;

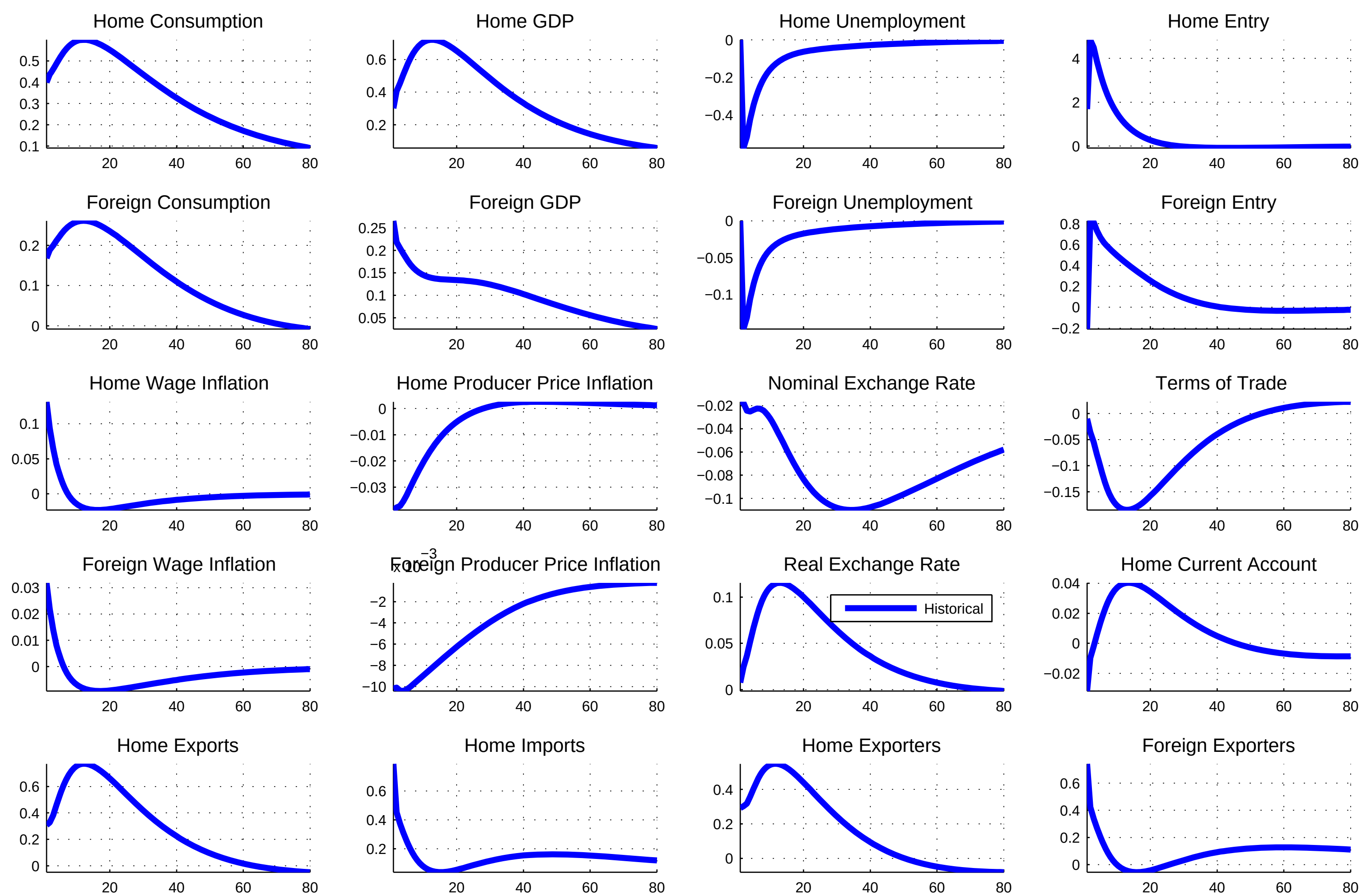

Figure 1. Home Productivity Shock, Flexible Regulation, Historical Policy.

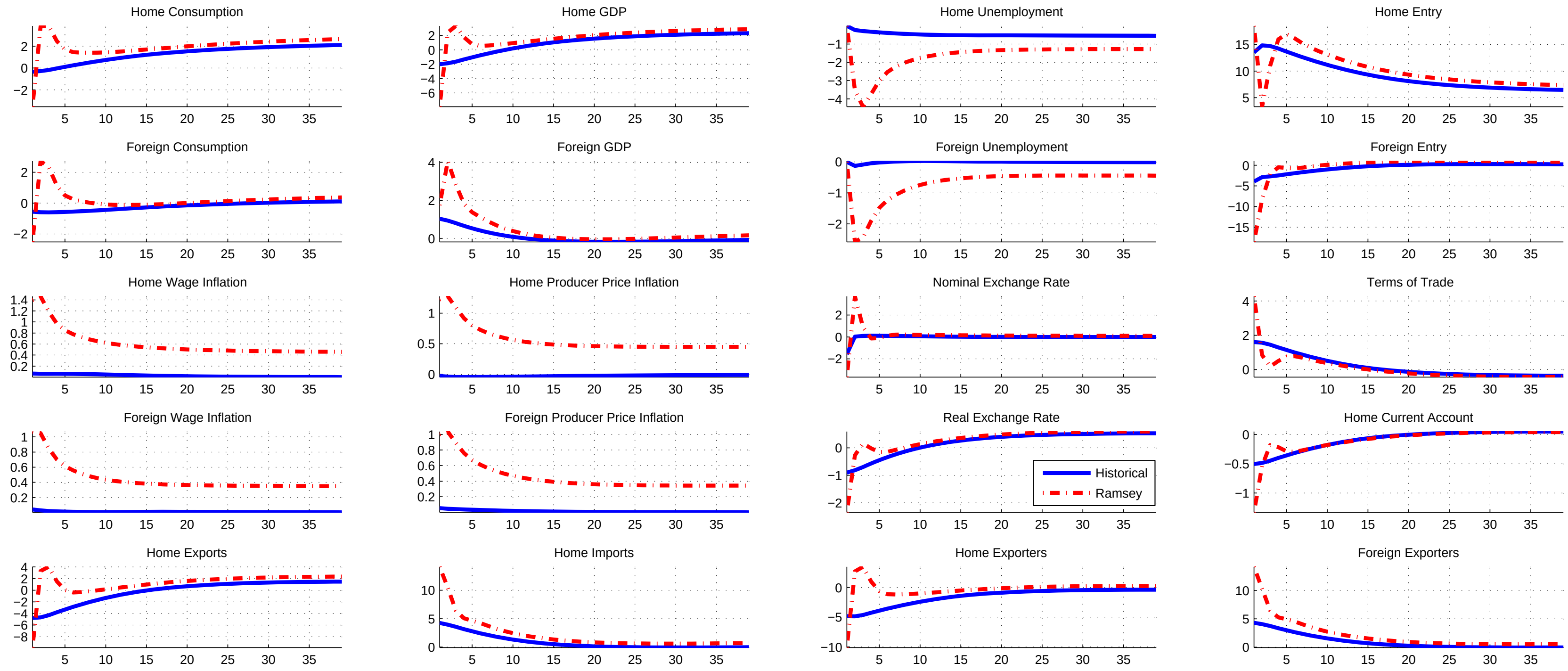

Figure 2. Home Product Market Deregulation, Flexible Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).

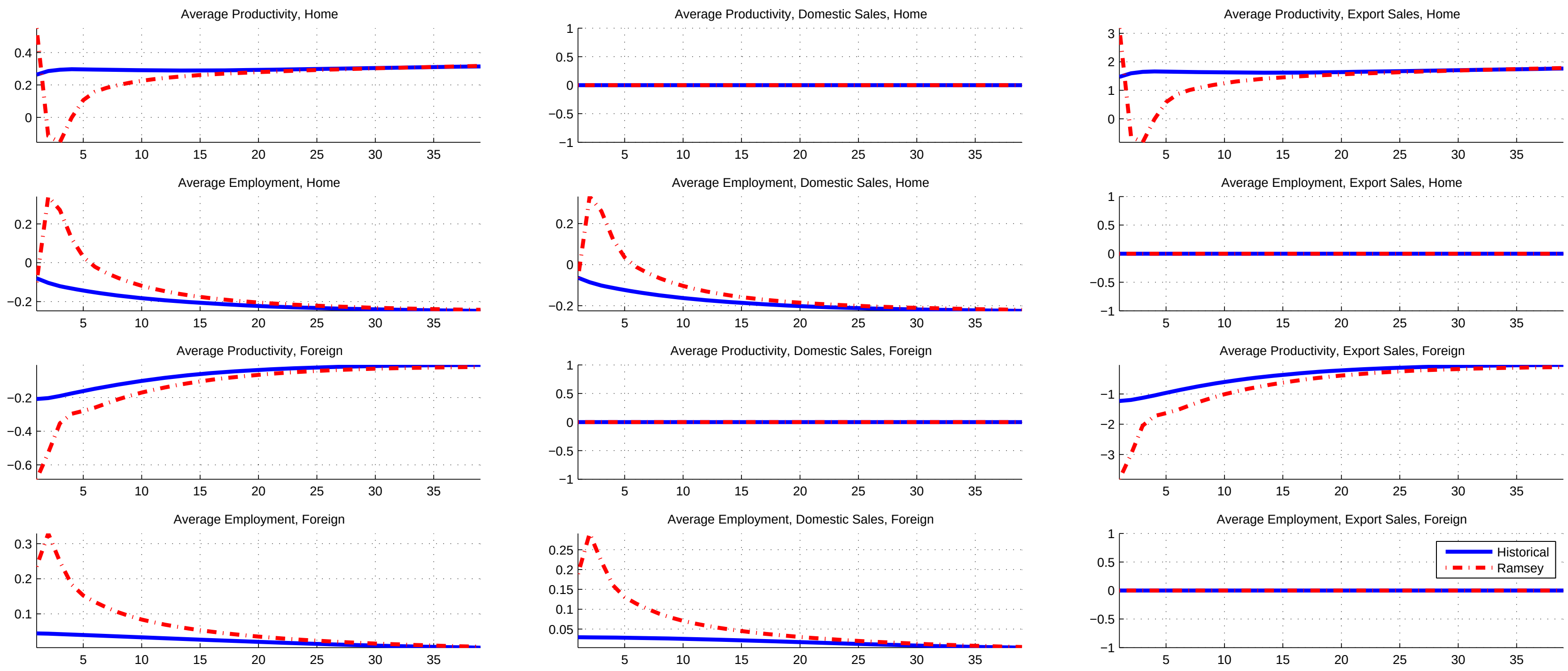

Figure 2b. Home Product Market Deregulation, Productivity and Labor Reallocation Effects.

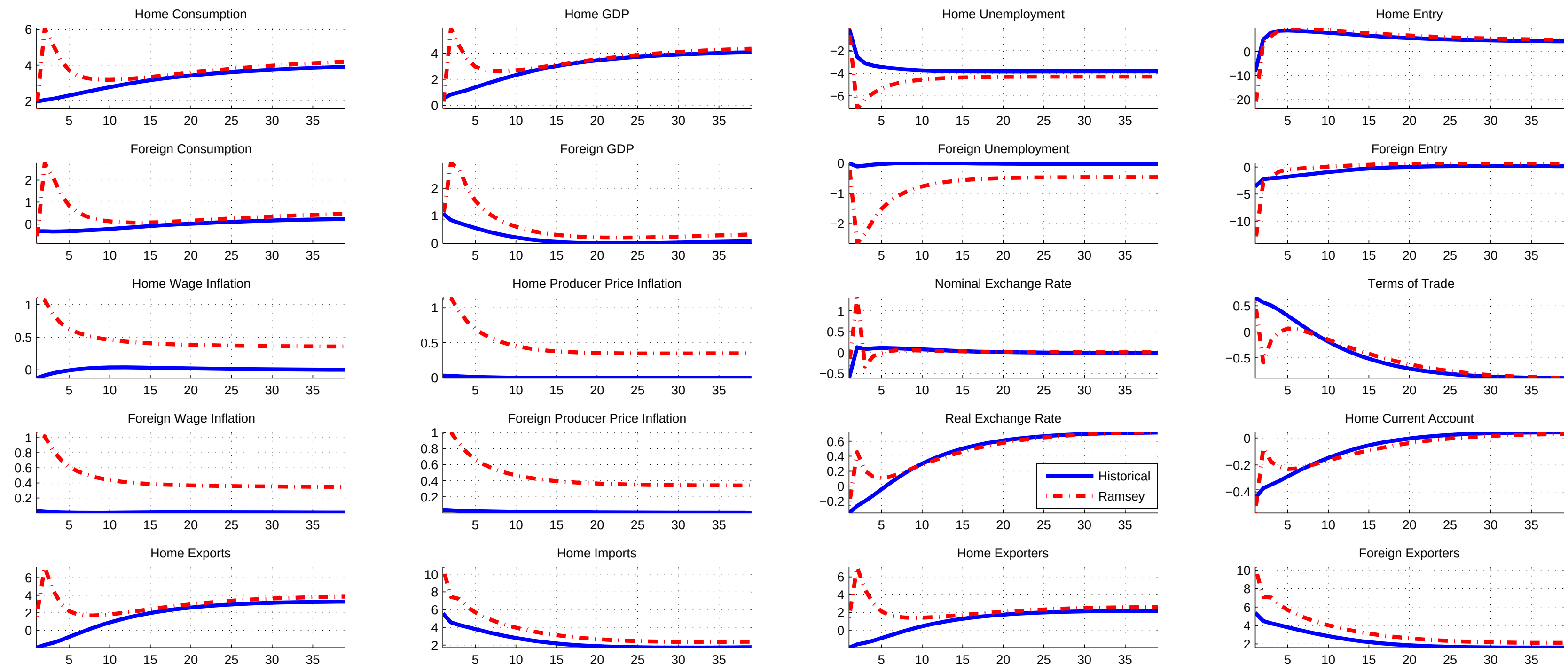

Figure 3. Home Labor Market Deregulation, Flexible Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).

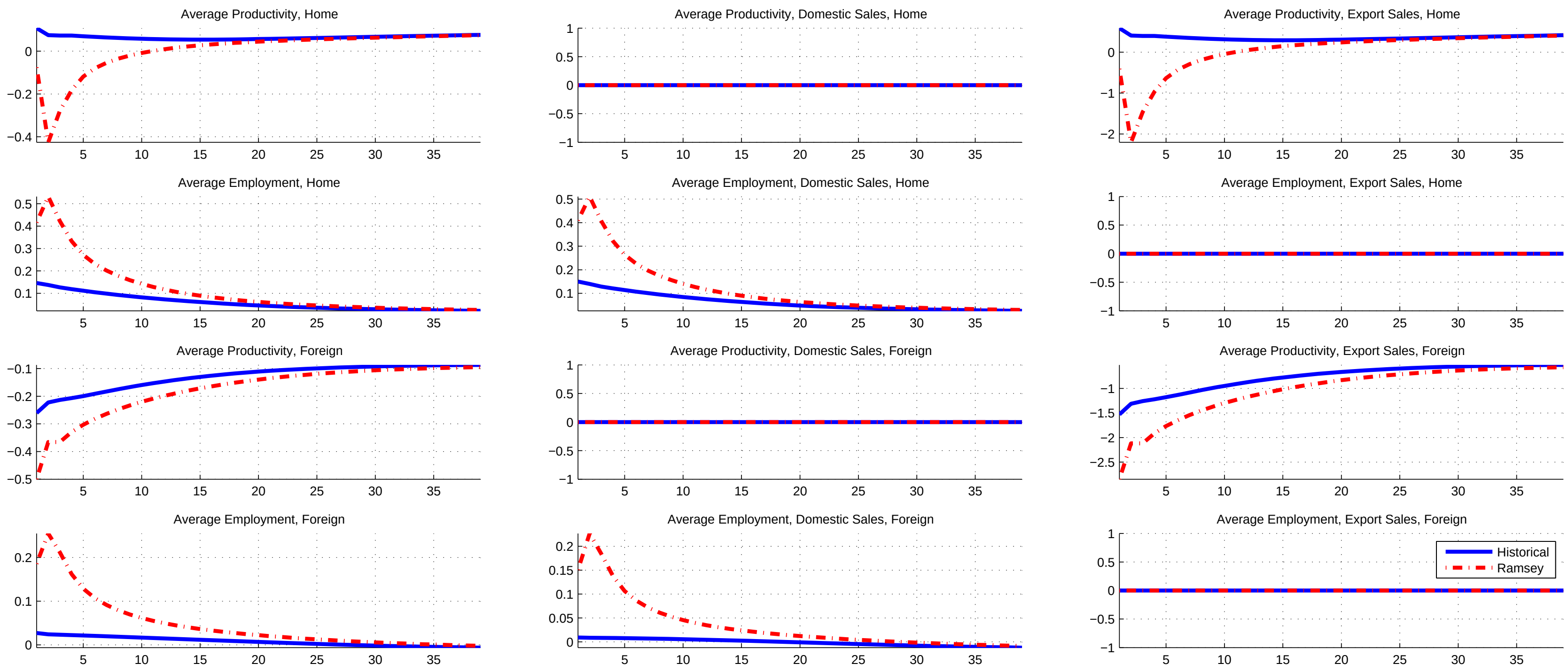

Figure 3b. Home Labor Market Deregulation, Productivity and Labor Reallocation Effects.

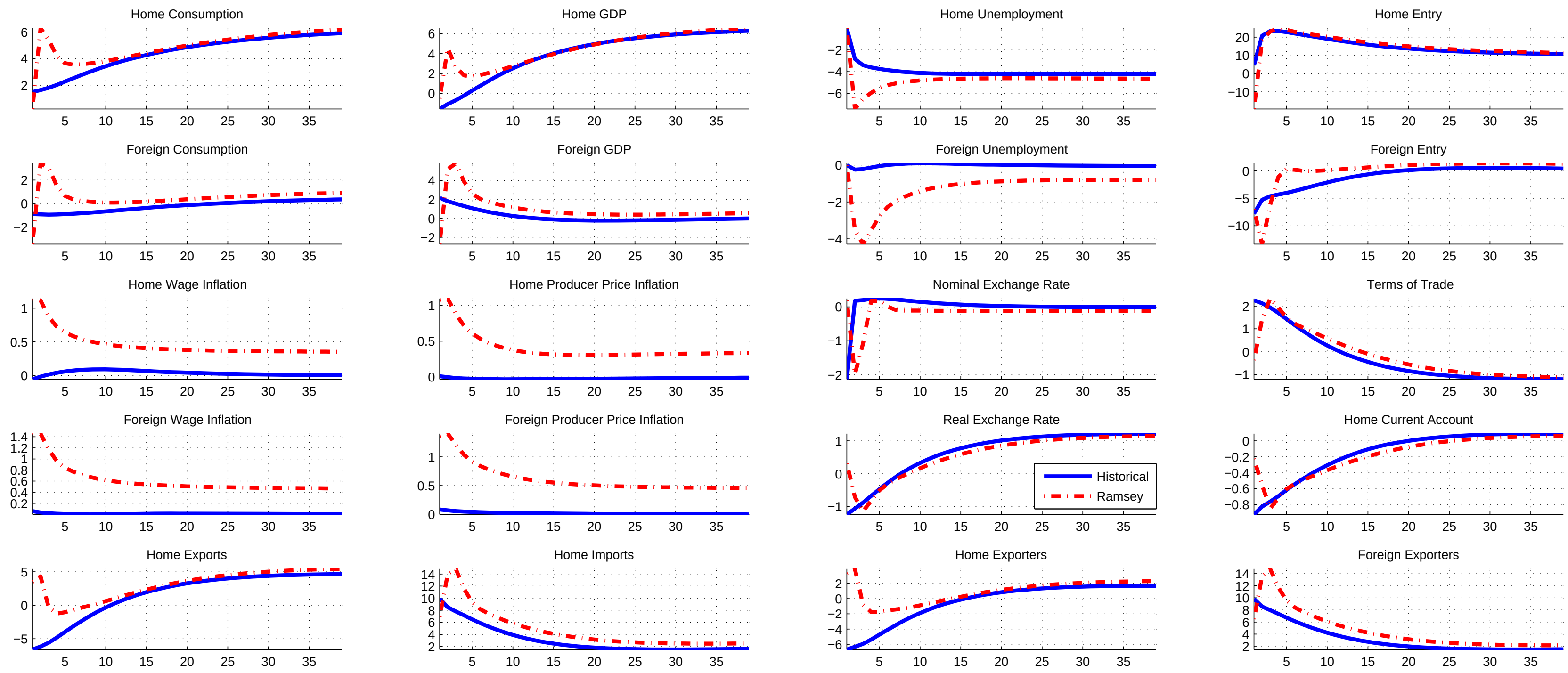

Figure 4. Home Product and Labor Market Deregulation, Flexible Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).

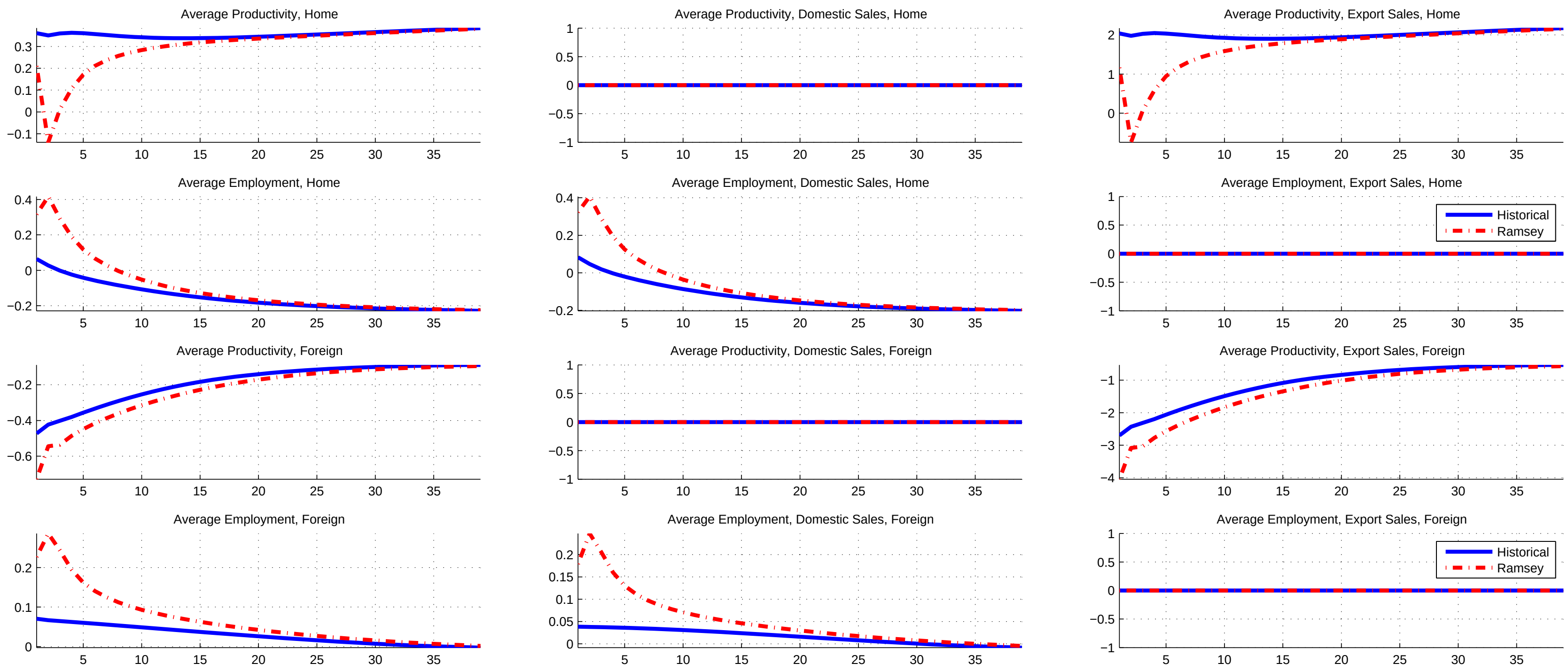

Figure 4b. Home Product and Labor Market Deregulation, Productivity and Labor Reallocation Effects.

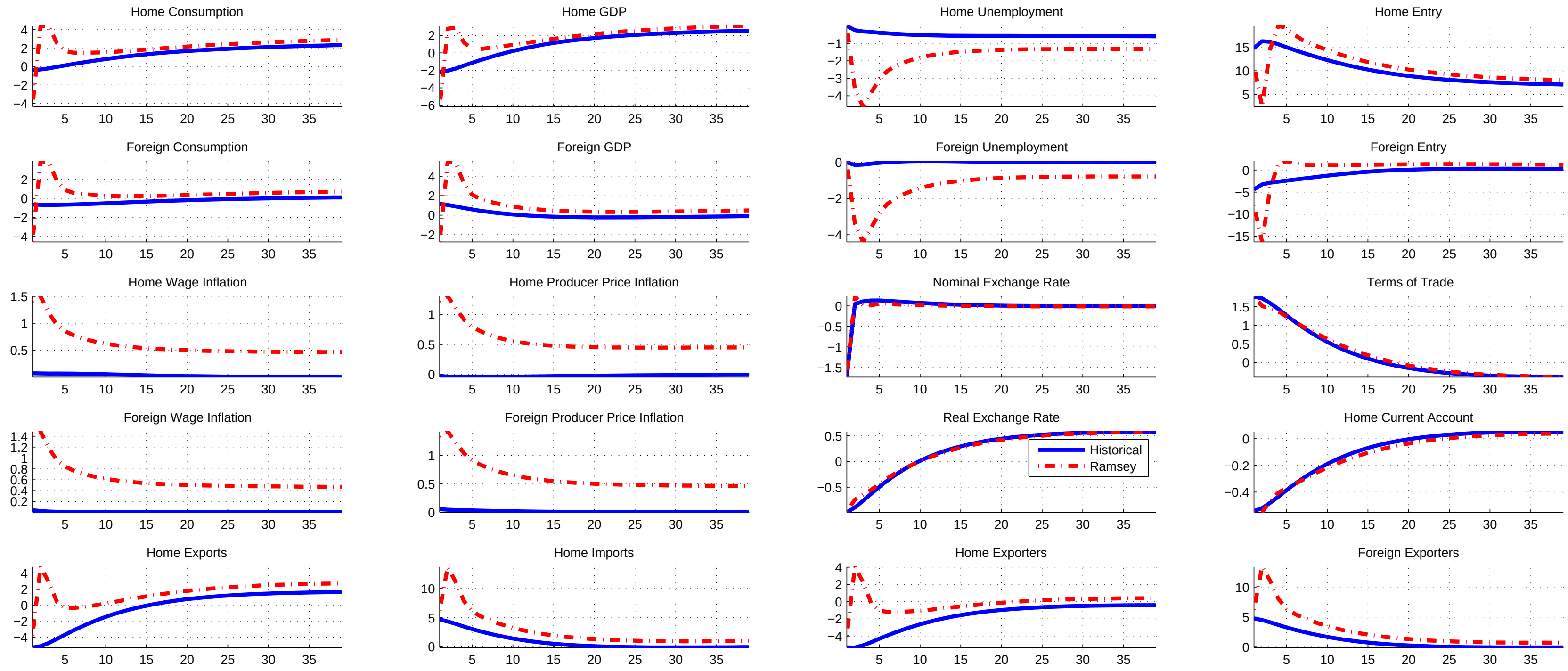

Figure A.1. Home Product Market Deregulation, Rigid Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).

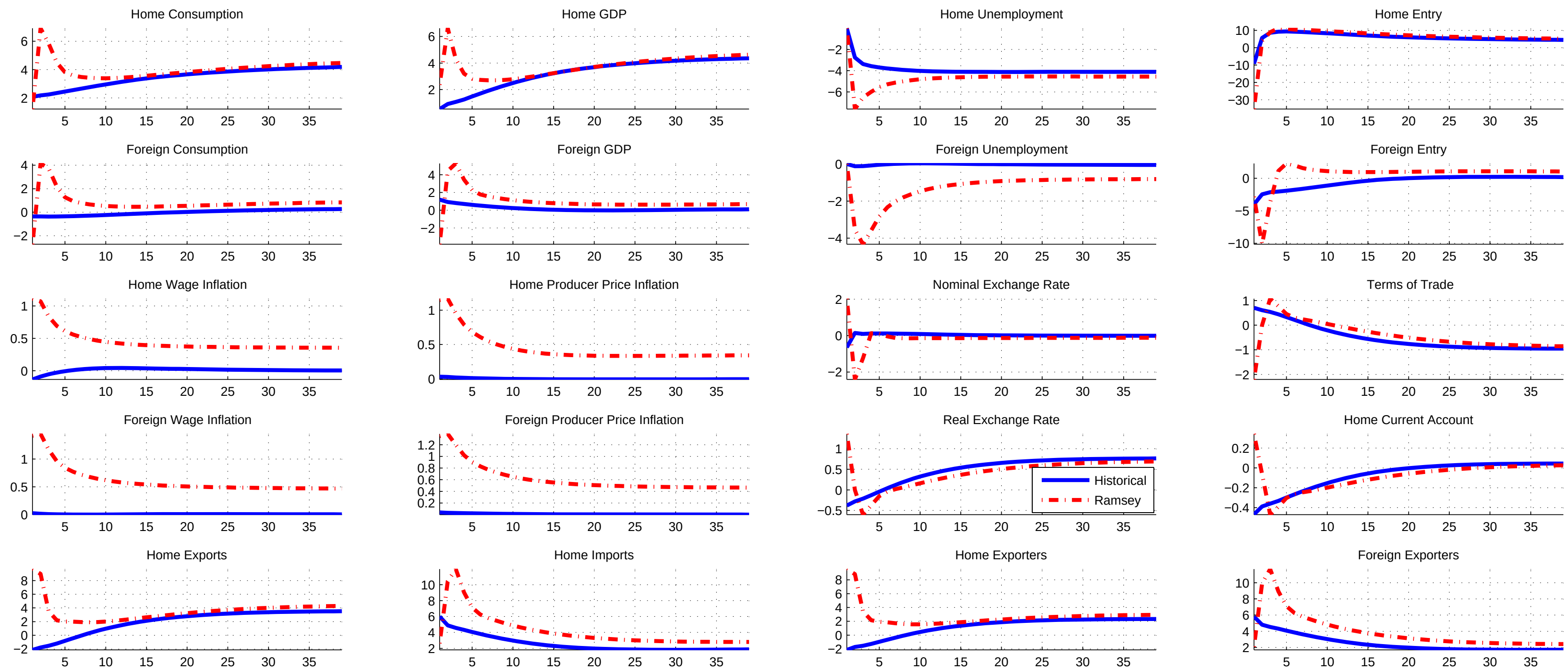

Figure A.2. Home Labor Market Deregulation, Rigid Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).

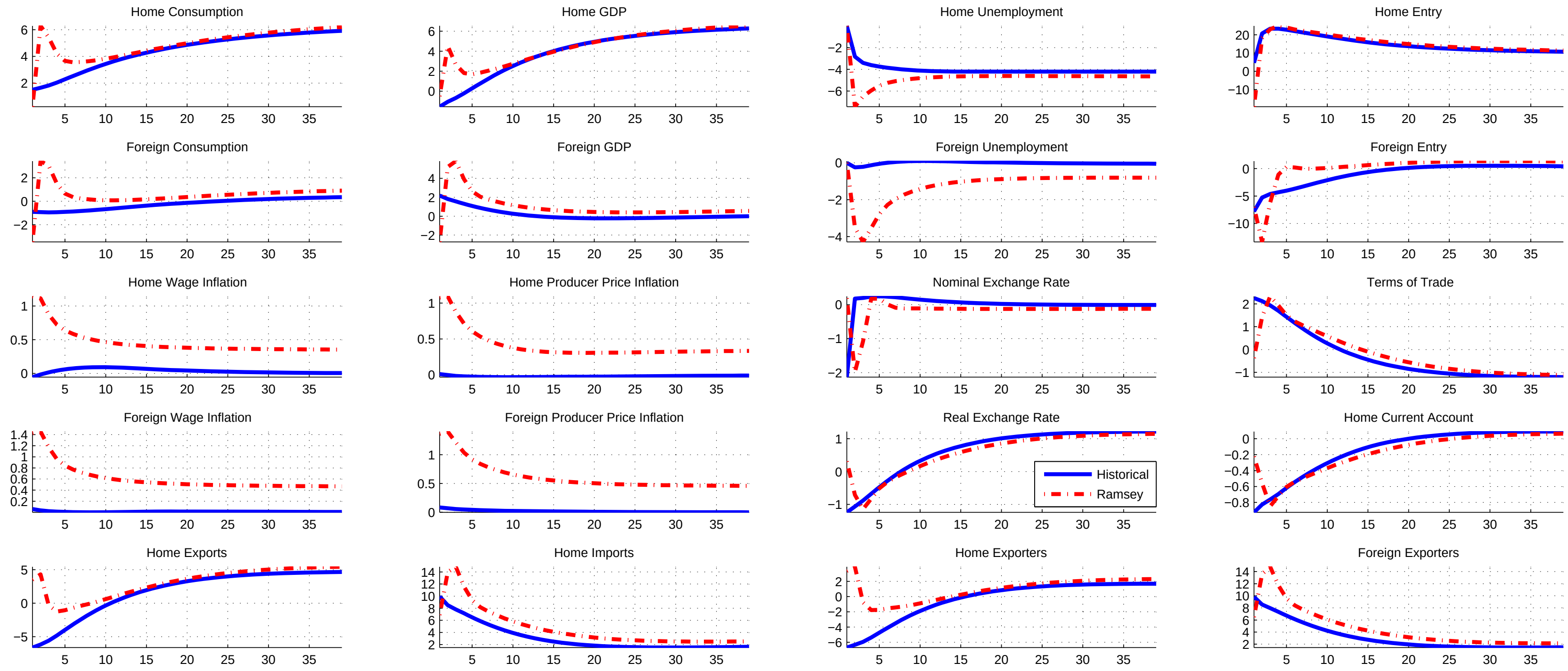

Figure A.3. Home Product and Labor Market Deregulation, Rigid Regulation in Foreign. Historical Policy (Solid) versus Optimal Policy (Dashes).