

Financial Heterogeneity and Monetary Union

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Abstract

We analyze the business cycle and welfare consequences of forming a monetary union among countries with varying degrees of financial market distortions, which interact with the firms' pricing decisions because of customer markets considerations. In response to an adverse financial shock, firms in financially weak countries (the periphery) try to maintain current cashflows by raising markups—in spite of losing their market share—while firms in countries with greater financial capacity (the core) lower markups, undercutting their financially constrained foreign competitors to gain market share. Because the core country firms do not internalize the effects of a price cut on the union-wide demand, a monetary union of countries with heterogeneous financial capacities creates a tendency toward internal devaluation for the core countries, leading to chronic current account deficits in the periphery. While complete risk sharing among countries can significantly improve welfare of the periphery, such an arrangement involves a large transfer of wealth from the core to the periphery. Depending on the strength of pecuniary externality not internalized by the pricing decisions of core country firms, a unilateral fiscal devaluation by the periphery can improve the union's overall welfare.

JEL CLASSIFICATION: E31, E32, F44, F45

KEYWORDS: financial crisis, monetary union, inflation dynamics, markups, fiscal devaluation, fiscal union

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1 Introduction

The consensus in both academic and policy circles is that the eurozone’s recent economic woes stem from a classic balance-of-payment crisis, which can be traced to the toxic mix of excessive credit growth and loss of competitiveness in the euro area “periphery.” Following the introduction of the euro in early 1999, periphery countries such as Greece, Ireland, Italy, Spain, and Portugal went on a borrowing spree, the proceeds of which were used largely to finance domestic consumption and housing investment. Foreign investors’ widespread reassessment of risks during the 2008–2009 global financial crisis, along with a growing recognition of an unsustainable fiscal situation in Greece, precipitated a sharp pullback in private capital from the euro area periphery in early 2010. This further tightening of financial conditions significantly exacerbated the already painful process of deleveraging, through which the periphery economies were attempting to bring domestic spending—both government and private—back into line with domestic incomes.¹

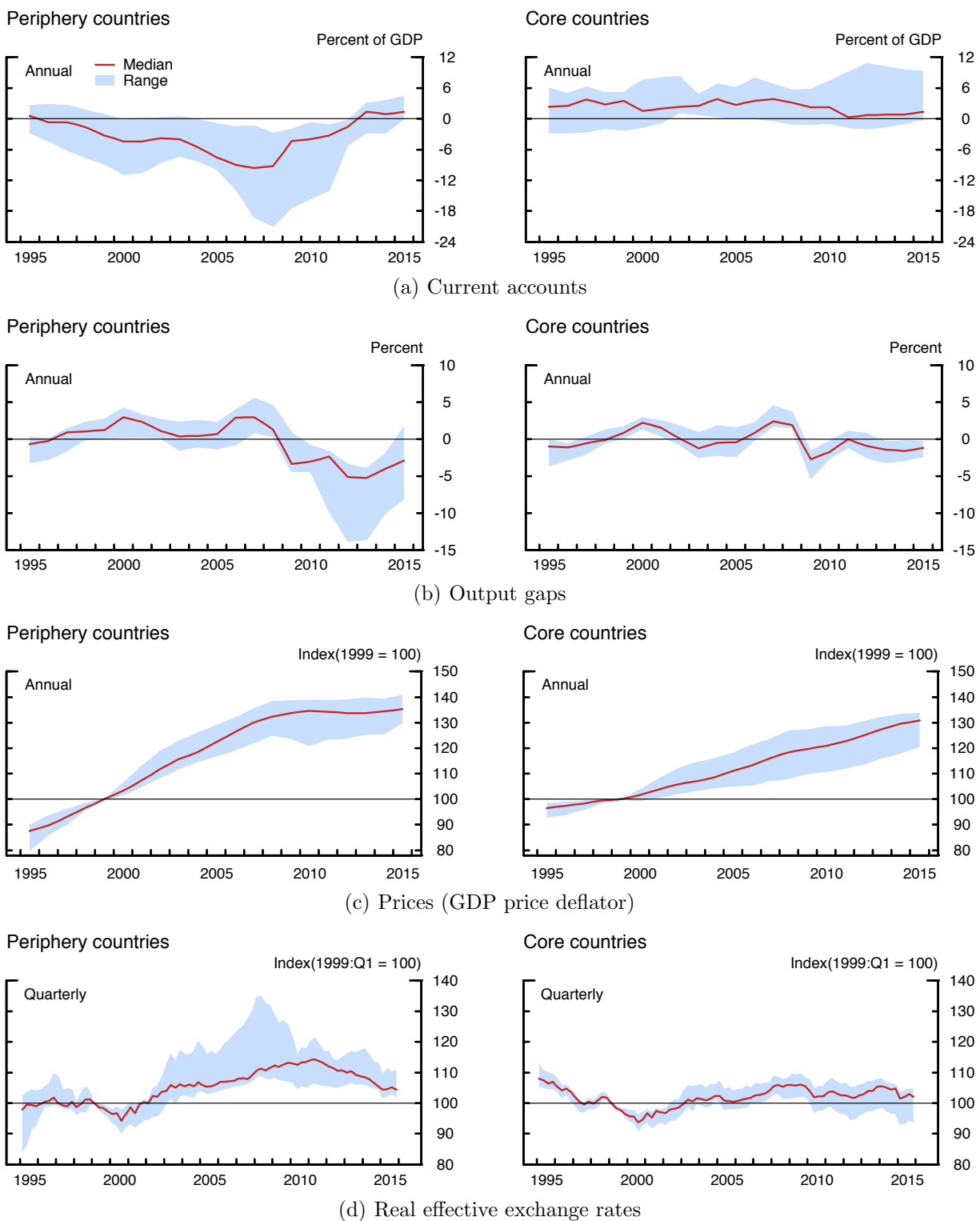
As shown in Figure 1, this narrative accords well with empirical evidence. The median current account deficit in the euro area periphery reached almost 10 percent of GDP on the eve of the global financial crisis, with some countries running current account deficits as high as 15 percent of their GDP (panel (a)).² The evidence of overheating that led to the crisis is provided in the next two panels: Between 1999 and 2007, periphery economies saw their real GDP growing persistently above its potential, whereas their counterparts in the core registered a much more balanced pattern of economic growth (panel (b)). As a result, prices in the periphery increased at a much faster pace during this period compared with those in the core countries (panel (c)). Given these developments, real exchange rates in the periphery appreciated substantially (panel (d)), eroding these countries’ competitiveness and producing large trade deficits, which were easily financed by foreign capital inflows against the backdrop of the convergence in domestic interest rates across the euro area.

In a monetary union comprised of countries in a dramatically different economic condition, with limited labor mobility, and no common fiscal policy, the crisis had to be resolved largely through a significant downward adjustment of the overvalued real exchange rates in the periphery. In the euro area, however, this adjustment has occurred very slowly. Although the periphery has endured significant disinflation since 2010, a noticeable gap remains, on balance, between the general level of prices in the core and periphery. As a result, real effective exchange rates in the periphery have tended to remain above those of the core euro area countries.

¹As emphasized by Auer (2014) and Higgins and Klitgaard (2014), the tightening of financial conditions was not as severe as might have been expected given the scale of capital flight from the periphery. The withdrawal of capital was tempered importantly by cross-border credits to central banks in deficit countries, extended by other euro area central banks through the so-called TARGET2 system, a mechanism for managing payment imbalances among eurozone member countries. In combination with policies to supply liquidity to banks in the periphery, this balance of payments financing helped offset the drain of funds abroad.

²Throughout the paper, we use the following definition of the euro area core and periphery. Core countries: Austria, Belgium, Finland, France, Germany, and Netherlands. Periphery countries: Greece, Ireland, Italy, Portugal, and Spain. We omit the Eastern European countries (Estonia, Latvia, Lithuania, Slovakia, and Slovenia) from the periphery because they adopted the euro relatively recently. Our analysis also excludes Cyprus, Luxembourg, and Malta because of limited data in some instances and because of their very specialized economies. All told, our sample of countries accounts for about 95 percent of the eurozone’s total economic output.

FIGURE 1 – Selected Macroeconomic Indicators for the Euro Area (1995–2015)



NOTE: The solid lines depict the evolution of the cross-sectional median of the specified macroeconomic series, while the shaded bands denote the corresponding cross-sectional range. Periphery countries: Greece, Ireland, Italy, Portugal, and Spain. Core countries: Austria, Belgium, Finland, France, Germany, and Netherlands.
SOURCE: AMECO database (European Commission); and Bank for International Settlements.

What economic forces are responsible for such a slow adjustment in the price levels between the core and periphery countries? Why have firms in the periphery—given the degree of resource underutilization in these economies—been so slow to cut prices? By the same token, why have firms in the core been reluctant to increase prices, despite an improvement in the economic outlook and highly stimulative monetary policy? In fact, some prominent commentators have argued that it is the core countries that are exporting deflationary pressures into the periphery, a dynamic contrary to that needed to reverse the real exchange rate appreciation that has eroded the periphery’s competitiveness (see [Krugman, 2014](#)).

To help answer these questions, we build on [Gilchrist et al. \(2016\)](#), GSSZ hereafter, and introduce the interaction of customer markets and financial frictions into an otherwise standard international macroeconomic framework. Specifically, we augment the conventional multi-country model featuring home bias, firms that price to market, and a low Armington elasticity of substitution between foreign and domestic goods with two new assumptions: First, we assume that firms operate in customer markets—both domestically and abroad.³ And second, we assume that foreign and domestic firms are subject to differing degrees of financial market frictions in the form of costly external (equity) finance.

We show that in such an environment firms from the “core”—that is, firms with a relatively unimpeded access to external finance—have a strong incentive to expand their market share at home and abroad by undercutting prices charged by their “periphery” competitors, especially when the latter are experiencing financial distress. By contrast, firms from the “periphery”—that is, financially constrained firms—have an incentive to increase markups in order to preserve internal liquidity, even though doing so means forfeiting some of their market share in the near term.

The general idea that firms set prices to actively manage current versus expected future demand in an environment of imperfect capital markets is not new to macroeconomics (see [Gottfries, 1991](#); [Chevalier and Scharfstein, 1996](#)). Our main contribution lies in bringing the interplay of customer markets and financial frictions into the international context and studying the implications of this interaction within a two-country dynamic stochastic general equilibrium model. As we show below, this pricing mechanism generates time-varying markups and import price dynamics that differ significantly from those in the international macro literature (see [Dornbusch, 1987](#); [Kimball, 1995](#); [Yang, 1997](#); [Bergin and Feenstra, 2001](#); [Atkeson and Burstein, 2008](#); [Gopinath and Itskhoki, 2010a,b](#); [Burstein and Gopinath, 2014](#); [Auer and Schoenle, 2016](#)).⁴ Specifically, this literature

³By customer markets, we mean markets in which a customer base is “sticky” and thus an important determinant of firm’s assets and its ability to generate profits. Various microeconomic mechanisms that can lead to sticky customer base include costly switching ([Klemperer, 1987](#)), costly search ([Hall, 2008](#)), or idiosyncratic preferences ([Bronnenberg et al., 2012](#)). As emphasized by [Bils \(1989\)](#), pricing decisions in such environment are a form of investment that builds the future customer base. Recent work by [Foster et al. \(2016\)](#) and [Hottman et al. \(2014\)](#) shows that customer markets feature prominently in the U.S. manufacturing and retail sectors. Moreover, [Roberts et al. \(2012\)](#), [Eaton et al. \(2015\)](#), and [Fitzgerald et al. \(2016\)](#) document that customer markets considerations importantly shape the pricing decision of exporting firms in both advanced and emerging market economies. The available evidence thus indicates that customer markets are a pervasive feature of the economic landscape.

⁴By exploiting the open economy setting, this literature tries to explain the firms’ pricing behavior by analyzing the responsiveness of international prices to fluctuations in exchange rates.

shows that following an adverse exchange rate shock, firms do not pass fully the resulting cost increase into import prices, but instead absorb some of this cost shock in their profits by *lowering* markups. In our model, by contrast, financially constrained firms, when hit by adverse shocks, try to maintain their cashflows by *increasing* markups in both the domestic and export markets, in effect trading off future market shares for current profits.

The interaction of customer markets and financial frictions helps explain several aspects of the eurozone financial crisis that are difficult to reconcile using conventional open-economy macro models. Most importantly, the pricing mechanism implied by this interaction is consistent with our empirical evidence, which shows that the acute tightening of financial conditions in the euro area periphery between 2009 and 2013 significantly attenuated the downward pressure on prices arising from the emergence of substantial and long-lasting economic slack. The tightening of financial conditions during this period is also strongly associated with a significant increase in markups in the periphery, which is exactly the pattern predicted by our model.⁵ Thus our framework can explain why the periphery countries have managed to avoid a potentially devastating Fisherian debt-deflation spiral in the face of massive and persistent economic slack. It also helps us to understand the chronic stagnation in the euro area periphery and how the “price war” between the core and periphery has impeded the adjustment process through which the latter economies have been trying to regain their external competitiveness.

The general equilibrium nature of our analysis also allows us to compare the macroeconomic implications of alternative exchange rate arrangements. As it is well known, with floating exchange rates, monetary authorities in the periphery should be able to largely offset the real economic effects of an asymmetric financial shock by aggressively cutting policy rates, inducing a significant depreciation of nominal exchange rates in the periphery. And although the price levels between the core and periphery move in opposite directions because of customer markets considerations in our model, the policy-induced currency devaluation can be sufficiently large to cause the real exchange rate to depreciate, thereby boosting exports of firms in the periphery and helping to stabilize the contraction in output.

In a monetary union, this policy option is, of course, not available. The pricing behavior of firms in the core in response to an asymmetric financial shock in the periphery implies a real exchange rate depreciation vis-à-vis the periphery, which causes a small export-driven boom in the core countries and a deepening of the recession in the periphery. The divergent economic trajectories between the core and periphery present a dilemma for the union’s central bank because monetary policy cannot be targeted to just one region. According to our simulations, common monetary policy in a situation where members of the union are at different phases of the business cycle can

⁵Our theoretical framework is also supported by the work of [Antoun de Almedia \(2015\)](#), who finds a strong negative relationship between firms’ internal liquidity positions and sectoral producer price inflation in the euro area periphery during the crisis. Moreover, our model is consistent with a significant increase in the estimated price-cost margins documented by [Montero and Urtasun \(2014\)](#) among Spanish firms that faced tight credit conditions or were operating in industries with a low degree of product market competition during the global financial crisis. Similar evidence for the United States during the Great Recession is provided by GSSZ and [Gilchrist and Zakrajšek \(2016\)](#) and for the 1990s Japan by [Kimura \(2013\)](#).

lead to an endogenous increase in macroeconomic volatility that is double that obtained in the case of floating exchange rates, even when the volatilities of shocks hitting the economies are the same. This translates into a welfare loss for the union as a whole, with the loss borne disproportionately by the periphery.

Given the union’s problem with a “one-size-fits-all” monetary policy, we consider two fiscal policy alternatives that have received significant attention from the policymakers: a fiscal union and a unilateral fiscal devaluation by the periphery. First, we show how a complete risk-sharing arrangement can significantly improve the welfare in the periphery. In principle, such a cross-country risk-sharing arrangement can be achieved by forming a fiscal union, a point emphasized by [Farhi and Werning \(2014\)](#). However, our simulations indicate that such a union involves a large transfer of wealth from the core to the periphery, casting doubt on its political feasibility.

As an alternative, we consider the macroeconomic implications of a fiscal devaluation. Recent work by [Adao et al. \(2009\)](#) and [Farhi et al. \(2014\)](#) explores the stabilization properties of certain fiscal policy mixes, intended to replicate the effects of a nominal devaluation in a fixed exchange rate regime. What makes such policies desirable, according to the theory, is the fact that they can be implemented unilaterally by the periphery countries encountering economic weakness. However, it is not clear why the core countries should welcome such unilateral policy interventions—in many instances, core countries have joined the monetary union precisely to avoid the manipulation of nominal exchange rates by the monetary authorities in the periphery.

A natural question that emerges in this context is whether the periphery can carry out a unilateral fiscal devaluation without worrying about a retaliatory reaction from the core. Our simulations show that a fiscal devaluation by the periphery can be beneficial even to the core, provided that the aggregate demand externality generated by the international price war is not remedied by the union’s policymakers. When firms in the core countries lower markups to expand their market shares, they do not internalize the pecuniary externality—in which driving out their foreign competitors by undercutting prices to an excessive degree—can also reduce aggregate demand for their own products. As shown by [Farhi and Werning \(2016\)](#), in such situations, a distortionary taxation can help firms from the core internalize this externality, and fiscal devaluations provide an effective means of achieving this goal. Furthermore, we show that benefits to the core resulting from such a unilateral fiscal devaluation by the periphery increase with the degree of financial market distortions that generate the pecuniary externality.

The remainder of the paper is organized as follows. In [Section 2](#), we provide new empirical evidence, which shows that price and markup dynamics in the eurozone periphery during the recent financial crisis were influenced importantly by the severe tightening of business credit conditions. [Section 3](#) presents our model and [Section 4](#) discusses its calibration. [Section 5](#) contains our baseline simulation results, while [Section 6](#) explores the welfare implications of a fiscal union and fiscal devaluations. [Section 7](#) concludes.

2 Inflation, Markups, and Financial Conditions

Through more than half of a century of evolution, the Phillips curve has provided macroeconomists with an increasingly coherent determination of aggregate inflation dynamics. In all of its reincarnation, one of its key predictions is that a high level of resource underutilization should cause inflation to decline over time. However, the absence of significant deflation in the euro area periphery during the recent financial crisis and its aftermath poses a significant empirical challenge to this central tenet of most macroeconomic models.⁶ In this section, we provide new empirical evidence, which shows that inflation and markup dynamics in the euro area periphery between 2009 and 2013 were influenced importantly by the severe disruptions in the credit-intermediation process.

We begin by examining the extent to which inflation forecast errors implied by the canonical Phillips curve relationships during the eurozone’s financial crisis are systematically related to difference in the tightness of credit conditions across countries. We do so in two steps. First, we use our panel of 11 euro area countries to estimate the following two Phillips curve specifications:

$$\pi_{it} = \alpha_i + \beta\pi_{i,t-1} + \lambda\text{gap}_{it} + \phi\Delta\text{VAT}_{it} + \psi\mathbf{1}[i \in \text{€}] + \epsilon_{it}; \quad (1)$$

and

$$\pi_{it} = \alpha_i + \beta_f E_t \pi_{i,t+1} + \beta_b \pi_{i,t-1} + \lambda \widehat{mc}_{it} + \phi\Delta\text{VAT}_{it} + \psi\mathbf{1}[i \in \text{€}] + \epsilon_{it}, \quad (2)$$

where i indexes countries and t represents time (in years). In both specifications, π_{it} denotes inflation as measured by the log-difference of the (implicit) GDP price deflator; gap_{it} is a measure of economic slack; \widehat{mc}_{it} is a proxy for marginal cost; ΔVAT_{it} is the change in the effective value-added tax (VAT) rate; and $\mathbf{1}[i \in \text{€}]$ is an indicator variable that equals one when country i adopts the euro and thereafter.

Specification (1) is the traditional “accelerationist” Phillips curve (APC), which assumes that inflation expectations are proportional to past inflation. Although Phillips curves of this sort tend to fit the data quite well, their major theoretical shortcoming involves the assumptions of adaptive inflation expectations. Accordingly, we also consider its New Keynesian variant (NKPC)—equation (34)—which incorporates into the process of inflation determination both rational expectations as well as more explicit microfoundations (see Galí and Gertler, 2000; Galí et al., 2001).

To ensure that our estimates of the Phillips curves are not unduly influenced by the unusual inflation dynamics during the recent global financial crisis, we estimate equations (1) and (34) using annual data from 1970 to 2008—that is, before the full-blown onset of the crisis in the euro area. To measure economic slack, we use either the unemployment gap—denoted by $(u_{it} - \bar{u}_{it})$ —the difference

⁶Two broad explanations have been advanced in an effort to explain the absence of a pernicious deflation cum recession spiral during the recent global financial crisis and its aftermath (see Simon et al., 2013). The first argues that much of the rise in unemployment during the crisis and its aftermath was structural—as a result, persistently high levels of unemployment exert less downward pressure on wages and prices than in the past. The second points to the strengthening of central banks’ credibility and their success in maintaining a low and stable inflation environment over the past decade or so, which, is argued, has led to more stable inflation expectations. We view the interaction of customer markets and financial frictions as a complementary mechanism to these two explanations, which far from settling the case of “missing deflation,” are nonetheless supported by the data.

TABLE 1 – Estimated Phillips Curves in the Euro Area

| Explanatory Variables | APC-1 | | APC-2 | | NKPC |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|
| | (1) | (2) | (3) | (4) | (5) |
| $\pi_{i,t-1}$ | 0.848 (0.046) | 0.883 (0.046) | 0.771 (0.047) | 0.849 (0.047) | 0.575 (0.060) |
| $(u_{it} - \bar{u}_{it})$ | -0.263 (0.114) | . | -0.489 (0.134) | . | . |
| $(y_{it} - \bar{y}_{it})$ | . | 0.252 (0.103) | . | 0.368 (0.105) | 0.152 (0.078) |
| $E_t \pi_{i,t+1}$ | . | . | . | . | 0.393 (0.062) |
| ΔVAT_{it} | 0.090 (0.040) | 0.070 (0.033) | 0.124 (0.063) | 0.097 (0.042) | 0.037 (0.056) |
| $\mathbf{1}[i \in \text{€}]$ | -0.672 (0.297) | -0.900 (0.370) | -0.651 (0.415) | -1.072 (0.412) | -0.295 (0.199) |
| Adj. R^2 | 0.840 | 0.833 | 0.844 | 0.832 | . |
| $\text{Pr} > J^a$ | . | . | . | . | 0.124 |
| Equal coeff. on $\pi_{i,t-1}^b$ | . | . | 0.013 | 0.033 | . |
| Equal coeff. on $(u_{it} - \bar{u}_{it})^c$ | . | . | 0.054 | . | . |
| Equal coeff. on $(y_{it} - \bar{y}_{it})^d$ | . | . | . | 0.146 | . |
| Equal coeff. on ΔVAT_{it}^e | . | . | <.001 | <.001 | . |
| Equal coeff. on $\mathbf{1}[i \in \text{€}]^f$ | . | . | 0.015 | 0.397 | . |

NOTE: Sample period: annual data from 1970 to 2008; No. of countries = 11; Obs. = 338. The dependent variable is π_{it} , the log-difference of the GDP price deflator of country i from year $t - 1$ to year t . Explanatory variables: $(u_{it} - \bar{u}_{it})$ = unemployment gap; $(y_{it} - \bar{y}_{it})$ = output gap; VAT_{it} = effective VAT rate; and $\mathbf{1}[i \in \text{€}]$ = indicator variable that equals 1 once country i joins the eurozone. APC-1 refers to an accelerationist Phillips curve with constant slope coefficients; APC-2 refers to an accelerationist Phillips curve with country-specific coefficients on all explanatory variables; and NKPC refers to a New Keynesian Phillips curve with constant slope coefficients. The entries in columns (1) and (2) denote the OLS estimates of the coefficients associated with the specified explanatory variable—in columns (3) and (4), the entries correspond to the average of the estimated OLS coefficients across the 11 countries; the entries in column (5) denote the corresponding GMM estimates. All specifications include country fixed effects (not reported). Robust asymptotic standard errors reported in parentheses are clustered in the time (t) dimension.

^a p -value for the Hansen (1982) J -test of the over-identifying restrictions.

^b p -value for the test of equality of country-specific coefficients on $\pi_{i,t-1}$.

^c p -value for the test of equality of country-specific coefficients on $(u_{it} - \bar{u}_{it})$.

^d p -value for the test of equality of country-specific coefficients on $(y_{it} - \bar{y}_{it})$.

^e p -value for the test of equality of country-specific coefficients on ΔVAT_{it} .

^f p -value for the test of equality of country-specific coefficients on $\mathbf{1}[i \in \text{€}]$.

between the unemployment rate and the estimate of the NAIRU, or the output gap—denoted by $(y_{it} - \bar{y}_{it})$ —defined as the difference between the log-level of real GDP and the estimated log-level of potential output (all data come from the AMECO databases maintained by the European Commission). In columns (1) and (2) of Table 1, we report estimates of the coefficients of the APC using the unemployment and output gap as measures of economic slack, respectively, and imposing common coefficients on all explanatory variables (APC-1 specifications). In columns (3) and (4),

we repeat the same exercise, except that we allow the coefficients on explanatory variables to differ across countries (APC-2 specifications). And lastly, column (5) reports coefficient estimates of the NKPC with common coefficients, using the output gap as a proxy for marginal cost.⁷

As indicated by the entries in the table, the degree of resource utilization—regardless of how measured—is an economically and statistically important determinant of inflation dynamics in all four specifications. Note that the estimated sensitivity of inflation to economic slack is, on average, somewhat higher in the APC-2 specifications, which allow for a greater degree of heterogeneity in the inflation processes across countries; all specifications, however, explain about the same proportion of the variability in annual inflation rates in the euro area. The estimates of the NKPC also indicate a statistically and economically significant effect of the output gap—our proxy for marginal cost—on inflation outcomes. These estimates also point to a significant forward-looking component in the euro area inflation, though the inflation processes appear to be also characterized by substantial inertial behavior, a result consistent with that of Benigno and López-Salido (2006).

As noted above, our interest is not in these estimates per se. Rather, we are interested in whether deviations of actual inflation from the trajectories implied by these Phillips curves during the crisis are systematically related to differences in the tightness of credit conditions across countries. To test this hypothesis, we first use the estimates in Table 1 to generate inflation prediction errors over the 2009–2013 period. In the second step, we estimate the following regression:

$$\hat{\epsilon}_{it} = \alpha + \theta_1 CC_{it} + \theta_2 CC_{it} \times \mathbf{1}[i \in P] + \chi \mathbf{1}[i \in P] + u_{it}, \quad (3)$$

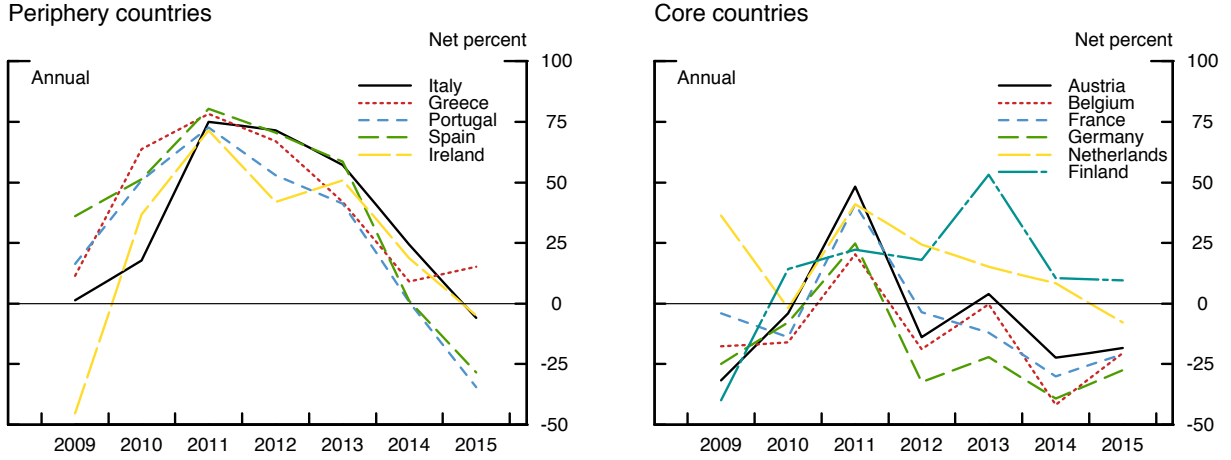
where $\hat{\epsilon}_{it}$ denotes the inflation residual from one of the estimated Phillips curves in Table 1, CC_{it} is a measure of the tightness of credit conditions, and $\mathbf{1}[i \in P]$ is an indicator variable that equals one if country i is in the periphery. The parameters θ_1 and θ_2 thus measure the extent to which differences in the evolution of financial conditions between the core and periphery countries during the crisis can explain deviations of inflation trajectories from those implied by canonical Phillips curve specifications.

To measure changes in credit conditions across euro area countries, we rely on the Survey on the Access to Finance of Enterprises (SAFE), a comprehensive semi-annual survey of small and medium-sized enterprises (SMEs) in the European Union conducted by the European Central Bank and the European Commission.⁸ As emphasized by Lane (2012), the European sovereign debt crisis originated over concerns related to the solvency of national banking systems in the periphery in the wake of the global financial crisis. The fact that SMEs—virtually all firms in the European Union—

⁷The APC-1 and APC-2 specifications are estimated by OLS; in the case of APC-2 specifications, we report the average of each coefficient across the 11 countries in our panel. The NKPC is estimated by GMM, treating $(y_{it} - \bar{y}_{it})$ and $E_t \pi_{i,t+1}$ as endogenous and instrumented with lags 1 to 3 of $(y_{it} - \bar{y}_{it})$ and π_{it} , and lags 0 to 2 of the log-difference of commodity prices. Note that all specifications include country fixed effects.

⁸Given the SMEs economic relevance in the European Union, the European Central Bank and the European Commission decided in 2008 to collaborate on a survey that is used to assess developments in financing conditions and credit availability for firms in the union countries. Twice a year (in March and October), thousands of businesses in Europe are contacted and asked about their ease of access to various forms of external finance and about financing conditions. For survey details see <http://www.ecb.europa.eu/stats/money/surveys/sme/html/index.en.html>

FIGURE 2 – Business Credit Conditions in the Euro Area (2009–2015)



NOTE: Each line depicts the net percent of firms in the specified country that reported that banks have increased loan interest rates over the survey period (see the text for details).

SOURCE: Survey on the Access to Finance of Enterprises.

are highly dependent on bank financing makes this survey uniquely suited to measure differences in the tightness of credit conditions faced by businesses in the euro area.

We focus on firms’ responses to the following survey question:

Please indicate how the level of interest rates on bank financing, such as bank loans, overdrafts, and credit lines, has changed over the past six months.

The possible answers are: (1) was increased by the bank; (2) remain unchanged; (3) was decreased by the bank; and (4) do not know or not applicable.⁹ Firm-level responses for each country in the survey are aggregated into a *net* proportion of respondents that indicated that banks increased interest rates, defined as a fraction of firms answering that banks have increased interest rates over the survey period, less a fraction of firms indicating that banks have decreased interest rates.

The left panel of Figure 2 shows these net percentages for the five periphery countries in our sample, while the panel to the right shows the same information for the six countries in the euro area core. Clearly evident is the massive tightening of business credit conditions in the euro area periphery during the 2009–2013 crisis period. By contrast, the tightening of credit conditions in the core countries—with the exception of Finland and Netherlands—was substantially less severe and considerably more short lived.

Table 2 details how these difference in the evolution of financial conditions affected euro area inflation dynamics during this period.¹⁰ Our results indicate that in the eurozone periphery, changes

⁹See Question 10a in Section 4: “Availability of Finance and Market Conditions.” As noted above, SAFE is a semi-annual survey and is conducted in March and October of each year. To align the survey with annual macroeconomic data, we use responses from the March Survey of year t to measure how business financing conditions have changed from year $t - 1$ to year t .

¹⁰We estimate equation (3) by OLS. However, the associated statistical inference that relies on the usual asymptotic

TABLE 2 – Phillips Curve Prediction Errors and Business Credit Conditions

| Specification | Explanatory Variable | | R^2 |
|---------------|---------------------------|--------------------------------------|-------|
| | CC_{it} | $CC_{it} \times \mathbf{1}[i \in P]$ | |
| APC-1 | | | |
| (1) | −0.003 [−0.011, 0.005] | 0.026 [0.018, 0.034] | 0.137 |
| (2) | −0.005 [−0.014, 0.005] | 0.027 [0.021, 0.033] | 0.128 |
| APC-2 | | | |
| (3) | −0.001 [−0.011, 0.008] | 0.019 [0.006, 0.031] | 0.065 |
| (4) | −0.004 [−0.014, 0.006] | 0.042 [0.039, 0.046] | 0.349 |
| NKPC | −0.006 [−0.015, 0.003] | 0.025 [0.019, 0.030] | 0.161 |

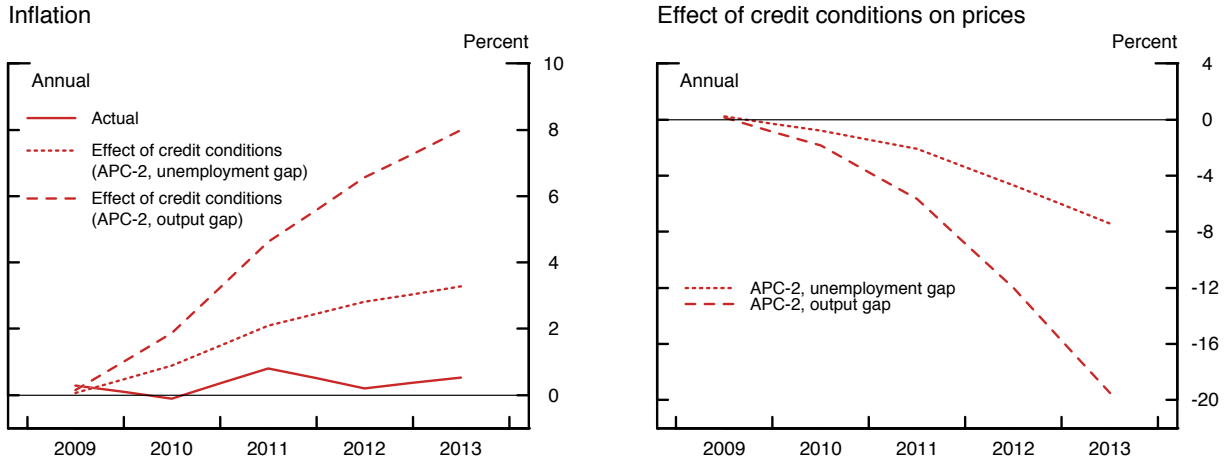
NOTE: Sample period: annual data from 2009 to 2013; No. of countries = 11; Obs. = 55. The dependent variable is $\hat{\epsilon}_{it}$, an inflation prediction error of country i in year t implied by the specified Phillips curve (see the text and notes to Table 1 for details). The entries denote the OLS estimates of the coefficients associated with an indicator of business credit conditions (CC_{it}), the net percent of firms in country i reporting that banks have increased loan interest rates in year t (see Figure 2 and the text for details). All specifications include a constant and $\mathbf{1}[i \in P]$, an indicator for whether country i is in the euro area periphery (not reported). The 95-percent confidence intervals reported in brackets are based on the empirical distribution of coefficients across 5,000 replications, using the wild bootstrap clustered in the time (t) dimension (see [Cameron et al., 2008](#)).

in business credit conditions during the crisis are systematically related to the deviations of inflation from the dynamics implied by canonical Phillips curve-type relationships. The positive point estimates of θ_2 , the coefficient on the interaction term $CC_{it} \times \mathbf{1}[i \in P]$, imply that a tightening of business credit conditions in the periphery is associated with inflation rates that exceed those predicted by our various estimated Phillips curves. The 95-percent confidence intervals bracketing the point estimates of θ_2 exclude zero, an indication that this relationship is statistically significant at conventional levels. For the core euro area countries, by contrast, there appears to be no systematic relationship between inflation residuals and changes in business financing conditions.

The economic significance of these results for the euro area periphery is summarized in Figure 3. The solid line in the left panel show the average inflation in the five periphery countries during the crisis. The dotted and dashed lines depict the estimated effects of the tightening in business credit conditions on average inflation implied by the APC specifications that allow for country-specific regression coefficients (rows 3 and 4 under the APC-2 heading in Table 2). According to these estimates, which span the range of estimates of the coefficient θ_2 reported in Table 2, the

arguments is likely to be unreliable, given a relatively small number of observations, especially in the time-series dimension. Accordingly, we report the 95-percent confidence intervals for coefficients θ_1 and θ_2 , based on the time-clustered wild bootstrap procedure of [Cameron et al. \(2008\)](#), which is designed for situations in which the number of clusters or the number of observations within each cluster is relatively small.

FIGURE 3 – Business Credit Conditions and Inflation in the Euro Area Periphery (2009–2013)



NOTE: The solid line in the left panel depicts the average inflation—measured by the log-difference of the GDP price deflator—across five euro area periphery countries (Greece, Ireland, Italy, Portugal, and Spain); the dotted and dashed lines in the same panel show the estimated effect of business credit conditions on average inflation in the euro area periphery, using the APC-2 (column 3 in Table 1) and APC-2 (column 4 in Table 1) specifications of the accelerationist Phillips curve. The dotted and dashed lines in the right panel depict the corresponding effects on the GDP price deflator.

SOURCE: Authors' calculations using data from the AMECO database and the Survey on the Access to Finance of Enterprises.

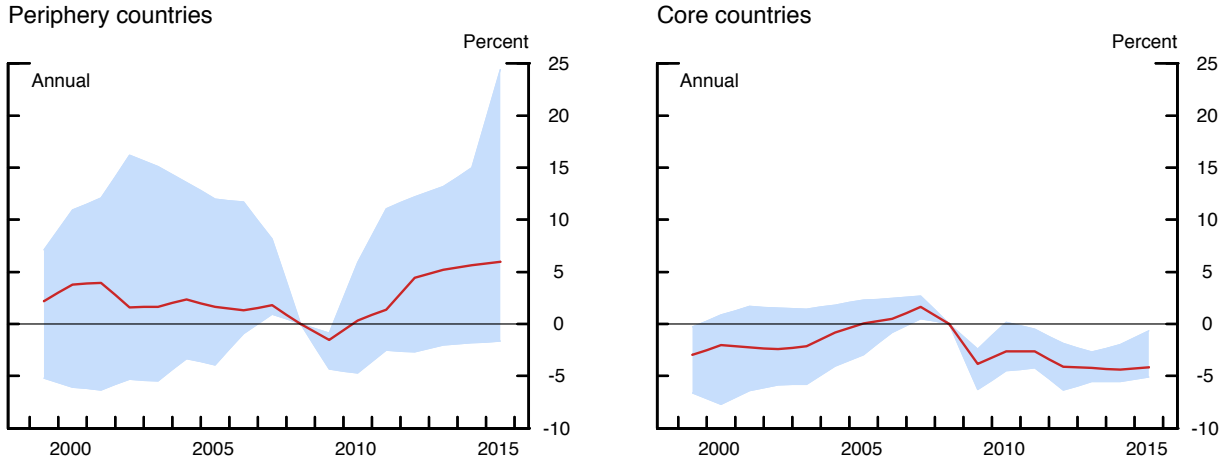
tightening of business credit conditions at the nadir of the crisis in 2011 contributed between 2 and 5 percentage points to average annual inflation in the euro area periphery.

In the right panel, we translate the cumulative effect of the tightening in business credit conditions during the 2009–2013 period on the average price *level* in the periphery. Our estimates imply that in the absence of these financial forces, the average price level in the eurozone periphery would have been between 8 and 20 percent lower by the end of 2013, an outcome entailing a rate of deflation with potentially devastating economic effects, given the high levels of debt—both private and public—in the periphery countries.

In our last empirical exercise, we turn directly to the behavior of markups during the crisis. As shown by Galí et al. (2007), the price markup can, under reasonable assumptions, be measured (up to an additive constant) as minus the log of real unit labor costs. Figure 4 shows the evolution of price markups in the eurozone periphery (left panel) and in the core countries (right panel) since the introduction of the euro in 1999. The divergence in markups between the core and periphery during the crisis is striking: The median markup in the periphery increased by about 5 percentage point between 2009 and 2013, while in the core, the median markup fell by about the same amount during this period.

To examine how changes in business credit conditions during the crisis affected the behavior of markups, we re-estimate regression (3) using the difference in the price markup as the dependent variable. As indicated in Table 3, the tightening of financial conditions is associated with

FIGURE 4 – Price Markups in the Euro Area (1999–2015)



NOTE: The solid lines depict the cross-sectional median of price markups, while the shaded bands denote the corresponding cross-sectional range. The price markup is defined as minus (100 times) the log of real unit labor costs (2008 = 1). Periphery countries: Greece, Ireland, Italy, Portugal, and Spain. Core countries: Austria, Belgium, Finland, France, Germany, and Netherlands.
SOURCE: AMECO database.

a statistically significant increase in markups in the euro area periphery. In economic terms, a net tightening of business credit conditions of one standard deviation—about 30 percent in the periphery—is estimated to boost the rate of increase in markups in those countries more than a full percentage point per year.

In sum, the results presented in this section add to the growing empirical evidence, which strongly supports the notion that financial conditions of firms in the euro area affected their pricing decisions during the global financial crisis and its aftermath (see [Montero and Urtasun, 2014](#); [Antoun de Almedia, 2015](#); [Baller et al., 2015](#)). As we show below, combining the theory of customer markets with financial market frictions provides a natural way to understand these new findings. The pricing mechanism implied by this interaction predicts exactly the differences in the behavior of prices and markups between the eurozone core and periphery documented above: In response to an adverse financial shock in the periphery, the tightening of credit conditions causes firms—in an effort to preserve internal liquidity—to boost prices by raising markups, thereby losing market share to their financially healthy competitors from the core.

Our last piece of empirical evidence does not involve any econometrics. The following quote from Sergio Marchionne, the CEO of Fiat Chrysler, in mid-2012 paints a visceral picture of the price dynamics implied by our theory:

Mr. Marchionne and other auto executives accuse Volkswagen of exploiting the crisis to gain market share by offering aggressive discounts. “It’s a bloodbath of pricing and it’s a bloodbath on margins,” he said.

The New York Times, July 25, 2012

TABLE 3 – Price Markups and Business Credit Conditions

| Explanatory Variable | | |
|----------------------|--------------------------------------|-------|
| CC_{it} | $CC_{it} \times \mathbf{1}[i \in P]$ | R^2 |
| 0.025 | 0.013 | 0.270 |
| [0.003, 0.045] | [0.006, 0.020] | |

NOTE: Sample period: annual data from 2009 to 2013; No. of countries = 11; Obs. = 55. The dependent variable is the change in the price markup in country i from year $t - 1$ to year t , where the markup is defined as minus the log of real unit labor costs. The entries denote the OLS estimates of the coefficients associated with an indicator of business credit conditions (CC_{it}), the net percent of firms in each country reporting that banks have increased loan interest rates (see Figure 2 and the text for details). All specifications include a constant and $\mathbf{1}[i \in P]$, an indicator for whether country i is in the euro area periphery (not reported). The 95-percent confidence intervals reported in brackets are based on the empirical distribution of coefficients across 5,000 replications, using the wild bootstrap clustered in the time (t) dimension (see Cameron et al., 2008).

3 Model

3.1 Preferences

The economy consists of two countries, referred to as “home” (h) and “foreign” (f), where foreign country variables are denoted by asterisks. We think of the home country as representing the eurozone periphery, while the foreign country corresponds to the euro area core. In each country, there exists a continuum of households indexed by $j \in N_c = [0, 1]$, $c = h, f$. Each household consumes two types, h and f , of differentiated varieties of consumption goods, indexed by $i \in N_h = [0, 1]$ in the home country and by $i \in N_f = [1, 2]$ in the foreign country. Consistent with the standard assumption used in international macroeconomics, the home country produces only the h -type goods, and the foreign country produces only the f -type goods. In this setting, $c_{i,f,t}^j$ denotes the consumption of product i of type f by a home country consumer j , while $c_{i,f,t}^{j*}$ denotes its foreign counterpart—that is, the consumption of product i of type f by a foreign country consumer j .¹¹

For simplicity, we assume that labor is perfectly immobile. The preferences of household j in the home country are given by

$$\mathbb{E}_t \sum_{s=0}^{\infty} \delta^s U(x_{t+s}^j, h_{t+s}^j); \quad (0 < \delta < 1). \quad (4)$$

The household’s per-period utility function $U(\cdot, \cdot)$ is strictly increasing and concave in the consumption bundle x_t^j and strictly decreasing and concave in hours worked h_t^j . Standard open economy models allow for home-bias in consumption by combining Dixit-Stiglitz preferences with an Armington aggregator of home and foreign goods. We introduce into this framework a sticky customer base via the Ravn et al. (2006) “deep habits” preference structure. This yields the consumption/habit

¹¹In our notation, $c_{i,f,t}^j$ denotes consumption of an imported good by a home country household j , while $c_{i,f,t}^{j*}$ denotes consumption of a domestically produced good by a foreign household j .

aggregator

$$x_t^j \equiv \left[\sum_{k=h,f} \Xi_k \left[\int_{N_k} (c_{i,k,t}^j / s_{i,k,t-1}^\theta)^{1-\frac{1}{\eta}} di \right]^{\frac{1-\frac{1}{\varepsilon}}{1-\frac{1}{\eta}}} \right]^{\frac{1}{1-\frac{1}{\varepsilon}}}; \quad \sum_{k=h,f} \Xi_k^\varepsilon = 1,$$

where $\eta > 0$ and $\varepsilon > 0$ are the elasticities of substitution within a type of goods produced in a given country and between the two types of goods, respectively, and the parameter Ξ_k governs the degree of home bias in the household's consumption basket in the steady state.

Define $c_{i,k,t}$ as the average level of consumption of good i in country k —that is, $c_{i,k,t} = \int_0^1 c_{i,k,t}^j dj$, for $k = h, f$. As in [Ravn et al. \(2006\)](#), $s_{i,k,t}$ denotes the *good-specific* habit, which evolves according to

$$s_{i,k,t} = \rho s_{i,k,t-1} + (1 - \rho) c_{i,k,t}; \quad (0 < \rho < 1) \quad k = h, f. \quad (5)$$

In this formulation, habits are external to the household and country specific.¹² When $\theta < 0$, the stock of habit formed by past consumption of the average household has a positive effect on the utility derived from today's consumption, making the household desire more of the same good. This creates an incentive for firms to lower prices in order to build their customer base.

In equilibrium, all households within a country choose the same consumption basket; hence we can omit the household index j going forward. The cost minimization associated with equation (4) implies the following demand function for good i (of type h or f) in the home country:

$$c_{i,k,t} = \left(\frac{P_{i,k,t}}{\tilde{P}_{k,t}} \right)^{-\eta} s_{i,k,t-1}^{\theta(1-\eta)} x_{k,t}; \quad k = h, f, \quad (6)$$

where the habit-adjusted price index $\tilde{P}_{k,t}$ and the corresponding consumption basket $x_{k,t}$ are given by

$$\tilde{P}_{k,t} = \left[\int_{N_k} (P_{i,k,t} s_{i,k,t-1}^\theta)^{1-\eta} di \right]^{\frac{1}{1-\eta}} \quad \text{and} \quad x_{k,t} = \left[\int_{N_k} (c_{i,k,t} / s_{i,k,t-1}^\theta)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}; \quad k = h, f,$$

respectively. In equilibrium, the habit-adjusted consumption basket $x_{k,t}$ is equal to

$$x_{k,t} = \Xi_k^\varepsilon \left(\frac{\tilde{P}_{k,t}}{\tilde{P}_t} \right)^{-\varepsilon} x_t; \quad k = h, f, \quad \text{and} \quad \tilde{P}_t = \left[\sum_{k=h,f} \Xi_k \tilde{P}_{k,t}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \quad (7)$$

where \tilde{P}_t denotes the welfare-based aggregate price index of the home country. Due to the symmetric structure of the two countries, the foreign country analogues of $c_{i,k,t}$, $x_{k,t}$, and \tilde{P}_t can be expressed simply by adding a superscript with an asterisk symbol to the respective variable.

¹²As a result, households take the habit stock as given and do not internalize the effect of their own consumption on future demand; see [Nakamura and Steinsson \(2011\)](#) for the analysis of firms' pricing-setting behavior implied by good-specific internal habits.

For later use, we also define the consumer price index (CPI)

$$P_t \equiv \left[\sum_{k=h,f} \Xi_k P_{k,t}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}, \text{ where } P_{k,t} \equiv \left[\int_{N_k} P_{i,k,t}^{1-\eta} di \right]^{\frac{1}{1-\eta}}; \quad k = h, f, \quad (8)$$

is the CPI corresponding to a k -type category of goods (see Appendix A for the derivation of equations 6–8).

3.2 Technology

In both countries there exists a continuum of firms, which produce output—denoted by $y_{i,t}$ in the home country and $y_{i,t}^*$ in the foreign country—using labor as the only input. We assume an identical production technology across the two countries:

$$y_{i,t} = \left(\frac{A_t}{a_{i,t}} h_{i,t} \right)^\alpha - \phi \quad \text{and} \quad y_{i,t}^* = \left(\frac{A_t^*}{a_{i,t}^*} h_{i,t}^* \right)^\alpha - \phi; \quad (0 < \alpha \leq 1),$$

where $\phi \geq 0$ represents fixed operating costs; A_t and A_t^* are country-specific aggregate technology shocks; and $a_{i,t}$ and $a_{i,t}^*$ are idiosyncratic “cost” shocks faced by the home and foreign firms, respectively.

We assume that cost shocks in both countries are distributed according to an identical log-normal distribution: $\ln a_{i,t} \stackrel{iid}{\sim} N(-0.5\sigma^2, \sigma^2)$ and $\ln a_{i,t}^* \stackrel{iid}{\sim} N(-0.5\sigma^2, \sigma^2)$. We let $F(\cdot)$ denote the common CDF of the idiosyncratic cost shocks $a_{i,t}$ and $a_{i,t}^*$. Note that the presence fixed costs makes it possible for firms to incur operating losses and hence find themselves in a liquidity squeeze if external financing is costly or, as during the acute phase of the crisis in the eurozone periphery, largely unavailable.

3.3 Frictions

For fixed costs to play a role in creating liquidity risk for firms, we introduce several frictions to the firm’s flow-of-funds constraint. First, we adopt a timing convention, whereby in the first half of period t , firms collect information about the aggregate state of the economy. Based on this aggregate information, firms post prices, take orders from customers, and plan production based on *expected* marginal cost. In the second half of the period, idiosyncratic uncertainty is resolved, and firms realize their *actual* marginal cost. They then hire labor to fulfill the agreed-upon orders and produce period- t output.

We also assume that firms pay out all realized operating profits as dividends within a given period—that is, we rule out corporate savings. Because of fixed costs, the firm’s operating profits may, ex post, be too low to cover the total cost of production. In that case, the firm must issue—within period t —new shares. Because of agency problems in equity markets, external financing involves a constant dilution cost per share issued, denoted by $0 < \varphi < 1$ and $0 < \varphi^* < 1$, which

can differ between the home and foreign countries.

The firm's objective is to maximize the present value of its dividend flow, $\mathbb{E}_t \left[\sum_{s=0}^{\infty} m_{t,t+s} d_{i,t+s} \right]$, where $d_{i,t} = D_{i,t}/P_t$ denotes the real dividend payout when positive and real equity issuance when negative. We assume that the firms are owned by households, and that they discount future cashflows using the stochastic discounting factor of the representative household, denoted by $m_{t,t+s}$, in their respective country.

Consistent with the fact that core euro area countries have deeper and more developed capital markets than the eurozone periphery, we assume that the dilution costs in the home country strictly exceed those in foreign country—that is, $0 \leq \varphi^* < \varphi$. As a result, firms in the home country are more exposed to liquidity risk than their foreign counterparts.¹³ The dilution cost associated with the newly issued equity implies that when a home country firm issues a notional amount of equity $d_{i,t} < 0$, the actual amount of funds raised is given by $-(1 - \varphi)d_{i,t}$.

In addition to financial market frictions, we also allow for nominal rigidities by assuming that firms incur costs when changing prices. Following Rotemberg (1982), these costs are given by

$$\frac{\gamma_p}{2} \left(\frac{P_{i,h,t}}{P_{i,h,t-1}} - 1 \right)^2 c_t + \frac{\gamma_p^* Q_t P_t^*}{2 P_t} \left(\frac{P_{i,h,t}^*}{P_{i,h,t-1}^*} - 1 \right)^2 c_t^*; \quad (\gamma_p, \gamma_p^* > 0),$$

where Q_t denotes the nominal exchange rate; in principle, the degree of price stickiness is allowed to differ between the two countries, as indicated by the fact that γ_p does not necessarily equal γ_p^* .¹⁴ Note that we also assume local currency pricing as opposed to producer currency pricing.

3.4 The Firm's Problem

Before presenting the optimization problem faced by firms, it is useful to define relative prices. The real product prices relative to home and foreign countries' CPIs can be written as

$$\frac{P_{i,h,t}}{P_t} = \frac{P_{i,h,t}}{P_{h,t}} \frac{P_{h,t}}{P_t} \equiv p_{i,h,t} p_{h,t} \quad \text{and} \quad \frac{P_{i,h,t}^*}{P_t^*} = \frac{P_{i,h,t}^*}{P_{h,t}^*} \frac{P_{h,t}^*}{P_t^*} \equiv p_{i,h,t}^* p_{h,t}^*.$$

Note that $p_{i,h,t}$ and $p_{i,h,t}^*$ are prices charged by the home country firm i relative to the average of prices charged by the home country firms in the home and foreign markets, respectively; $p_{h,t}$ and $p_{h,t}^*$ are the *average* prices—relative to the national CPI—in the home and foreign markets, respectively. As such, $p_{h,t}$ and $p_{h,t}^*$ are taken as given by individual firms. The corresponding relative prices $p_{i,f,t}$, $p_{i,f,t}^*$, $p_{f,t}$, and $p_{f,t}^*$ have an analogous interpretation from the perspective of foreign country firms.

¹³An implicit assumption of our setup is that the equity markets of the two countries are fully segmented—only domestic (foreign) households invest in the shares of domestic (foreign) firms. Empirical evidence of significant home bias in equity holdings is provided by French and Poterba (1991), Tesar and Werner (1995), and Obstfeld and Rogoff (2000).

¹⁴Note that the price adjustment costs are proportional to local consumption (c_t and c_t^*). This assumption is made solely to preserve the homogeneity of the firm's problem and has no first-order consequences for dynamics of the model.

We now turn to the problem of the firm, which to conserve space, we describe from the vantage point of the home country. A home country firm maximizes the present value of real dividends, subject to a flow-of-funds constraint:

$$d_{i,t} = p_{i,h,t} p_{h,t} c_{i,h,t} + q_t p_{i,h,t}^* p_{h,t}^* c_{i,h,t}^* - w_t h_{i,t} + \varphi \min \{0, d_{i,t}\} - \frac{\gamma_p}{2} \left(\frac{p_{i,h,t}}{p_{i,h,t-1}} \pi_{h,t} - 1 \right)^2 c_t + \frac{\gamma_p^*}{2} q_t \left(\frac{p_{i,h,t}^*}{p_{i,h,t-1}^*} \pi_{h,t}^* - 1 \right)^2 c_t^*, \quad (9)$$

where $w_t = W_t/P_t$ is the real wage; $q_t = Q_t P_t^*/P_t$ is the real exchange rate; and $\pi_{h,t} = P_{h,t}/P_{h,t-1}$ and $\pi_{h,t}^* = P_{h,t}^*/P_{h,t-1}^*$ are the market-specific (gross) inflation rates of home country firms. The firm also faces the law of motion for the habit stock (equation 5), the demand constraint (equation 6), and a production constraint:

$$\left(\frac{A_t}{a_{i,t}} h_{i,t} \right)^\alpha - \phi \geq c_{i,h,t} + c_{i,h,t}^*. \quad (10)$$

Formally, the firm is choosing the sequence $\{d_{i,t}, h_{i,t}, c_{i,h,t}, c_{i,h,t}^*, s_{i,h,t}, s_{i,h,t}^*, p_{i,h,t}, p_{i,h,t}^*\}_{t=0}^\infty$ to maximize the following Lagrangian:

$$\begin{aligned} \mathcal{L} = \mathbb{E}_0 \sum_{t=0}^\infty m_{0,t} & \left\{ d_{i,t} + \kappa_{i,t} \left[\left(\frac{A_t}{a_{i,t}} h_{i,t} \right)^\alpha - \phi - (c_{i,h,t} + c_{i,h,t}^*) \right] \right. \\ & + \xi_{i,t} \left[p_{i,h,t} p_{h,t} c_{i,h,t} + q_t p_{i,h,t}^* p_{h,t}^* c_{i,h,t}^* - w_t h_{i,t} - d_{i,t} + \varphi \min \{0, d_{i,t}\} \right. \\ & - \frac{\gamma_p}{2} \left(\frac{p_{i,h,t}}{p_{i,h,t-1}} \pi_{h,t} - 1 \right)^2 c_t - \frac{\gamma_p^*}{2} q_t \left(\frac{p_{i,h,t}^*}{p_{i,h,t-1}^*} \pi_{h,t}^* - 1 \right)^2 c_t^* \left. \right] \\ & + \nu_{i,h,t} \left[(p_{i,h,t})^{-\eta} \tilde{p}_{h,t}^{\eta} s_{i,h,t-1}^{\theta(1-\eta)} x_{h,t} - c_{i,h,t} \right] \\ & + \nu_{i,h,t}^* \left[(p_{i,h,t}^*)^{-\eta} \tilde{p}_{h,t}^{*\eta} s_{i,h,t-1}^{*\theta(1-\eta)} x_{h,t}^* - c_{i,h,t}^* \right] \\ & + \lambda_{i,h,t} [\rho s_{i,h,t-1} + (1-\rho) c_{i,h,t} - s_{i,h,t}] \\ & + \lambda_{i,h,t}^* [\rho s_{i,h,t-1}^* + (1-\rho) c_{i,h,t}^* - s_{i,h,t}^*] \left. \right\}, \quad (11) \end{aligned}$$

where $\tilde{p}_{h,t} = \tilde{P}_{h,t}/P_{h,t}$ and $\tilde{p}_{h,t}^* = \tilde{P}_{h,t}^*/P_{h,t}^*$; $\kappa_{i,t}$ and $\xi_{i,t}$ are the Lagrange multipliers associated with the production constraint (10) and the flow-of-funds constraint (9), respectively; $\nu_{i,h,t}$ and $\nu_{i,h,t}^*$ are the Lagrange multipliers associated with the domestic and foreign demand constraints (equation 6 and its foreign counterpart), while $\lambda_{i,h,t}$ and $\lambda_{i,h,t}^*$ are the multipliers associated with the domestic and foreign habit accumulation processes (equation 5 and its foreign counterpart).

We begin by describing the firm's optimal choice of labor hours and equity issuance, the two decisions made by the firm after the realization of the idiosyncratic cost shock a_{it} . We then present the optimality conditions that govern decisions made by the firm prior to the realization of the cost shock. Most importantly, these include the firm's pricing policy for the domestic and foreign

markets; the pricing policy determines the amount of output sold in both markets and the overall level of production. For maximum intuition, we focus on the case without nominal price rigidities. We then discuss the implications of our model for inflation and the Phillips curve when firms face quadratic costs of changing prices.

The first-order condition for labor hours in problem (11) is given by

$$a_{i,t}\xi_{i,t}w_t = \kappa_{i,t}\alpha A_t \left(\frac{A_t}{a_{i,t}} h_{i,t} \right)^{\alpha-1}, \quad (12)$$

where given the production function, labor hours should satisfy the conditional labor demand:

$$h_{i,t} = \frac{a_{i,t}}{A_t} (\phi + c_{i,h,t} + c_{i,h,t}^*)^{\frac{1}{\alpha}}. \quad (13)$$

Our timing assumptions imply that $c_{i,h,t}$ and $c_{i,h,t}^*$ are determined prior to the realization of the idiosyncratic cost shock $a_{i,t}$. Let \mathbb{E}_t^A denote the expectation operator, conditional on all aggregate information up to time t , but excluding the realization of the idiosyncratic cost shock $a_{i,t}$ (that is, $\mathbb{E}_t^A[x] = \int x dF(a)$). Then combining equations (12) and (13), applying the expectation operator \mathbb{E}_t^A to both sides of the resulting expression, and dividing through by $\mathbb{E}_t^A[\xi_{i,t}]$ yields the following expression for the expected real marginal cost, normalized by the expected shadow value of internal funds:

$$\frac{\mathbb{E}_t^A[\kappa_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} = \frac{\mathbb{E}_t^A[a_{i,t}\xi_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} \frac{w_t}{\alpha A_t} (\phi + c_{i,h,t} + c_{i,h,t}^*)^{\frac{1-\alpha}{\alpha}}. \quad (14)$$

To gain some intuition behind equation (14), consider the case with no financial market frictions. In that case, the shadow value of internal funds $\xi_{i,t} = 1$, for all t , and hence $\mathbb{E}_t^A[\xi_{i,t}] = 1$ and $\mathbb{E}_t^A[a_{i,t}\xi_{i,t}] = \mathbb{E}_t^A[a_{i,t}]\mathbb{E}_t^A[\xi_{i,t}] = 1$. Assuming constant returns-to-scale (CRS), the expected marginal cost $\mathbb{E}_t^A[\kappa_{i,t}] = w_t/A_t$, that is, unit labor costs. With the decreasing returns-to-scale (DRS), the expected real marginal cost is also a function of the firm's output: $\mathbb{E}_t^A[\kappa_{i,t}] = (w_t/\alpha A_t)(\phi + c_{i,h,t} + c_{i,h,t}^*)^{\frac{1-\alpha}{\alpha}} = (w_t/\alpha A_t)y_{i,t}^{\frac{1-\alpha}{\alpha}}$.

With financial distortions, however, the shadow value of internal funds does not always equal one; in fact, it becomes stochastic, according to the realization of the idiosyncratic cost shock $a_{i,t}$, which influences the liquidity condition of the firm. The first-order condition for dividend payouts (or equity issuance) implies

$$\xi_{i,t} = \begin{cases} 1 & \text{if } d_{i,t} \geq 0 \\ 1/(1-\varphi) & \text{if } d_{i,t} \leq 0. \end{cases} \quad (15)$$

The shadow value of internal funds thus equals one when the firm's profits are sufficiently high to cover labor and fixed costs and pay positive dividends. If profits are negative, however, the firm issues new equity to cover its operating costs, and the shadow value of internal funds rises to $1/(1-\varphi)$. Intuitively, given the dilution costs, a firm must issue $1/(1-\varphi)$ dollars of new equity to obtain one dollar of external financing. These conditions imply that $\mathbb{E}_t^A[\xi_{i,t}] > 1$. It is also the case that the realized shadow value of internal funds covaries positively with the idiosyncratic

cost shock $a_{i,t}$ because profits—and hence dividends—are negative when operating costs are high. As we show below $\mathbb{E}_t^A[a_{i,t}\xi_{i,t}] > \mathbb{E}_t^A[\xi_{i,t}]$, which implies that financial frictions raise real marginal cost normalized by the valuation of internal funds.

In contrast to the firm's optimal choices of labor and dividends, the optimality conditions for prices ($p_{i,h,t}$ and $p_{i,h,t}^*$), output ($c_{i,h,t}$ and $c_{i,h,t}^*$), and habit stocks ($s_{i,h,t}$ and $s_{i,h,t}^*$) in domestic and foreign markets are determined prior to the realization of the idiosyncratic shock a_{it} . The optimality conditions for prices require firms to set the real relative price in each market equal to a constant multiple of the shadow value of marginal sales in each market, normalized by the shadow value of internal funds:

$$p_{i,h,t}p_{h,t} = \eta \frac{\mathbb{E}_t^A[\nu_{i,h,t}]}{\mathbb{E}_t^A[\xi_{i,t}]}; \quad (16)$$

$$p_{i,h,t}^*q_t p_{h,t}^* = \eta \frac{\mathbb{E}_t^A[\nu_{i,h,t}^*]}{\mathbb{E}_t^A[\xi_{i,t}]}; \quad (17)$$

The normalized value of marginal sales is given by the first-order condition for sales in each market (that is, $c_{i,h,t}$ and $c_{i,h,t}^*$):

$$\frac{\mathbb{E}_t^A[\nu_{i,h,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} = p_{i,h,t}p_{h,t} - \frac{\mathbb{E}_t^A[\kappa_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} + (1-\rho) \frac{\mathbb{E}_t^A[\lambda_{i,h,t}]}{\mathbb{E}_t^A[\xi_{i,t}]}; \quad (18)$$

$$\frac{\mathbb{E}_t^A[\nu_{i,h,t}^*]}{\mathbb{E}_t^A[\xi_{i,t}]} = p_{i,h,t}^*q_t p_{h,t}^* - \frac{\mathbb{E}_t^A[\kappa_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} + (1-\rho) \frac{\mathbb{E}_t^A[\lambda_{i,h,t}^*]}{\mathbb{E}_t^A[\xi_{i,t}]}; \quad (19)$$

To the firm, the value of a marginal sale is equal to the current marginal profit—price minus marginal cost—plus the additional value that the firm receives from increasing its customer base by expanding the habit stock.

The optimality conditions for habit stocks imply that the marginal value of the habit stock—in both the domestic and foreign markets—satisfies the recursion:

$$\frac{\mathbb{E}_t^A[\lambda_{i,h,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} = \theta(1-\eta)\mathbb{E}_t\left[\tilde{m}_{t,t+1} \frac{\mathbb{E}_{t+1}^A[\nu_{i,h,t+1}]}{\mathbb{E}_{t+1}^A[\xi_{i,t+1}]} \frac{c_{h,t+1}}{s_{h,t}}\right] + \rho\mathbb{E}_t\left[\tilde{m}_{t,t+1} \frac{\mathbb{E}_{t+1}^A[\lambda_{i,h,t+1}]}{\mathbb{E}_{t+1}^A[\xi_{i,t+1}]} \right]; \quad (20)$$

$$\frac{\mathbb{E}_t^A[\lambda_{i,h,t}^*]}{\mathbb{E}_t^A[\xi_{i,t}]} = \theta(1-\eta)\mathbb{E}_t\left[\tilde{m}_{t,t+1} \frac{\mathbb{E}_{t+1}^A[\nu_{i,h,t+1}^*]}{\mathbb{E}_{t+1}^A[\xi_{i,t+1}]} \frac{c_{i,h,t+1}^*}{s_{h,t}^*}\right] + \rho\mathbb{E}_t\left[\tilde{m}_{t,t+1} \frac{\mathbb{E}_{t+1}^A[\lambda_{i,h,t+1}^*]}{\mathbb{E}_{t+1}^A[\xi_{i,t+1}]} \right], \quad (21)$$

where the firm's effective stochastic discount factor

$$\tilde{m}_{t,t+1} = m_{t,t+1} \frac{\mathbb{E}_{t+1}^A[\xi_{i,t+1}]}{\mathbb{E}_t^A[\xi_{i,t}]}$$

equals the discount factor $m_{t,t+1}$ of the representative household, modified by the term reflecting the firm's internal valuation of one dollar tomorrow relative to today. Equations (20) and (21) highlight the forward-looking nature of the firm's price-setting behavior. The marginal value of having a higher customer base today is equal to the present-discounted value of future marginal

sales. How fast this present value decays depends on three things: the survival rate of the habit (ρ); the representative household's discount factor ($m_{t,t+1}$); and the firm's liquidity condition as measured by the shadow value of internal funds today versus tomorrow ($\mathbb{E}_{t+1}^A[\xi_{i,t+1}]/\mathbb{E}_t^A[\xi_{i,t}]$).

3.5 Symmetric Equilibrium

With risk-neutral firms and i.i.d. idiosyncratic costs shocks, our timing assumptions imply that all firms in a given country are identical ex ante. As a result, we focus on an equilibrium that has a number of symmetric features. Specifically, all home country firms choose identical relative prices ($p_{i,h,t} = 1$ and $p_{i,h,t}^* = 1$), scales of production ($c_{i,h,t} = c_{h,t}$ and $c_{i,h,t}^* = c_{h,t}^*$), and habit stocks ($s_{i,h,t} = s_{h,t}$ and $s_{i,h,t}^* = s_{h,t}^*$).

The symmetric equilibrium condition $p_{i,h,t} = p_{i,h,t}^* = 1$ implies that firms in the home country set the same relative prices in domestic and foreign markets vis-à-vis other competitors from the same origin.¹⁵ Similarly, foreign firms make pricing decisions among themselves, both in the domestic and foreign markets, such that $p_{i,f,t} = p_{i,f,t}^* = 1$. However, the asymmetric nature of financial conditions induces differences in the firms' internal liquidity positions and causes home and foreign firms to adopt different pricing policies. As a result, $p_{h,t} = P_{h,t}/P_t \neq 1$, $p_{h,t}^* = P_{h,t}^*/P_t^* \neq 1$, $p_{f,t} = P_{f,t}/P_t \neq 1$, and $p_{f,t}^* = P_{f,t}^*/P_t^* \neq 1$, implying that $p_{h,t} \neq p_{f,t}$ and $p_{h,t}^* \neq p_{f,t}^*$, in general. As we show below, the relatively weaker financial positions of home country firms forces them to maintain higher prices and markups in the neighborhood of the (nonstochastic) steady state, such that $p_h > p_f$ and $p_h^* > p_f^*$. (In our notation, variables without a time subscript denote steady-state values.)

Imposing the relevant symmetric equilibrium conditions, the internal funds of the firm are given by the revenues less production costs:

$$p_{h,t}c_{h,t} + q_t p_{h,t}^* c_{h,t}^* - w_t \frac{a_{i,t}}{A_t} (\phi + c_{h,t} + c_{h,t}^*)^{\frac{1}{\alpha}},$$

where we used the conditional labor demand given by equation (13) to substitute out for h_t . The firm thus resorts to costly external finance—that is, issues new shares—if and only if

$$a_{i,t} > a_t^E \equiv \frac{A_t}{w_t} \left[\frac{p_{h,t}c_{h,t} + q_t p_{h,t}^* c_{h,t}^*}{(\phi + c_{h,t} + c_{h,t}^*)^{\frac{1}{\alpha}}} \right]. \quad (22)$$

Using the above definition of the equity issuance trigger a_t^E , we can rewrite the first-order conditions for dividends (equation 15) as

$$\xi_{i,t} = \begin{cases} 1 & \text{if } a_{i,t} \leq a_t^E \\ 1/(1 - \varphi) & \text{if } a_{i,t} > a_t^E, \end{cases}$$

¹⁵Recall that $p_{i,h,t}$ and $p_{i,h,t}^*$ are relative prices measured against average prices charged by firms in the home country. These are different from the relative prices against local and foreign CPIs, which are averages of prices of both domestic and imported goods (see equation 8).

which states that because of costly external financing, the shadow value of internal funds jumps from 1 to $1/(1-\varphi) > 1$ when the realization of the idiosyncratic cost shock $a_{i,t}$ exceed the threshold value a_t^E .

Let z_t^E denote the standardized value of a_t^E (that is, $z_t^E = (\ln a_t^E + 0.5\sigma^2)/\sigma$). The expected shadow value of internal funds can then be expressed as

$$\mathbb{E}_t^A[\xi_{i,t}] = \int_0^{a_t^E} dF(a) + \int_{a_t^E}^{\infty} \frac{1}{1-\varphi} dF(a) = 1 + \frac{\varphi}{1-\varphi} [1 - \Phi(z_t^E)] \geq 1, \quad (23)$$

where $\Phi(\cdot)$ denotes the standard normal CDF. Thus, the expected shadow value of internal funds is strictly greater than one as long as equity issuance is costly ($\varphi > 0$) and future costs are uncertain ($\sigma > 0$). As emphasized by GSSZ, this makes firms de facto risk averse when making their pricing decisions: A policy of setting a low markup and committing to fulfilling the resulting large number of orders exposes the firm to operating losses, which must be covered by issuing costly new equity. To mitigate this liquidity risk, firms choose a higher markup than they would in the absence of financial market frictions.

In our context, $\mathbb{E}_t^A[\xi_{i,t}]$ directly captures the firm's ex ante valuation of an additional dollar obtained from increasing marginal revenue. As discussed above, the firm's ex ante internal valuation of marginal cost depends on $\mathbb{E}_t^A[\xi_{i,t}a_{i,t}]$. From the assumption that $\mathbb{E}_t^A[a_{i,t}] = 1$ and properties of the log-normal distribution (see [Kotz et al. \(2000\)](#)), it follows that

$$\mathbb{E}_t^A[\xi_{i,t}a_{i,t}] - \mathbb{E}_t^A[\xi_{i,t}] = \text{Cov}[\xi_{i,t}, a_{i,t}] = \frac{\varphi}{1-\varphi} [\Phi(z_t^E) - \Phi(z_t^E - \sigma)].$$

Because the realized shadow value of internal funds covaries positively with the cost shock, the ex ante internal valuation of marginal cost exceeds the ex-ante valuation of marginal revenue so that

$$\frac{\mathbb{E}_t^A[\xi_{i,t}a_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} = \frac{1 - \varphi\Phi(z_t^E - \sigma)}{1 - \varphi\Phi(z_t^E)} > 1. \quad (24)$$

3.5.1 Optimal Pricing Strategy

To streamline the notation, we define the markup μ_t as the inverse of real marginal cost, inclusive of expected financing costs:

$$\mu_t = \left[\frac{\mathbb{E}_t^A[a_{i,t}\xi_{i,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} \frac{w_t}{\alpha A_t} (\phi + c_{h,t} + c_{h,t}^*)^{\frac{1-\alpha}{\alpha}} \right]^{-1}. \quad (25)$$

Using the fact that $\mathbb{E}_t^A[\kappa_{i,t}]/\mathbb{E}_t^A[\xi_{i,t}] = \mu_t^{-1}$ and substituting the rational expectations solutions of equations (20) and (21) into equations (18) and (19), yields the closed-form solutions for the

normalized shadow values of marginal sales in the two markets:

$$\frac{\mathbb{E}_t^A[\nu_{i,h,t}]}{\mathbb{E}_t^A[\xi_{i,t}]} = p_{h,t} - \frac{1}{\mu_t} + \chi \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \tilde{\beta}_{h,t,s} \frac{\mathbb{E}_s^A[\xi_{i,s}]}{\mathbb{E}_t^A[\xi_{i,t}]} \left(p_{h,s} - \frac{1}{\mu_s} \right) \right]; \quad (26)$$

$$\frac{\mathbb{E}_t^A[\nu_{i,h,t}^*]}{\mathbb{E}_t^A[\xi_{i,t}]} = q_t p_{h,t}^* - \frac{1}{\mu_t} + \chi \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \tilde{\beta}_{h,t,s}^* \frac{\mathbb{E}_s^A[\xi_{i,s}]}{\mathbb{E}_t^A[\xi_{i,t}]} \left(q_s p_{h,s}^* - \frac{1}{\mu_s} \right) \right], \quad (27)$$

where $\chi = (1 - \rho)\theta(1 - \eta) > 0$ and $\tilde{\beta}_{t,s}$ and $\tilde{\beta}_{t,s}^*$ denote the the growth-adjusted, compound discounting factors given by

$$\begin{aligned} \tilde{\beta}_{h,t,s} &= m_{s,s+1} g_{h,s+1} \prod_{j=1}^{s-t} (\rho + \chi g_{h,t+j}) m_{t+j-1,t+j}, \text{ with } g_{h,t} = \frac{s_{h,t}/s_{h,t-1} - \rho}{1 - \rho}; \\ \tilde{\beta}_{h,t,s}^* &= m_{s,s+1} g_{h,s+1}^* \prod_{j=1}^{s-t} (\rho + \chi g_{h,t+j}^*) m_{t+j-1,t+j}, \text{ with } g_{h,t}^* = \frac{s_{h,t}^*/s_{h,t-1}^* - \rho}{1 - \rho}. \end{aligned}$$

Substituting equations (26) and (27) into equations (16) and (17), we can, after imposing the symmetric equilibrium conditions, express the firm's optimal pricing strategies in the home and foreign markets as

$$p_{h,t} = \frac{\eta}{\eta - 1} \frac{1}{\mu_t} + (1 - \rho)\theta\eta \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \tilde{\beta}_{h,t,s} \frac{\mathbb{E}_s^A[\xi_{i,s}]}{\mathbb{E}_t^A[\xi_{i,t}]} \left(p_{h,s} - \frac{1}{\mu_s} \right) \right]; \quad (28)$$

$$q_t p_{h,t}^* = \frac{\eta}{\eta - 1} \frac{1}{\mu_t} + (1 - \rho)\theta\eta \mathbb{E}_t \left[\sum_{s=t+1}^{\infty} \tilde{\beta}_{h,t,s}^* \frac{\mathbb{E}_s^A[\xi_{i,s}]}{\mathbb{E}_t^A[\xi_{i,t}]} \left(q_s p_{h,s}^* - \frac{1}{\mu_s} \right) \right]. \quad (29)$$

Note that without customer markets—that is, $\theta = 0$ —the second term on the right-hand side of equations (28) and (29) disappears, and we obtain the standard pricing equations for a static monopolist facing isoelastic demand: The firm sets price as a constant markup $\eta/(\eta - 1)$ over current marginal cost, inclusive of expected financing costs. With $\theta < 0$, the presence of customer market relationships implies that, on average, prices are strictly lower than those set by the static monopolist because firms have an incentive to lower prices to expand their market shares.

Financial frictions create a tension between the firm's desire to expand its market share and maintain a liquid balance sheet. The terms inside the square brackets of equations (28) and (29) are the present values of future profits. When expanding its market share becomes more important, which happens through the increase in the growth-adjusted, compound discount rates $\tilde{\beta}_{t,s}$ and $\tilde{\beta}_{t,s}^*$, the firm has a greater incentive to reduce prices. However, when the firm faces a liquidity problem in the sense that the shadow value of internal funds today is strictly larger than future values—that is, $\mathbb{E}_t^A[\xi_{i,t}] > \mathbb{E}_t^A[\xi_{i,s}]$, for $s > t$ —the firm discounts future profits more heavily. The fact that $(1 - \rho)\theta\eta < 0$ implies that the firm is more likely to raise prices in order to boost current cashflows, even though doing so cannibalizes its future market share.

It is worth noting that the terms in square brackets represent a new price-adjustment chan-

nel in the international macroeconomics literature. This literature has emphasized the role of variable markups, micro-founded via oligopolistic competition (see [Dornbusch, 1987](#); [Yang, 1997](#); [Atkeson and Burstein, 2008](#); [Gopinath and Itskhoki, 2010a](#); [Auer and Schoenle, 2016](#)). In these models, firms absorb adverse cost shocks by lowering markups, pricing behavior that is associated with the preservation of current market shares. As a result, the pass-through of shocks is incomplete. The tension between concerns about future market shares due to customer markets considerations and financial frictions opens up a distinct, though complementary, pass-through channel in our model, one that weakens the degree of pass-through for firms with liquid balance sheets but strengthens the degree of pass-through for their cash-strapped counterparts.

Given the optimal dividend policy specified by equation (22), equations (23), (24), and (25) completely specify the ex ante shadow value of internal funds $\mathbb{E}_t^A[\xi_{i,t}]$ and the financially adjusted markup μ_t as static functions of aggregate variables w_t/A_t , $c_{h,t}$, $c_{h,t}^*$, $p_{h,t}$, $p_{h,t}^*$, and q_t . This implies that equations (28) and (29) completely summarize the firm's pricing policy, where, in equilibrium, the firm's production and demand constraints imply that $A_t h_t^\alpha = c_{h,t} + c_{h,t}^* + \phi$; $c_{h,t} = s_{h,t}^\theta x_{h,t}$, where $s_{h,t} = \rho s_{h,t-1} + (1 - \rho)c_t$; and $c_{h,t}^* = s_{h,t-1}^{*\theta} x_{h,t}^*$, where $s_{h,t}^* = \rho s_{h,t-1}^* + (1 - \rho)c_t^*$. Demand in the home country for domestic and foreign goods, $x_{h,t}$ and $x_{h,t}^*$, respectively, depends on aggregate domestic and foreign consumption baskets x_t and x_t^* and their respective relative prices:

$$\begin{aligned} x_{h,t} &= \Xi_h^\varepsilon \left(\frac{\tilde{p}_{h,t}}{\tilde{p}_t} \right)^{-\varepsilon} x_t, \text{ where } \tilde{p}_{k,t} = p_{k,t} s_{k,t-1}^\theta \text{ and } \tilde{p}_t = \left[\sum_{k=h,f} \Xi_k \tilde{p}_{k,t}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}; \\ x_{h,t}^* &= \Xi_h^{*\varepsilon} \left(\frac{\tilde{p}_{h,t}^*}{\tilde{p}_t^*} \right)^{-\varepsilon} x_t^*, \text{ where } \tilde{p}_{k,t}^* = p_{k,t}^* s_{k,t-1}^{*\theta} \text{ and } \tilde{p}_t^* = \left[\sum_{k=h,f} \Xi_k^* \tilde{p}_{k,t}^{*(1-\varepsilon)} \right]^{\frac{1}{1-\varepsilon}}. \end{aligned}$$

In the absence of nominal rigidities, the household equilibrium conditions then allow us to determine aggregate consumption x_t , the household's stochastic discount factor $m_{t,t+1}$, and the real exchange rate q_t .

3.5.2 Inflation Dynamics

Adding nominal rigidities to the model does not alter the nature of the firm's optimal pricing problem fundamentally. The key relationships that generate tension between the firm's desire to maximize its market share versus its current cashflow when faced with costly external finance—namely, the relationships captured by equations (26) and (27)—continue to hold even when prices are sticky. Therefore, instead of repeating the analysis, we simply close this section by showing how financial market frictions and customer market relationships modify the well-known, log-linearized Phillips curve.

Using equation (8), we express the log-linearized inflation dynamics of national CPIs as

$$\hat{\pi}_t = \Xi_h p_h (\hat{p}_{h,t-1} + \hat{\pi}_{h,t}) + \Xi_f p_f (\hat{p}_{f,t-1} + \hat{\pi}_{f,t}); \quad (30)$$

$$\hat{\pi}_t^* = \Xi_h^* p_h^* (\hat{p}_{h,t-1}^* + \hat{\pi}_{h,t}^*) + \Xi_f^* p_f^* (\hat{p}_{f,t-1}^* + \hat{\pi}_{f,t}^*), \quad (31)$$

where variables with a “hat” denote the log-linearized deviations from their respective steady-state values. Equations (30) and (31) show how import prices affect the overall inflation dynamics of national CPIs. As such, they require construction of Phillips curves for $\hat{\pi}_{h,t}$, $\hat{\pi}_{f,t}$, $\hat{\pi}_{h,t}^*$, and $\hat{\pi}_{f,t}^*$. To conserve space, we focus on the first and the third—that is, Phillips curves governing inflation dynamics of home country firms in the domestic and foreign markets, respectively.

Log-linearizing the first-order conditions for $p_{i,h,t}$ and $p_{i,h,t}^*$ yields:

$$\hat{\pi}_{h,t} = \frac{1}{\gamma_p} \frac{p_h c_h}{c} [\hat{p}_{h,t} - (\hat{\nu}_{h,t} - \hat{\xi}_t)] + \delta \mathbb{E}_t \hat{\pi}_{h,t+1}; \quad (32)$$

$$\hat{\pi}_{h,t}^* = \frac{1}{\gamma_p} q \frac{p_h^* c_h^*}{c^*} [\hat{q}_t + \hat{p}_{h,t}^* - (\hat{\nu}_{h,t}^* - \hat{\xi}_t)] + \delta \mathbb{E}_t \hat{\pi}_{h,t+1}^*, \quad (33)$$

where $\hat{\nu}_{h,t}$, $\hat{\nu}_{h,t}^*$, and $\hat{\xi}_t$ are the log-deviations of $\mathbb{E}_t^A[\nu_{i,h,t}]$, $\mathbb{E}_t^A[\nu_{i,h,t}^*]$, and $\mathbb{E}_t^A[\xi_{i,t}]$ from their respective steady-state values. In the absence of customer markets, the terms in brackets are exactly equal to the log-deviation of the financially adjusted real marginal cost μ_t^{-1} , and we recover the standard forward-looking Phillips curve for each market.

With customer markets, however, we obtain a richer set of dynamics. Log-linearizing equations (26) and (27) and substituting the results into equations (32) and (33) yields the following Phillips curve for the domestic market:

$$\begin{aligned} \hat{\pi}_{h,t} = & \frac{1}{\gamma_p} \frac{p_h c_h}{c} \left[\hat{p}_{h,t} - \eta \left(\hat{p}_{h,t} + \frac{\hat{\mu}_t}{p_h \mu} \right) - \eta \chi \mathbb{E}_t \sum_{s=t+1}^{\infty} \tilde{\delta}^{s-t} \left(\hat{p}_{h,s} + \frac{\hat{\mu}_s}{p_h \mu} \right) \right] \\ & + \frac{\eta \chi}{\gamma_p} \frac{p_h c_h}{c} \left(1 - \frac{1}{p_h \mu} \right) \mathbb{E}_t \sum_{s=t+1}^{\infty} \tilde{\delta}^{s-t} [(\hat{\xi}_t - \hat{\xi}_s) - \hat{\beta}_{h,t,s}] + \delta \mathbb{E}_t \hat{\pi}_{h,t+1}; \end{aligned} \quad (34)$$

and for the foreign market:

$$\begin{aligned} \hat{\pi}_{h,t}^* = & \frac{1}{\gamma_p} q \frac{p_h^* c_h^*}{c^*} \left[\hat{q}_t + \hat{p}_{h,t}^* - \eta \left((\hat{q}_t + \hat{p}_{h,t}^*) + \frac{\hat{\mu}_t}{q p_h^* \mu} \right) + \chi \mathbb{E}_t \sum_{s=t+1}^{\infty} \tilde{\delta}^{s-t} \left((\hat{q}_s + \hat{p}_{h,s}^*) + \frac{\hat{\mu}_s}{q p_h^* \mu} \right) \right] \\ & + \frac{\eta \chi}{\gamma_p} q \frac{p_h^* c_h^*}{c^*} \left(1 - \frac{1}{q p_h^* \mu} \right) \mathbb{E}_t \sum_{s=t+1}^{\infty} \tilde{\delta}^{s-t} [(\hat{\xi}_t - \hat{\xi}_s) - \hat{\beta}_{h,t,s}^*] + \delta \mathbb{E}_t \hat{\pi}_{h,t+1}^*, \end{aligned} \quad (35)$$

where $\tilde{\delta} \equiv \delta(\rho + \chi)$. Note that with $\chi > 0$, a deterioration in the firm’s current liquidity position, as reflected by $\hat{\xi}_t - \hat{\xi}_s > 0$, leads the firm to raise the market-specific inflation rates. Also note that because $\chi > 0$, the importance of future market shares, represented by $\hat{\beta}_{t,s} > 0$ and $\hat{\beta}_{h,t,s}^* > 0$, causes the firm to lower the market-specific inflation rates. Hence, the terms $(\hat{\xi}_t - \hat{\xi}_s) - \hat{\beta}_{h,t,s}$ and

$(\hat{\xi}_t - \hat{\xi}_s) - \hat{\beta}_{h,t,s}^*$ capture how the tension between the maximization of current cashflows versus market shares affects the aggregate inflation dynamics.

3.6 The Household's Problem

We begin by describing the optimization problem of the representative household in an environment with incomplete risk sharing and floating exchange rates. We then impose restrictions that deliver the baseline model of a monetary union. We also develop an alternative version of the model that allows for complete risk sharing, which we use to analyze the welfare implications of different exchange rate regimes.

3.6.1 Floating Exchange Rates with Incomplete Risk Sharing

The representative household in the home country works h_t hours. It allocates its savings between shares of the home country firms and international bonds that are not state contingent. We denote the home country's holdings of international bonds issued in home and foreign currencies by $B_{h,t+1}$ and $B_{f,t+1}$, respectively, while $B_{h,t+1}^*$ and $B_{f,t+1}^*$ denote their foreign counterparts.¹⁶ The respective (gross) nominal interest rates on these securities are denoted by R_t and R_t^* .

We assume that investors in both countries face identical portfolio rebalancing costs. Focusing on the home country, these costs are given by

$$\frac{\tau}{2} P_t \left[\left(\frac{B_{h,t+1}}{P_t} \right)^2 + q_t \left(\frac{B_{f,t+1}}{P_t^*} \right)^2 \right]; \quad (\tau > 0).$$

The marginal cost of borrowing in the home currency is thus given by $R_t/(1 + \tau B_{h,t+1}/P_t)$, which is strictly greater than R_t if $B_{h,t+1} < 0$. The marginal return on foreign lending in the home currency is given by $R_t(Q_t/Q_{t+1})/(1 + \tau B_{h,t+1}^*/P_t^*)$, which is strictly less than $R_t(Q_t/Q_{t+1})$ if $B_{h,t+1}^* > 0$. Thus, $(1 + \tau B_{h,t+1}/P_t)^{-1}$ represents a welfare loss, not only to the borrowers, but also to the lenders. As pointed out by [Ghironi and Melitz \(2005\)](#), the role of such portfolio rebalancing costs is to pin down the steady-state levels of international bond holdings, as varying τ does not modify the model dynamics in any significant way.

The number of outstanding shares of home country firm i in period t equals $S_{i,t}$. Let $P_{i,t-1}^S$ be the period- t per-share value of the shares outstanding as of period $t-1$, while $P_{i,t}^S$ is the (ex-dividend) per-share value of shares in period t . Using the fact that $\int_{N_k} P_{i,k,t} c_{i,k,t} di = \tilde{P}_{k,t} x_{k,t}$, for

¹⁶Note that our notation implies that $B_{h,t+1} + B_{h,t+1}^* = 0$, where $B_{h,t+1}$ and $B_{h,t+1}^*$ are denominated in home currency—as denoted by the subscript h —and are held by the home and foreign country residents, respectively. If $B_{h,t+1} < 0$ ($B_{f,t+1} < 0$), residents of the home country have borrowed money in their domestic (foreign) currency from the foreign country, whose residents hold claims $B_{h,t+1}^* > 0$ ($B_{f,t+1}^* > 0$).

$k = h, f$ (see Appendix A), we can express the household's intertemporal budget constraint as

$$0 = W_t h_t + R_{t-1} B_{h,t} + Q_t R_{t-1}^* B_{f,t} + \int_{N_h} [\max\{D_{i,t}, 0\} + P_{i,t-1}^S] S_{i,t} di \\ - \tilde{P}_t x_t - B_{h,t+1} - Q_t B_{f,t+1} - \frac{\tau}{2} P_t \left[\left(\frac{B_{h,t+1}}{P_t} \right)^2 + q_t \left(\frac{B_{f,t+1}}{P_t^*} \right)^2 \right] - \int_{N_h} P_{i,t}^S S_{i,t+1} di \quad (36)$$

Note that we have expressed the household's consumption expenditure problem as purchasing the habit-adjusted consumption basket x_t using the price index \tilde{P}_t , which is possible because \tilde{P}_t is a welfare-based price index.

The representative household maximizes the life-time utility given by equation (4) subject to the budget constraint (36). Letting Λ_t denote the Lagrange multiplier associated with the budget constraint, the first-order condition for x_t is given by $\Lambda_t = U_{x,t}/\tilde{P}_t = U_{x,t}/(\tilde{P}_t/P_t)P_t = (U_{x,t}/\tilde{p}_t)/P_t$. We can then express the first-order condition for labor as $U_{x,t}w_t/\tilde{p}_t = -U_{h,t}$.

Note that the two equity valuation terms that appear in the budget constraint (36) are related through an accounting identity $P_{i,t}^S = P_{i,t-1}^S + E_{i,t}^S$, where $E_{i,t}^S$ equals the per-share value of new equity issued by a firm i in period t . Because of equity dilution costs, $E_{i,t}^S = -(1-\varphi) \times \min\{D_{i,t}, 0\}$.¹⁷ By substituting $P_{i,t-1}^S = P_{i,t}^S - E_{i,t}^S = P_{i,t}^S + (1-\varphi) \times \min\{D_{i,t}, 0\}$ into the budget constraint, we can derive the following first-order conditions for the holdings of international bonds and shares of the firms:

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}/\tilde{p}_{t+1}}{U_{x,t}/\tilde{p}_t} \left(\frac{R_t}{\pi_{t+1}} \frac{1}{1 + \tau b_{h,t+1}} \right) \right]; \quad (37)$$

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}/\tilde{p}_{t+1}}{U_{x,t}/\tilde{p}_t} \left(\frac{q_{t+1}}{q_t} \frac{R_t^*}{\pi_{t+1}^*} \frac{1}{1 + \tau b_{f,t+1}} \right) \right]; \quad (38)$$

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}/\tilde{p}_{t+1}}{U_{x,t}/\tilde{p}_{t+1}} \frac{1}{\pi_{t+1}} \left(\frac{\mathbb{E}_{t+1}^A[\tilde{D}_{i,t+1}] + P_{t+1}^S}{P_t^S} \right) \right], \quad (39)$$

where $\tilde{D}_{i,t} = \max\{D_{i,t}, 0\} + (1-\varphi) \times \min\{D_{i,t}, 0\}$, $b_{h,t+1} = B_{h,t+1}/P_t$, and $b_{f,t+1} = B_{f,t+1}/P_t^*$. In deriving equation (39), we have exploited the fact that the ex-ante firm valuations—that is, valuations prior to the realization of the idiosyncratic cost shocks—are equalized across firms; in other words, $\mathbb{E}_{t+1}^A[P_{i,t+1}^S] = P_{t+1}^S$ in the symmetric equilibrium.

Conditions that ensure the clearing of the bond market are given by

$$0 = b_{h,t+1} + b_{h,t+1}^* \quad \text{and} \quad 0 = b_{f,t+1} + b_{f,t+1}^*, \quad (40)$$

where foreign holdings of international bonds denominated in home and foreign currencies— $b_{h,t+1}^*$

¹⁷In our model, costly equity financing takes the form of sales of new shares at a discount. Because the owners of old and new shares are the same, there is no direct wealth effect associated with equity dilution costs, as the losses of the old shareholders are exactly offset by the gains of the new shareholders.

and $b_{f,t+1}^*$, respectively—satisfy the foreign counterparts of equations (37) and (38), given by

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}^*/\tilde{p}_{t+1}^*}{U_{x,t+1}^*/\tilde{p}_{t+1}^*} \frac{q_t}{q_{t+1}} \frac{R_t}{\pi_{t+1}} \frac{1}{1 + \tau b_{h,t+1}^*} \right]; \quad (41)$$

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}^*/\tilde{p}_{t+1}^*}{U_{x,t+1}^*/\tilde{p}_{t+1}^*} \frac{R_t^*}{\pi_{t+1}^*} \frac{1}{1 + \tau b_{f,t+1}^*} \right]. \quad (42)$$

Assuming that the portfolio rebalancing costs are transferred back to the household in a lump-sum fashion, imposing the stock market equilibrium condition $S_{i,t} = S_{i,t+1} = 1$, $i \in N_h$, and dividing the budget constraint through by P_t , equation (36) then implies the following law of motion for the bond holdings in the home country:

$$b_{h,t+1} + q_t b_{f,t+1} = \frac{R_{t-1}}{\pi_t} b_{h,t} + \frac{R_{t-1}^*}{\pi_t^*} q_t b_{f,t} + w_t h_t + \tilde{d}_t - \tilde{p}_t x_t, \quad (43)$$

where $\tilde{d}_t = \tilde{D}_t/P_t$; the corresponding law of motion for the bond holdings in the foreign country is given by

$$\frac{1}{q_t} b_{h,t+1}^* + b_{f,t+1}^* = \frac{R_{t-1}}{q_t \pi_t} b_{h,t}^* + \frac{R_{t-1}^*}{\pi_t^*} b_{f,t}^* + w_t^* h_t^* + \tilde{d}_t^* - \tilde{p}_t^* x_t^*, \quad (44)$$

where $\tilde{d}_t^* = \tilde{D}_t^*/P_t^*$. Multiplying equation (44) by q_t , subtracting the resulting expression from equation (43), and imposing the bond market clearing conditions given by equation (40) yields

$$\begin{aligned} b_{h,t+1} + q_t b_{f,t+1} &= \frac{R_{t-1}}{\pi_t} b_{h,t} + \frac{R_{t-1}^*}{\pi_t^*} q_t b_{f,t} \\ &+ \frac{1}{2} (w_t h_t - q_t w_t^* h_t^*) + \frac{1}{2} (\tilde{d}_t - q_t \tilde{d}_t^*) - \frac{1}{2} (\tilde{p}_t x_t - q_t \tilde{p}_t^* x_t^*). \end{aligned} \quad (45)$$

This condition, together with the bond market clearing conditions in equation (40), should hold for the balance of payments between the two countries. It replaces the risk-sharing condition that would exist if the two countries traded a complete set of state-contingent bonds in a complete market setting.

Closing the model requires us to specify a monetary policy rule. In the case of floating exchange rates, we assume that monetary authorities in the home and foreign countries set prices of government bonds in their respective countries using an interest-rate rule of the form:

$$R_t = R_{t-1}^{1-\psi_r} \left[R \left(\frac{y_t}{y} \right)^{\psi_y} \left(\frac{\pi_t}{\pi} \right)^{\psi_\pi} \right]^{\psi_r} \quad \text{and} \quad R_t^* = R_{t-1}^{*1-\psi_r} \left[R^* \left(\frac{y_t^*}{y^*} \right)^{\psi_y} \left(\frac{\pi_t^*}{\pi^*} \right)^{\psi_\pi} \right]^{\psi_r}, \quad (46)$$

where the reaction coefficients ψ_r , ψ_y , and ψ_π are assumed to be the same across the two countries.

3.6.2 Monetary Union with Incomplete Risk Sharing

In a monetary union, all products and financial assets are denominated in common currency. As a result, the nominal exchange rate Q_t is not defined. In addition, a single monetary authority sets the interest rate, denoted by R_t^U , and all investors, regardless of their country of origin and current location, earn the same nominal return on their bond holdings.¹⁸ Again, to close the model, we assume that monetary policy in the union is conducted in a manner that reflects the economic fundamentals of both countries:

$$R_t^U = (R^U)^{1-\psi_r} \left[R_{t-1}^U \left(\frac{y_t^U}{y^U} \right)^{\psi_y} \left(\frac{\pi_t^U}{\pi^U} \right)^{\psi_\pi} \right]^{\psi_r},$$

where the union-wide variables are constructed as weighted averages of country-specific aggregates, with the weights given by the steady-state shares of output:¹⁹

$$y_t^U = y_t \left(\frac{y}{y + qy^*} \right) + q_t y_t^* \left(\frac{qy^*}{y + qy^*} \right) \quad \text{and} \quad \pi_t^U = \pi_t \left(\frac{y}{y + qy^*} \right) + \pi_t^* \left(\frac{qy^*}{y + qy^*} \right).$$

Because there is no longer any distinction between bonds issued in home and foreign currency, we replace the bond market clearing conditions given in equation (40) by

$$b_{t+1} + b_{t+1}^* = 0, \tag{47}$$

where b_{t+1} and b_{t+1}^* denote the holdings of international bonds—denominated in common currency—by the home and foreign countries, respectively. In this case, however, there are only two, instead of four, Euler equations characterizing the equilibrium in the international bond market:

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}/\tilde{p}_{t+1}}{U_{x,t+1}/\tilde{p}_{t+1}} \frac{R_t^U}{\pi_{t+1}} \frac{1}{1 + \tau b_{t+1}} \right]; \tag{48}$$

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}^*/\tilde{p}_{t+1}^*}{U_{x,t+1}^*/\tilde{p}_{t+1}^*} \frac{q_t}{q_{t+1}} \frac{R_t^U}{\pi_{t+1}^*} \frac{1}{1 + \tau b_{t+1}^*} \right]. \tag{49}$$

Note that $q_t/q_{t+1} = (Q_t/Q_{t+1})(\pi_{t+1}/\pi_{t+1}^*) = \pi_{t+1}/\pi_{t+1}^*$ in a monetary union. Finally, the monetary union implies that the combined law of motion for the international bond holdings given in equation (45) can be expressed as

$$b_{t+1} = \frac{R_{t-1}^U}{\pi_t} b_t + \frac{1}{2}(w_t h_t - q_t w_t^* h_t^*) + \frac{1}{2}(\tilde{d}_t - q_t \tilde{d}_t^*) - \frac{1}{2}(\tilde{p}_t x_t - q_t \tilde{p}_t^* x_t^*). \tag{50}$$

¹⁸However, the *real* returns on international bond holdings will differ in equilibrium, depending on the reference location of investors. This divergence in real returns reflects two factors. First, the two countries have different consumption baskets in the long run, owing to the presence of home bias in consumption. Second, at any point in time, the law of one price does not hold in the monetary union because two consumers residing in different countries have accumulated different stocks of habit for an identical product. Because firms price their products to markets—the so-called pricing to habits [Ravn et al. \(2007\)](#)—inflation rates are not equalized across countries, despite the adoption of a single currency and common monetary policy.

¹⁹The model dynamics are robust to alternative weighting schemes (real time or lagged weights, and so on).

3.6.3 Monetary Union with Complete Risk Sharing

As a topical policy exercise, we also analyze the welfare gains implied by a complete risk-sharing arrangement between the two countries, under both floating exchange rates and in a monetary union. We model complete risk sharing by introducing state-contingent bonds that are traded internationally, along with government bonds that are in zero net supply. With complete risk sharing, we no longer need to rely on imperfections in the government bond market to induce a long-run stationary equilibrium—accordingly, we set $\tau = 0$. As shown in Appendix A, the presence of a complete set of state-contingent bonds implies the following risk-sharing condition:

$$q_t = \varrho_0 \frac{U_{x,t}^*/\tilde{p}_t^*}{U_{x,t}/\tilde{p}_t}, \text{ where } \varrho_0 = q_0 \frac{U_{x,0}/\tilde{p}_0}{\tilde{U}_{x,0}^*/\tilde{p}_0^*}, \quad (51)$$

which replaces the bond holding condition (45) derived under incomplete markets.

The risk-sharing condition in equation (51) should hold in any exchange rate regime. However, to determine the equilibrium in a monetary union, only one of the two consumption Euler equations that characterize the equilibrium under floating exchange rates is needed. This is because the combination of common monetary policy and the assumption of complete risk sharing introduces linear dependence into the two Euler equations. Hence, only the following efficiency condition enters the system of equations characterizing the equilibrium in a monetary union:²⁰

$$1 = \delta \mathbb{E}_t \left[\frac{U_{x,t+1}/\tilde{p}_{t+1}}{U_{x,t}/\tilde{p}_t} \frac{R_t^U}{\pi_{t+1}} \right].$$

4 Calibration

Unless noted otherwise, our calibration is symmetric—that is, we use the same parameter values for the home and foreign countries. Given the quarterly frequency of the model, we set the time discount factor $\delta = 0.995$. The deep habit parameter $\theta = -0.86$, a value close to that used by Ravn et al. (2007), while the persistence of the habit-formation process $\rho = 0.85$ —in other words, 15 percent of the habit stock depreciates within a quarter. The CRRA parameter of the representative household’s utility function is then set equal to 1, given that our deep-habit specification provides a strong motive to smooth consumption. We set the elasticity of labor supply to $1/3$, while the aggregate technology shocks A_t and A_t^* are both assumed to follow a first-order autoregressive process with the persistence parameter $\rho_A = 0.9$.

The elasticity of substitution between goods of a given type (η) is the key parameter in our customer market environment: The greater the firm’s market power, the greater the incentive to invest in customer base. We set $\eta = 2$, a value that is virtually identical to the median of the point estimates of the elasticity of substitution among differentiated goods estimated by Broda and Weinstein (2006) on the post-1990 U.S. data; this choice is also broadly consistent with the structural esti-

²⁰If both consumption Euler equations were satisfied, then common monetary policy and complete risk sharing would imply that $\pi_{t+s} = \pi_{t+s}^*$, for all s , which cannot be satisfied in equilibrium.

mates of the elasticity obtained by [Ravn et al. \(2010\)](#). With regard to Ξ_h and Ξ_f , the weights of domestic and foreign goods in the utility function, we choose these two parameters such that the share of imported goods in the steady-state consumption basket is equal to 0.4, the middle of the range of the ratios of imports to GDP for the euro area countries since 2000.²¹ As for the elasticity of substitution between goods from different countries, we set $\varepsilon = 1.5$, in order to stay close to the near-unit Armington elasticity estimated by [Feenstra et al. \(2014\)](#).²²

Consistent with the international macroeconomics literature, we assume constant returns-to-scale ($\alpha = 1$).²³ Given our assumption of identical production technologies in the two countries, fixed operating costs $\phi = 0.1$. To introduce financial heterogeneity into the model, we set the degree of financial distortions in the home country $\varphi = 0.2$, whereas $\varphi^* = 0.02$. The volatility of the idiosyncratic cost shocks (σ) is set to 20 percent, implying that firms in both countries are exposed to a fair amount of idiosyncratic uncertainty. In combination, our parameter choices imply that the expected shadow value of external funds $\mathbb{E}_t^A[\xi_{i,t}]$ for home country firms is equal to about 1.05, implying an external finance premium of 5 percent. Given the minimal degree of distortions to foreign capital markets, foreign country firms face, for all practical purposes, no external finance premium. [ADD A COUPLE OF SENTENCES ON WHAT THIS CALIBRATION IMPLIES FOR STEADY-STATE MARKUPS.]

With regards to nominal rigidities, we set the parameters governing the costs of adjusting nominal prices $\gamma_p = \gamma_p^* = 10$. For the ease of exposition, our presentation of the model above treated nominal wages as completely flexible. In the numerical implementation of the model, however, we introduce nominal wage rigidities along the lines of [Bordo et al. \(2000\)](#) and [Erceg et al. \(2000\)](#). Consistent with the symmetric treatment of nominal price rigidities, we assume that households supplying differentiated labor have identical market power in both countries, while firms face identical quadratic costs—parameterized by $\gamma_w = \gamma_w^*$ —of adjusting nominal wages. With a separable utility function and a constant elasticity of labor supply, $U_{h,t} = -h_t^{1/\zeta}$, the first-order condition for labor implies that

$$\begin{aligned} \eta_w \frac{h_t^{1/\zeta} / U_{x,t}}{w_t / \tilde{p}_t} &= \eta_w - 1 + \gamma_w (\pi_{w,t} - \pi_w) \pi_{w,t} \\ &\quad - \delta \mathbb{E}_t \left[\frac{U_{x,t+1} / \tilde{p}_{t+1}}{U_{x,t} / \tilde{p}_t} \gamma_w (\pi_{w,t+1} - \pi_w) \pi_{w,t+1} \frac{\pi_{w,t+1}}{\pi_{t+1}} \frac{h_{t+1}}{h_t} \right], \end{aligned} \quad (52)$$

where $\pi_{w,t} = W_{t+1}/W_t$ and η_w is the elasticity of substitution between differentiated labor. We

²¹Note that Ξ_f itself does not equal the ratio of imports to GDP; rather, it is set to a value such that $\Xi_f^\varepsilon = p_f c_f / \sum_{k=h,f} p_k c_k$.

²²As long as ε is greater than one, its value does not affect our main results. For example, setting ε very close to one reduces, in a monetary union, the impact of a financial shock on aggregate output to two-thirds of that implied by our baseline calibration of $\varepsilon = 1.5$. This attenuation reflects the fact that lower elasticity of substitution between domestic and imported goods reduces the intensity of the “price war” between financially strong foreign firms and their weaker domestic counterparts in response to an adverse financial shock in the home country. However, even in this case, the qualitative features of the equilibrium remain the same.

²³It is worth noting that decreasing returns-to-scale in our framework enhance the link between financial frictions and the firms’ pricing decisions.

set $\eta_w = 3$ and $\gamma_w = \gamma_w^* = 30$. Overall, our calibration of nominal wage and price rigidities is close to the values of $\gamma_p = 14.5$ and $\gamma_w = 41$ estimated by Ravn et al. (2010), who show that deep habits substantially enhance the persistence of inflation without imposing an implausible degree of adjustment frictions in nominal prices.²⁴

Lastly, we set the inertial coefficient in the interest-rate rule (46) $\psi_r = 0.85$ and the response coefficient on the inflation gap $\psi_\pi = 1.5$, values consistent with those of Taylor (1993). The value for the response coefficient on the output gap, by contrast, is less obvious. In the traditional New Keynesian models, this coefficient does not play an important role because of the “divine coincidence,” the fact that a strong reaction to inflation, in general, makes the response to the output gap redundant, or even inefficient. As emphasized by GSSZ and Gilchrist and Zakrajšek (2016), however, this is not the case in our framework, as the combination of customer markets and financial frictions can break the divine coincidence in certain situations. In particular, adverse financial shocks imply negative comovement between inflation and output, thereby presenting monetary authorities with a nontrivial dilemma in those circumstances. As a result, we set $\psi_y = 0.25$, the mid-point of the range suggested by Taylor (1993). (Table A-1 in Appendix A conveniently summarizes our baseline calibration of the model.)

5 Model Simulations

In this section, we use the calibrated model to study the macroeconomic consequences of home and foreign countries forming a monetary union—and hence being subject to common monetary policy—in an environment where the two countries are subject to differing degrees of financial market frictions and the home country is hit by a severe financial shock. We assume that the two countries are unable to achieve a complete risk-sharing arrangement, either through cross-border transfers of funds or cross-border labor mobility. Using this setup, we analyze standard international macroeconomic dynamics under both a floating exchange rate regime and monetary union.

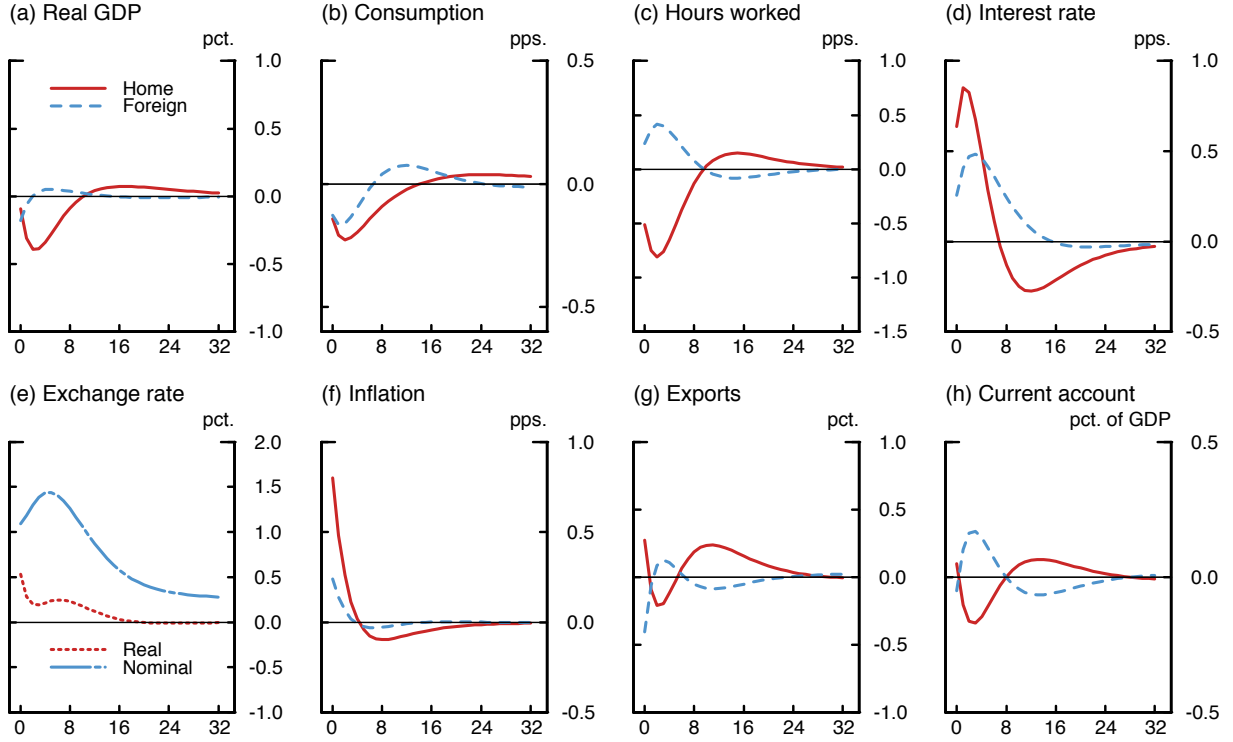
5.1 The Impact of Financial Shocks

To study the effects of financial instability on macroeconomic performance under various monetary frameworks, we introduce an exogenous disturbance that temporarily increases the degree of financial distortions in the home country. Specifically, as in GSSZ, we assume that the cost of issuing new shares by home country firms is subject to a persistent shock f_t :

$$\varphi_t = \varphi f_t, \text{ where } \ln f_t = 0.90 \ln f_{t-1} + u_t \text{ and } u_t \stackrel{iid}{\sim} N(-0.5\sigma_u^2, \sigma_u^2).$$

²⁴The presence of nominal wage rigidities does not modify the dynamics of main macroeconomic aggregates in any appreciable way. It does, however, induce an empirically plausible degree of volatility in the real exchange rate. The more volatile real exchange rate reflects the fact that the countercyclical dynamics of markups in the country subject to an adverse financial shock owe importantly to an increase in product prices, rather than to a decline in nominal wages, as would be the case if wages were completely flexible.

FIGURE 5 – An Asymmetric Financial Shock: Floating Exchange Rates



NOTE: The panels of the figure depict the model-implied responses of selected variables to an adverse financial shock in the home country in period 0 (see the text for details). Unless noted otherwise, the solid lines show responses of variables in the home country, while the dashed lines show those of the foreign country. Exchange rates (panel (e)) are expressed as home currency relative to foreign currency.

Our interpretation of an unanticipated and persistent increase in the cost of external finance in the home country is that such a financial shock represents a “Minsky moment,” a sudden realization on the part of investors in the home country that agency problems in domestic capital markets are much more severe than previously believed (see [Eggertsson and Krugman, 2012](#)). We calibrate the volatility of the financial shock (the variance σ_u^2) so that a realization of u_t of one standard deviation increases the expected shadow value of internal funds for firms in the home country from 5 percent to 10 percent upon impact; the tightening of financial conditions then dissipates gradually, according to the autoregressive dynamics specified above. While firms in the home country experience the tightening of financial conditions, equity issuance costs in the foreign country are assumed to remain unchanged—that is, $\varphi_t^* = \varphi^* = 0.02$, for all t .

To highlight the essential features of our mechanism in an international setting, Figure 5 traces out the macroeconomic implications of such an asymmetric financial shock in the case of floating exchange rates. The interaction of customer markets and financial frictions causes firms in the home country to increase their prices significantly (panel (f)) in an effort to preserve internal liquidity and avoid issuing costly new shares. Indirectly, the shock also raises inflation in the foreign country through the international trade dynamics at work in general equilibrium, though the increase in

prices in the foreign country is notably less pronounced.

As emphasized by GSSZ, financial disturbances in this framework resemble cost-push shocks that can lead to sizable and persistent declines in output. In the absence of nominal exchange rate depreciation, the differential responses of inflation in the two countries would imply a substantial real appreciation for the home country. However, the nominal exchange rate depreciates significantly in response to such an asymmetric shock (panel (c)). In fact, the depreciation is strong enough that the real exchange rate also depreciates, despite the countervailing effect of the movement in relative price levels. Thus as in the data, the short-run dynamics of real exchange rates are dominated by fluctuations in nominal exchange rates, rather than by changes in relative prices.²⁵

The sharp depreciation of the nominal exchange rate generates an initial gain in exports (panel (g)), which explains why real GDP in the home country (panel (a)) declines only modestly, despite the significant and persistent tightening of domestic financial conditions.²⁶ In effect, the nominal exchange rate depreciation helps firms in the home country avoid having to increase the relative prices of their export products too much in order to boost current cashflows. In turn, domestic firms lose relatively little of their export market share to their foreign competitors, which helps to contain the adverse macroeconomic effects of the financial shock.

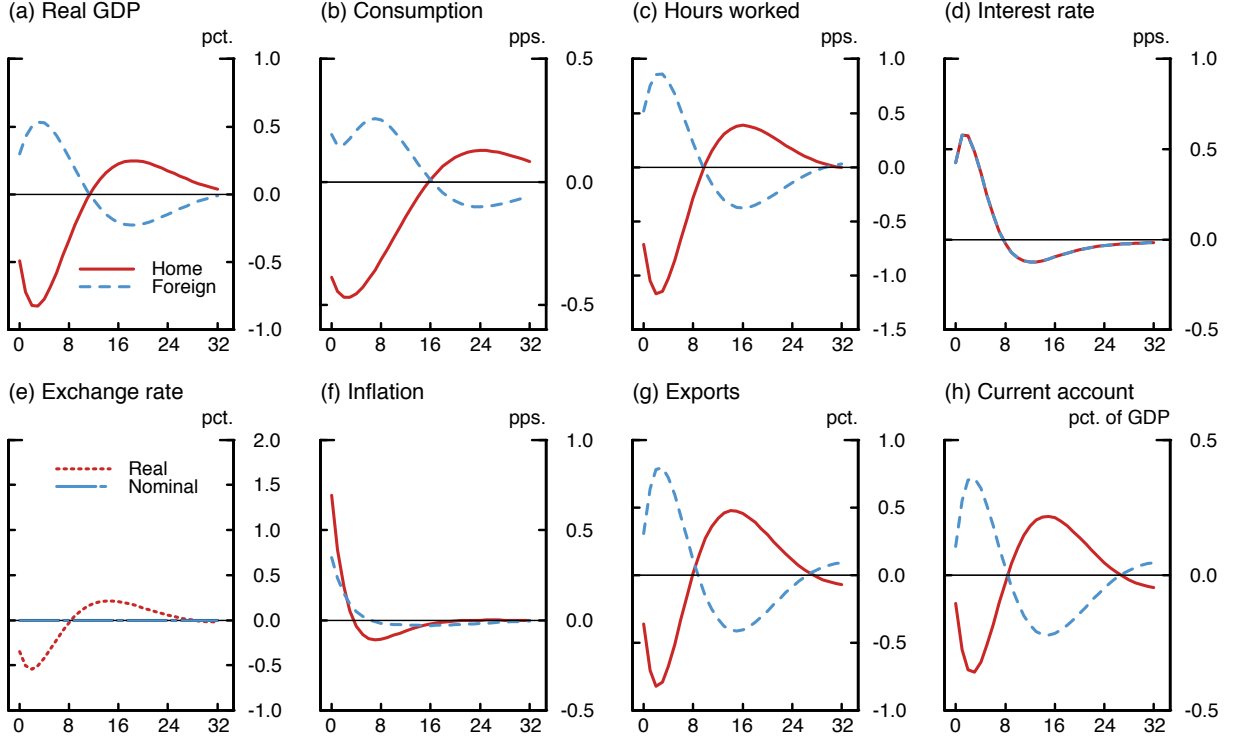
As shown in Figure 6, macroeconomic dynamics following an asymmetric financial shock in the home country are completely different in a monetary union. First, the declines in real GDP, consumption, and hours worked in the home country (panels (a), (b), and (c)) are about twice as large as those under floating exchange rates. Second, the trough in exports and the peak current account deficit (relative to GDP) of the home country are substantially more severe when the two countries share a common currency (panels (g) and (h)). Third and perhaps most strikingly, the recession in the home country is accompanied by a modest boom in the foreign country: Foreign real GDP, consumption, and hours worked all increase in the near term; similarly, exports from the foreign country to the home country rise markedly, and the foreign country registers a sizable current account surplus during the first year or so of the crisis in the home country. In contrast, the behavior of inflation in the two countries when they are in a monetary union (panel (f) of Figure 6) hardly differs from that under floating exchange rates (panel (f) of Figure 5). This result reflects the fact that regardless of the institutional arrangement, firms in the home country, when confronted with a significant tightening of financial conditions, have a strong incentive to raise markups compared with their foreign counterparts.

So what accounts for such stark differences in international macroeconomic adjustment patterns between these two monetary frameworks? The answer involves the differential dynamics of real exchange rates. With floating exchange rates, the efficiency conditions governing sovereign bond

²⁵In all simulations, we assume that the initial value of the nominal exchange rate is equal to one, an arbitrary but innocuous assumption, as only changes in the nominal exchange rate are a well-defined concept in our model. Note also that the nominal exchange rate shown in panel (e) returns to its steady-state value in the long run. However, this is simply a coincidence because our framework does not pin down the level of nominal exchange rate, just as it does not pin down the price level.

²⁶Real GDP in the model is defined as (real) domestic consumption plus (real) net exports (that is, $p_{h,t}c_{h,t} + q_t p_{h,t}^* c_{h,t}^* - p_{f,t}c_{f,t}$), which does not equal the volume index of aggregate output y_t .

FIGURE 6 – An Asymmetric Financial Shock: Monetary Union



NOTE: The panels of the figure depict the model-implied responses of selected variables to an adverse financial shock in the home country in period 0 (see the text for details). Unless noted otherwise, the solid lines show responses of variables in the home country, while the dashed lines show those of the foreign country. Exchange rates (panel (e)) are expressed as home currency relative to foreign currency.

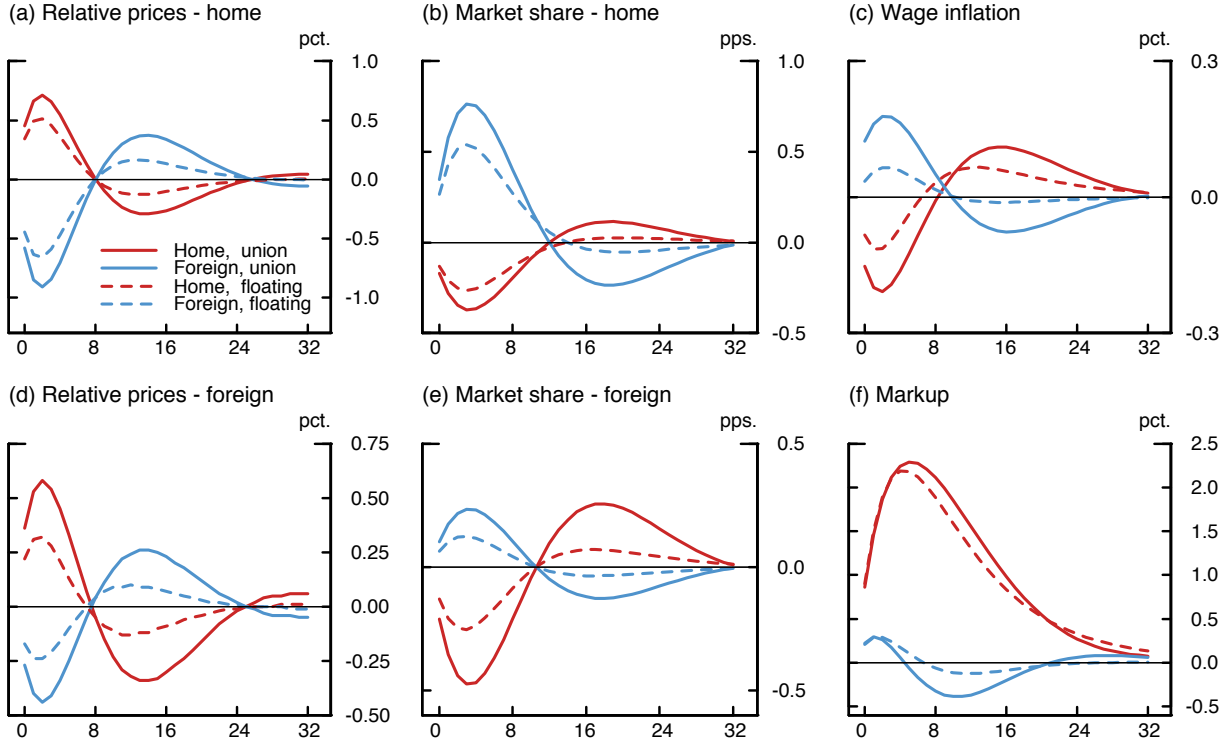
holdings in the home country imply the following no-arbitrage condition:

$$\tau(b_{h,t+1} - b_{f,t+1}) = \mathbb{E}_t \left[m_{t,t+1} \left(\frac{R_t}{\pi_{t+1}} - \frac{q_{t+1}}{q_t} \frac{R_t^*}{\pi_{t+1}^*} \right) \right].$$

Given the relatively small portfolio rebalancing costs τ , the left side of the above expression is close to zero in equilibrium, which means that $R_t/\pi_{t+1} - (q_{t+1}/q_t)(R_t^*/\pi_{t+1}^*)$ should also be close to zero in expectation. As shown in Figure 5, differences in the responses of nominal interest rates between the two countries (panel (d)) are upon impact smaller than differences in the corresponding responses of inflation (panel (f)). This implies a lower real interest rate in the home country than in the foreign country, a result consistent with the fact that the former is experiencing an economic downturn. In the absence of capital controls, the above no-arbitrage condition implies that the real exchange rate should *appreciate* over time (that is, $q_{t+1}/q_t < 1$), so as to prevent the outflow of capital from the home country. In turn, this requires the nominal exchange rate to *depreciate* today.

In a monetary union, however, the equilibrating forces arising from the free capital account

FIGURE 7 – An Asymmetric Financial Shock and International Price War



NOTE: The panels of the figure depict the model-implied responses of selected variables to an adverse financial shock in the home country in period 0 (see the text for details). The solid lines show responses when the two countries are in a monetary union, while the dashed lines show responses under floating exchange rates.

are absent. In that case, the bond market efficiency conditions (equations 48 and 49) impose no restrictions on dynamics of the real exchange rate. Differences in real interest rates induced by a financial shock in the home country do not have to be arbitrated away by expected changes in the nominal exchange rate. As a result, any differential in inflation rates is reflected immediately in the real exchange rate. Because firms in the home country optimally choose higher relative prices in response to the tightening of financial conditions, the real exchange rate appreciates substantially and exports of the home country firms drop sharply, as does real GDP. In comparison, the decline in consumption is noticeably less severe because international borrowing—while subject to costly portfolio rebalancing—allows consumers in the home country to smooth out the effects of the financial shock to a certain extent. The foreign economic boom is simply a mirror image of the home country's economic plight and is reminiscent of the dichotomy in economic outcomes between the eurozone core and periphery during the recent financial crisis.

As note above, despite the significantly worse economic performance of the home country in a monetary union, inflation dynamics in both countries in those circumstances are very similar to those under floating exchange rates. The nearly identical behavior of home and foreign inflation in response to an asymmetric financial shock across these two very different monetary frameworks

reflects the offsetting effects of the international price war, sparked by the interaction of customer markets and financial frictions. As shown in Figure 7, the financial shock in the home country induces a significant dispersion in relative prices in both countries, regardless of the institutional arrangement (panels (a) and (d)). The increase in the cost of external finance causes home country firms to raise relative prices in both their domestic and export markets. Foreign country firms, in contrast, optimally follow the opposite strategy and lower relative prices in both markets in order to steal market share from their financially constrained home country counterparts (panels (b) and (e)). Gauging by the degree of endogenous dispersion in relative prices, this “predatory” price war is noticeably more intense when the two countries share a common currency—in that case, home country firms are unable to rely on the depreciation of their currency to improve their internal liquidity positions.

In a monetary union and with floating exchange rates, foreign firms cut export prices—that is, prices they charge in the home country—notably more than their domestic prices. This pricing behavior lies at the heart of the interaction between customer markets and financial frictions, which provides an especially strong incentive to steal market share from competitors in financial distress. As a result, the large increase in relative prices by firms in the home country (domestic prices in the home country) is partially offset by an aggressive price discount offered by foreign firms (import prices in the home country), which attenuates the upward pressure on the overall inflation in the home country arising from the financial “cost-push” shock. These opposing forces also result in aggregate inflation dynamics that in both countries differ very little between the two institutional frameworks.

According to the above results, an asymmetric financial shock implies a strongly countercyclical markup in the home country, irrespective of whether the two countries share a common currency or have floating exchange rates. The model-implied dynamics of markups in the home country in response to a financial shock are thus consistent with the behavior of the price markups in the eurozone periphery during the recent financial crisis and its aftermath shown in Figure 4. It is also worth noting that the deleterious effects of a monetary union on the volatilities of macroeconomic variables are not confined to asymmetric financial shocks. As shown in Appendix B, the same conclusion emerges in the case when a home country is hit by an adverse technology shock.

An aspect of the macroeconomic dynamics shown in Figure 6 that appears at odds with the crisis in the euro area is the fact that following the financial shock, imports to the home country (that is, exports from the foreign country) increase notably (panel (g)), causing a deterioration in the current account deficit of the home country (panel (h)). After about eight quarters, this pattern is reversed, and the home country begins to register an improvement in its external position. The current account deficits in the periphery countries, however, started to improve immediately with the onset of the crisis in 2009 (panel (a) of Figure 1), owing primarily to a sharp decline in imports. This discrepancy in the timing of external adjustment patterns should not be taken as evidence that the model-implied crisis dynamics are inconsistent with the data. The impulse responses are expressed as deviations from the steady state—that is, the experiment assumes the two economies

are at their respective steady states prior to being hit by a shock, a situation that is unlikely to characterize the euro area on the eve of the crisis. Moreover, in Appendix C, we show how a sequence of positive demand shocks—a proxy for the buoyant economic sentiment that prevailed in the eurozone periphery prior to the crisis—followed by an asymmetric financial shock can generate current account reversal dynamics that are consistent with the data.

An important prediction of our model concerns the relative behavior of market shares in response to an asymmetric financial shock in the home country (solid lines in panels (b) and (e) in Figure 7). According to these simulations, foreign firms, by undercutting prices charged by their home country counterparts, significantly expand market shares in both the domestic and export markets. To examine whether such patterns are consistent with the data, we use the Eurostat trade data to construct relative import shares by major product groups defined on the basis of Broad Economic Categories (BECs)—our proxy for market shares in different industries—for the eurozone core and periphery.²⁷

Specifically, for each eurozone region—that is, core (C) and periphery (P)—and BEC (indexed by k), we calculate an import share as

$$\text{ImpShr}_{t,P \rightarrow C}^k = \frac{\text{Imp}_{t,P \rightarrow C}^k}{\text{Imp}_{t,C}^k} \quad \text{and} \quad \text{ImpShr}_{t,C \rightarrow P}^k = \frac{\text{Imp}_{t,C \rightarrow P}^k}{\text{Imp}_{t,P}^k},$$

where $\text{Imp}_{t,P \rightarrow C}^k$ is the value of imports (in BEC k) by the core countries from the periphery ($P \rightarrow C$) in year t , $\text{Imp}_{t,C \rightarrow P}^k$ is the value of imports (in BEC k) by the periphery countries from the core ($C \rightarrow P$) over the same period, and $\text{Imp}_{t,C}^k$ and $\text{Imp}_{t,P}^k$ denote total imports (in BEC k) by the core and periphery countries, respectively. We use the relative growth in import shares between the periphery and core, defined as

$$\Delta \ln \text{RelImpShr}_t^k \equiv \Delta \ln \text{ImpShr}_{t,C \rightarrow P}^k - \Delta \ln \text{ImpShr}_{t,P \rightarrow C}^k,$$

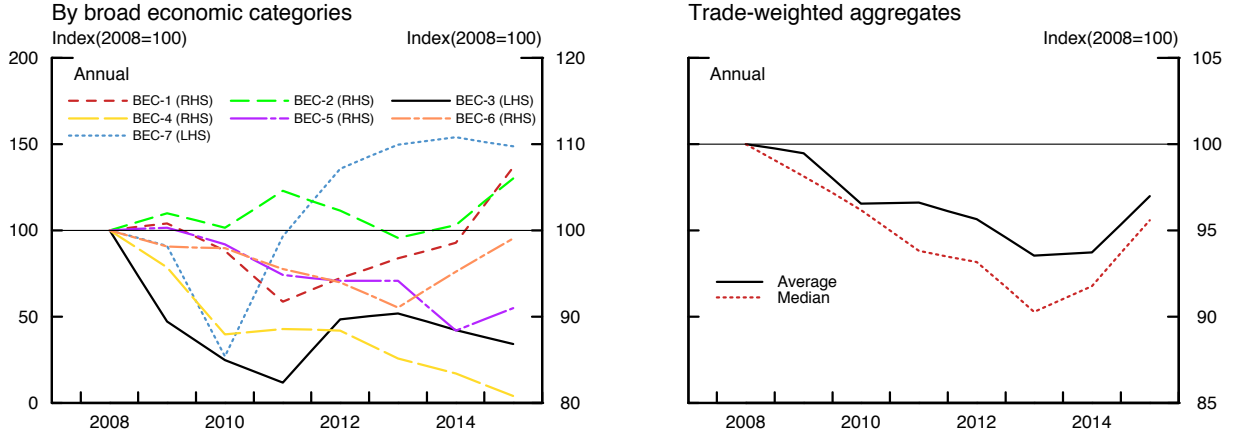
as a proxy for changes in relative market shares between the two regions.

The left panel of Figure 8 shows the cumulative relative growth in import shares between the periphery and core for the seven BECs. With the exception of BEC-2 (Industrial Supplies)—a category of goods for which the relative import share between the eurozone periphery and core was about unchanged—the relative import shares for all other categories declined markedly during the crisis. Although in BEC-7 (Goods, not elsewhere classified), the sharp drop in the relative import share was fairly transient, the relative import shares in the remaining categories registered appreciably more persistent declines.

To gauge the aggregate implications of these trade patterns, the right panel shows the cumulative trade-weighted average and the trade-weighted median of the relative growth in import shares across the seven BECs, using total trade flows between the two regions as weights. Both measures paint

²⁷The seven categories are BEC-1: Food & Beverages; BEC-2: Industrial Supplies; BEC-3: Fuels & Lubricants; BEC-4: Capital Goods (excluding transport equipment); BEC-5: Transport Equipment; BEC-6: Consumer Goods; and BEC-7: Goods, not elsewhere specified.

FIGURE 8 – Relative Import Shares: Periphery and Core Countries (2008–2015)



NOTE: The left panel depicts the behavior of relative import shares between the eurozone periphery in seven broad economic categories (BECs): BEC-1 = Food & Beverages; BEC-2 = Industrial Supplies; BEC-3 = Fuels & Lubricants; BEC-4 = Capital Goods (excluding transport equipment); BEC-5 = Transport Equipment; BEC-6 = Consumer Goods; and BEC-7 = Goods, not elsewhere specified. The right panel depicts the cumulative trade-weighted average and the trade-weighted median of the relative growth in import shares across the seven BECs, using total trade flows between the two regions as weights (see the text for details).

SOURCE: Eurostat.

the same picture: As the crisis in the euro area unfolded, imports by the periphery countries from the core countries—normalized by the periphery’s total imports—declined by considerably more than the imports by the core countries from the periphery, normalized by the total imports of the core countries.²⁸ Such dynamics in relative import shares are consistent with our model, which predicts that in periods of financial distress, firms in the home country will lose their market share—both at home and abroad—to their financially stronger foreign counterparts.

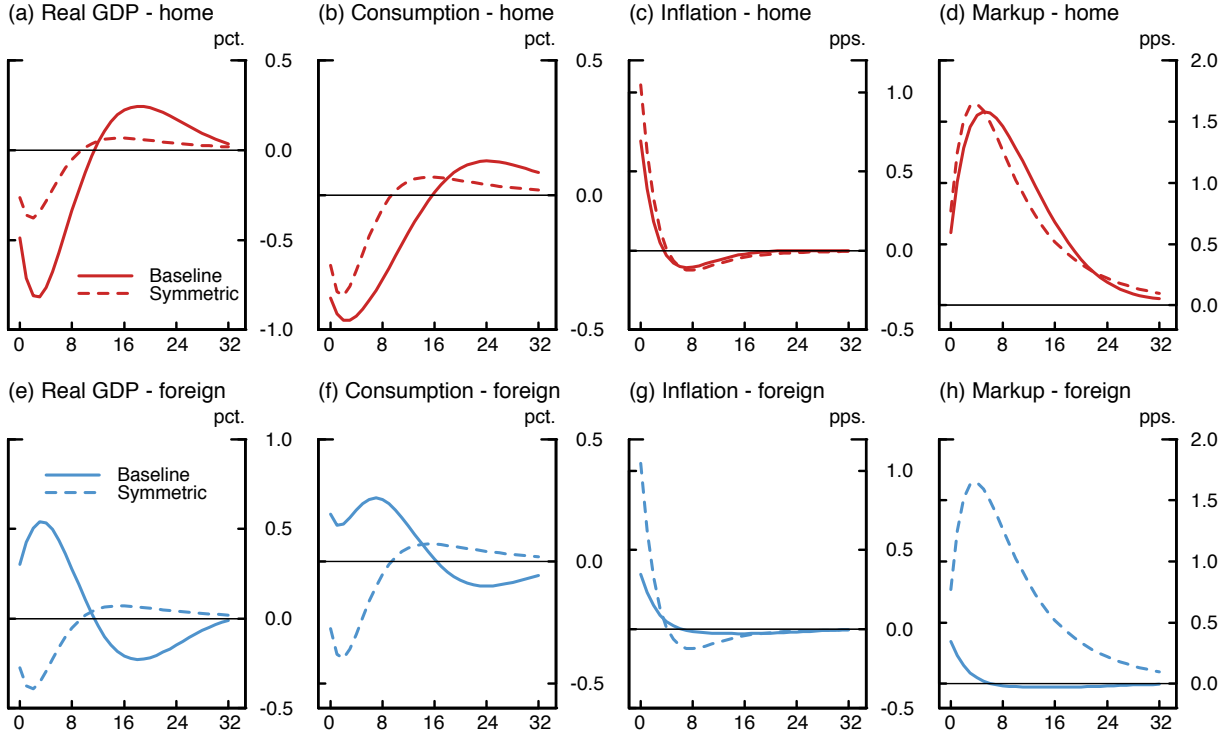
5.2 Financial Heterogeneity as a Propagation Mechanism

In a monetary union, differences in the degree of financial distortions between the home and foreign countries play a critical role in propagating the effects of an asymmetric financial shock in the home country. When firms in the home country experience a tightening of financial conditions, the relative financial strength of foreign firms allows them to lower markups in an effort to drive out their home country competitors from both the domestic and foreign markets. A question that then emerges is whether the model can generate the same degree of endogenous propagation if the two countries were identical in terms of financial capacity and the composition of shocks hitting their economies.

To answer this question, we consider an alternative calibration of the model, in which firms in both countries face the same degree of financial market frictions ($\varphi = \varphi^* = 0.2$) and both economies are perturbed by a financial shock of the type considered above; given that firms in both countries

²⁸The aggregate patterns are qualitatively the same if instead of total imports by each region, imports from the periphery and core and vice versa are normalized by the relevant region’s nominal GDP.

FIGURE 9 – Financial Heterogeneity and Monetary Union



NOTE: The solid lines depict the model-implied responses of selected variables to an adverse financial shock in the home country in period 0 under the baseline calibration of the model. The dashed lines depict the corresponding responses under the alternative calibration and when both countries are hit by an adverse financial shock in period 0. Panels (a)–(d) depict responses of selected variables of the home country, while panels (e)–(h) depict the corresponding variables of the foreign country; see the text for details.

have the same fixed operating costs, this alternative calibration implies that both economies have the same financial capacity. The dashed lines in Figure 9 show the impulse responses of selected variables under this alternative calibration, while the solid lines show the corresponding responses under our baseline calibration that features an asymmetric financial shock in the home country. Note that our baseline exercise allows for a greater financial capacity for the monetary union as a whole, as well as for less financial distress in the aggregate, compared with the alternative calibration; the baseline exercise, however, features more heterogeneity in financial capacity across countries compared with the “symmetric” calibration.

The results clearly indicate that the home country would prefer the alternative economic environment, in which firms in the foreign country also have limited financial capacity and are subject to the same degree of tightening in financial conditions. Although the dynamics of inflation and markups in the home country (panels (c) and (d)) are quite similar across the two experiments, the recession in the home country is considerably less severe (panels (a) and (b)) in the case where members of the monetary union are homogeneous with respect to their financial capacity and all countries are hit by the same adverse financial shock.

This seemingly paradoxical results reflects the fact that under the alternative calibration, firms in the foreign country are also experiencing a liquidity squeeze and are thus unable to maintain, in relative terms, lower markups, which exacerbates the downturn in the home country in the baseline case. In response to the tightening of their own financial conditions, foreign firms raise markups significantly in order to maintain current cashflows, and foreign inflation dynamics mirror those in the home country (panels (g) and (h)). Consequently, there is no movement in the real exchange rate, and the foreign country undergoes the same contraction in economic activity as the home country, a result that stands in stark contrast to the baseline case in which the foreign country experiences an export-driven boom (panels (e) and (f)), while the home country falls into a recession.

6 Welfare Analysis and Policy Implications

6.1 Welfare Consequences of a Monetary Union

[THIS SECTION NEEDS TO BE REWRITTEN AND TABLE 4 NEEDS TO BE UPDATED.]

The above simulations show that when financial markets of countries in a monetary union are subject to a differing degree of distortions, the financially weaker members of the union undergo a much more severe recession when hit by an exogenous shock, compared with a monetary arrangement characterized by floating exchange rates. In this section, we examine formally the welfare implications of forming a monetary union among countries whose economies have different financial capacities.

To highlight the welfare effects of such a political choice, we adopt a stylized calibration strategy, in which we assume that the home and foreign countries are subject to only two types of country-specific aggregate shocks: technology shocks and financial shocks. We calibrate the standard deviation of aggregate technology shocks to 4 percent and then set the standard deviation of financial shocks so that they account for one-half of the variance in the real GDP of the home country.²⁹ To compare welfare across different monetary frameworks, we approximate the value functions of the representative households in the two countries up to a second order and report their analytical first moments in panel (a) of Table 4.

Forming a monetary union clearly results in lower welfare in both countries. To provide an economic context for these welfare losses, we also report the consumption equivalent (CE), which is formally defined as a percent change in consumption per period—holding hours worked constant—that is required to make the representative household in each country indifferent with transitioning from a floating exchange rate regime to a monetary union. While the sign of the certainty equivalent change in consumption is intuitive, the degree of welfare loss is, at least according to this metric, quite small in both countries.

²⁹With financial shocks playing such an outsized role in economic fluctuations, this calibration clearly does not provide the most realistic representation of the two economies. However, our main conclusions are qualitatively the same under alternative calibrations, whereby the business cycles are driven primarily by the aggregate technology shocks.

TABLE 4 – Welfare Consequences of a Monetary Union

| (a) Welfare | Union | Floating | CE (%) ^a |
|--|---------|----------|---------------------|
| Home country | −274.86 | −274.37 | 0.22 |
| Foreign country | −217.86 | −217.37 | 0.38 |
| <i>Memo: Both countries</i> | −492.82 | −491.48 | . |
| (b) Volatilities | Union | Floating | Ratio ^b |
| <i>Std. deviation of real GDP (%)</i> | | | |
| Home country | 1.51 | 1.08 | 0.72 |
| Foreign country | 1.49 | 0.87 | 0.58 |
| <i>Std. deviation of consumption (%)</i> | | | |
| Home country | 2.19 | 0.99 | 0.45 |
| Foreign country | 2.04 | 0.93 | 0.46 |

NOTE: In panel (a), the entries under the column headings “Union” and “Floating” denote the welfare of the representative households in the home and foreign countries under different institutional frameworks; in panel (b), the entries denote the standard deviations of the specified macroeconomic aggregate. Union = monetary union; and Floating = floating exchange rate regime.

^a The consumption equivalent, a change in the average consumption per period (holding hours worked constant) that is required to make the representative household in the specified country—under a floating exchange rate regime—no worse off when the two countries form a monetary union.

^b The ratio of the standard deviation under the floating exchange rate regime to that in the monetary union.

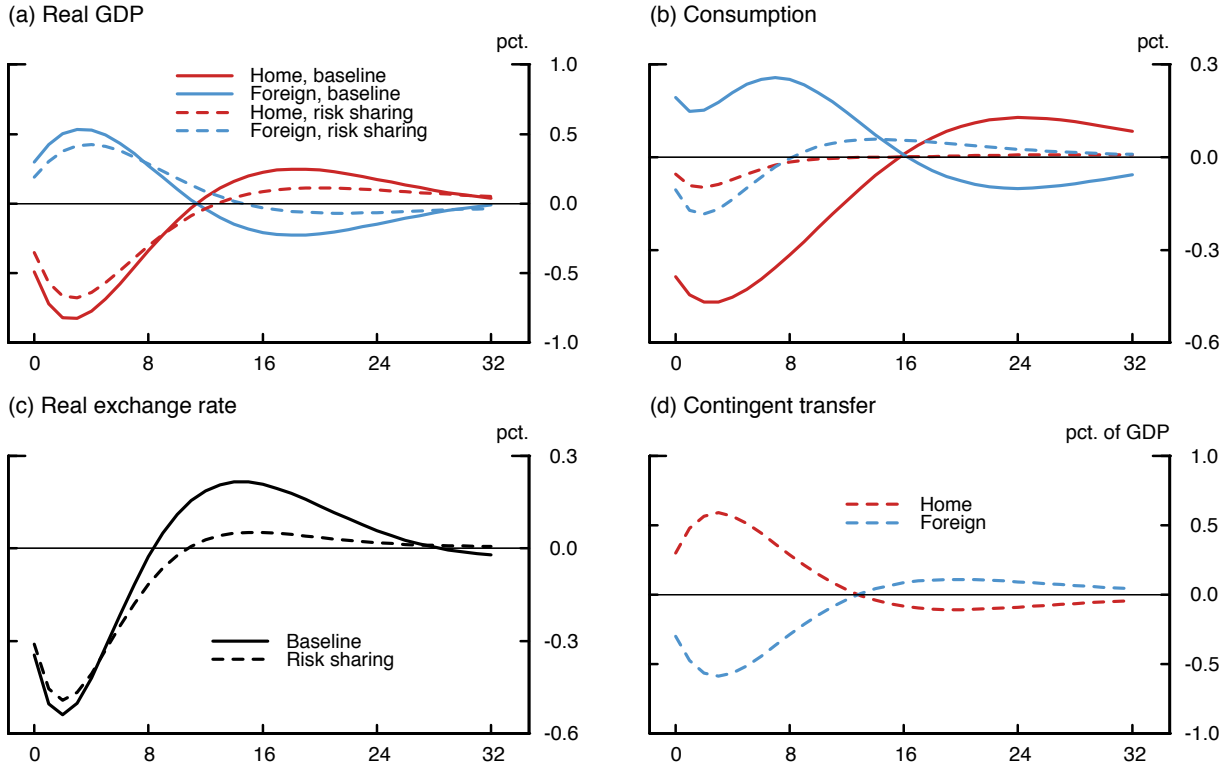
It may be that the above welfare calculations do not paint a complete picture of the costs associated with forming a monetary union—because they are based on the representative household, aggregate uncertainty tends to understate the uncertainty facing heterogeneous households without perfect insurance. As a result, we also report in panel (b) the volatilities of real GDP and consumption under the two institutional frameworks. According to this alternative metric, the cost of forming a monetary union is considerably greater compared with the standard welfare calculations: By dissolving the union and re-establishing a floating exchange rate regime, the home and foreign countries would see declines in output volatility of about 30 percent and 40 percent, respectively, while the volatility of consumption in both countries would be more than halved.

6.2 Fiscal Union

Because dissolving the monetary union may be difficult for political reasons, a natural question that emerges is whether there exist other policy options that could alleviate the distortions induced by the interaction of financial frictions and customer markets, while preserving the common currency. A standard approach to analyze this question, which also provides a benchmark against which to judge the efficacy of other policy proposals, is by assuming that the households of the two countries in the union can trade a full set of state-contingent bonds—that is, a complete risk-sharing arrangement or, equivalently, a fiscal union.

The dashed lines in Figure 10 trace out dynamics of the key macroeconomic aggregates in response to an asymmetric financial shock in the home country under a complete risk-sharing

FIGURE 10 – An Asymmetric Financial Shock: Monetary Union with Risk Sharing



NOTE: In panels (a) and (b), the solid lines depict the model-implied responses of selected variables to an adverse financial shock in the home country in period 0 under the baseline calibration of the model (see Figure 6); the dashed lines depict the corresponding responses under the assumption of complete risk sharing between the two countries. Panel (c) depicts the model-implied responses of the real exchange rate (expressed as home currency relative to foreign currency) under the two institutional frameworks, while panel (d) depicts the contingent transfers between the two countries under the risk-sharing arrangement.

arrangement. To conserve space, we show responses of only real GDP and consumption (panels (a) and (b)), the real exchange rate (panel (c)), and the state-contingent transfers between the two countries (panel (d)); for comparison purposes, the solid lines in panels (a)–(c) replicate responses from Figure 6, which considers the same experiment, but without risk sharing among the union members.

As shown in panel (b), allowing households of the two countries to trade a full set of state-contingent bonds clearly spreads the deleterious effects of the financial disruption in the home country. Relative to the baseline consumption trajectories, the representative households of the two countries experience roughly the same degree of improvement or sacrifice—depending on their domicile—in response to a financial shock in the home country. Because in a fiscal union production is organized so as to equalize the marginal costs across the two countries, insurance is achieved by redistributing the proceeds between the households. According to panel (d), this requires a substantial amount of wealth transfer between the two countries—at the peak of the financial crisis in the home country, the foreign country is transferring about 0.5 percent of its real economic output

TABLE 5 – Welfare Consequences of a Fiscal Union

| | w/ Fiscal Union | w/o Fiscal Union | CE (%) ^a |
|-----------------------------|-----------------|------------------|---------------------|
| Home country | −253.21 | −274.86 | 10.28 |
| Foreign country | −236.96 | −217.86 | −9.13 |
| <i>Memo:</i> Both countries | −490.17 | −492.82 | . |

NOTE: The entries under the column headings “w/ Fiscal Union” and “w/o Fiscal Union” denote the welfare of the representative households in the home and foreign countries under different institutional frameworks: w/ Fiscal Union = monetary union with a complete risk-sharing arrangement; and w/o Fiscal Union = monetary union without risk sharing.

^a The consumption equivalent, a change in the average consumption per period (holding hours worked constant) that is required to make the representative household in the specified country no worse off when risk sharing is not allowed in the monetary union.

to the home country.

The fact that risk sharing works primarily through cross-border wealth transfers—rather than through changes in the countries’ production shares—is consistent with the pattern of output trajectories in the two countries (panel (a)), which differ little across the two allocations; that said, a fiscal union does reduce the volatility of real GDP somewhat in both countries. Finally, the formation of a fiscal union does not significantly alter the dynamics of the real exchange rate (panel (c)). These results are consistent with the recent literature, which shows that the assumption of complete risk sharing in standard open-economy macro models has little effect on the behavior endogenous quantities, including the real exchange rate (see [Steinsson, 2008](#)).

Welfare consequences of forming a fiscal union are shown in Table 5 [NEEDS TO BE UPDATED]. According to the first column, a complete risk-sharing arrangement between the two countries substantially improves welfare of the representative household in the home country, while reducing welfare in the foreign country. For the union as a whole, the welfare gain in the home country outstrips the loss in the foreign country, as joint welfare increases somewhat with the formation of a fiscal union. As shown in the last column, this outcome requires a substantial cross-border transfer of wealth: In terms of the certainty equivalent changes in consumption, a fiscal union increases steady-state level of consumption in the home country by about 10 percent, while lowering that in the foreign country by roughly the same amount. In combination with the results shown in Figure 10, these welfare calculations underscore the political difficulties of forming a fiscal union, as residents of the foreign country are unlikely to agree with the size of such transfers.

6.3 Fiscal Devaluations

Given the likely political obstacles and the lengthy process of forming a fiscal union, we now turn to a potentially more feasible and frequently advocated policy option in the context of the European sovereign debt crisis: a budget-neutral fiscal devaluation by the periphery countries. As emphasized by [Adao et al. \(2009\)](#) and [Farhi et al. \(2014\)](#), the aim of such policies is to use a mix of fiscal measures to replicate the effects of a nominal exchange rate depreciation in a fixed exchange rate system, in order to improve competitiveness and support the rebalancing of external accounts.

Fiscal measures can, for example, include a combination of import tariffs and export subsidies or a shift from labor to consumption taxation.³⁰

A particular form of fiscal devaluation that received a lot of attention in policy circles during the crisis involved the following (budget neutral) combination of fiscal measures in the periphery: a reduction in employers' social security contributions, coupled with an increase in the VAT rate (see Puglisi, 2014).³¹ Within the eurozone, however, the non-cooperative nature of a unilateral fiscal devaluation by the periphery could potentially have negative spillover effects on the core countries, especially if the latter viewed the adoption of the euro as a way to avoid the manipulation of nominal exchange rates by the monetary authorities in the periphery. In addition, any short-term improvements in external competitiveness resulting from a fiscal devaluation will be diminished as more periphery countries engage in this policy simultaneously. Hence a natural question to ask is whether the eurozone periphery can carry out such a fiscal devaluation without the fear of retaliation from the core?

To provide a qualitative insight into this question, we consider a situation, whereby the home country introduces a payroll subsidy (ς_t^P) that is financed by a VAT (τ_t^V).³² With these policies, the marginal revenue of a home country firm selling its product in the domestic market becomes $(1 - \tau_t^V)p_{i,h,t}p_{h,t}$, while its marginal labor cost is equal to $(1 - \varsigma_t^P)w_t$. We assume that the home country firms are not subject to the same VAT in the foreign country and that the foreign country does not respond to the unilateral adoption of these fiscal measures by the home country. In addition, we assume that the government of the home country uses these fiscal policies to stabilize the economy by following linear policy rules:

$$\tau_t^V = \varsigma_t^P = \frac{\Delta_t}{1 + \Delta_t}, \text{ where } \Delta_t = \alpha^{FD} \times \ln\left(\frac{y_t}{y}\right);$$

that is, the size of fiscal devaluation Δ_t depends linearly on the output gap in the home country. In this context, a countercyclical policy corresponds to $\alpha^{FD} < 0$.

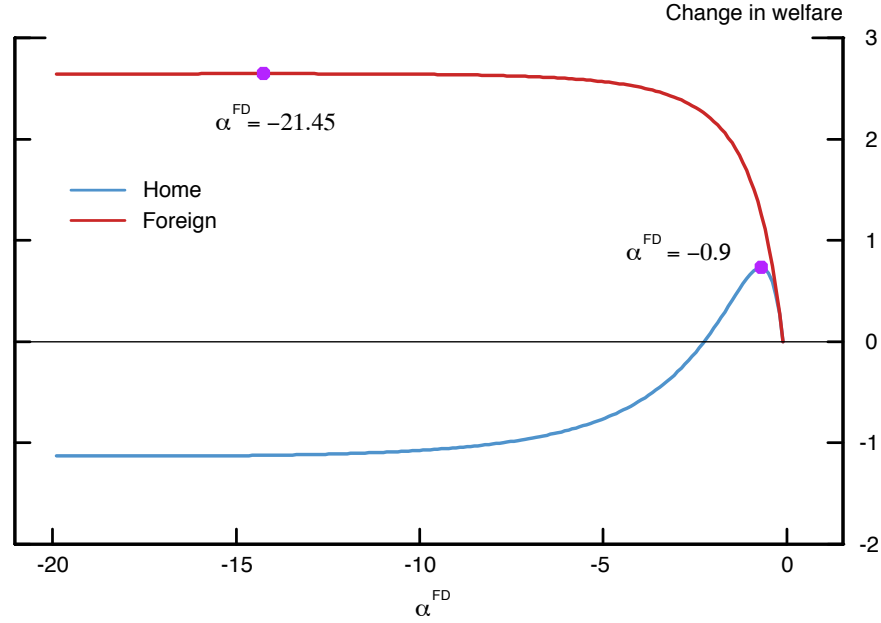
Using our baseline calibration of the model, we perform an extensive grid search to find the value of α^{FD} that maximizes the second-order approximation of the value function of the representative

³⁰Farhi et al. (2014) provide an in-depth analysis of various policy mixes that can under various asset market conditions replicate the effects of a given size of nominal exchange rate depreciation.

³¹A reduction in employers' social security contributions would directly lower labor costs of firms in the periphery countries. If lower labor costs were to be passed through to producer prices—and if wages were not to fall—domestically produced goods would become less expensive, which would reduce relative export prices and induce a depreciation of the real effective exchange rate vis-à-vis the core. At the same time, the increase in the VAT rate would not be fully offset by the reduction in labor costs because only final consumption would be taxed at a higher rate. With a decline in relative export prices and an increase in relative import prices, the domestic demand for imports would fall. Because consumer prices for domestically produced goods would have remained essentially unchanged—as the VAT hike and a cut in employers' social security contributions more or less offset each other—the increase in the VAT rate would have fallen primarily on imports, causing a shift towards domestic production. In effect, such fiscal devaluation would stimulate exports and lower domestic import demand, factors that would in the short run improve external competitiveness of the periphery countries and lead to an improvement in the trade balance.

³²We stress the qualitative nature of this exercise because the effectiveness of a fiscal devaluation depends importantly on a variety of country-specific factors: the degree of price and wage rigidities, the degree of price passthrough, the elasticity of labor supply, the size of the economy, its trade openness, and the share of labor as variable production input.

FIGURE 11 – Welfare Implications of a Fiscal Devaluation in a Monetary Union



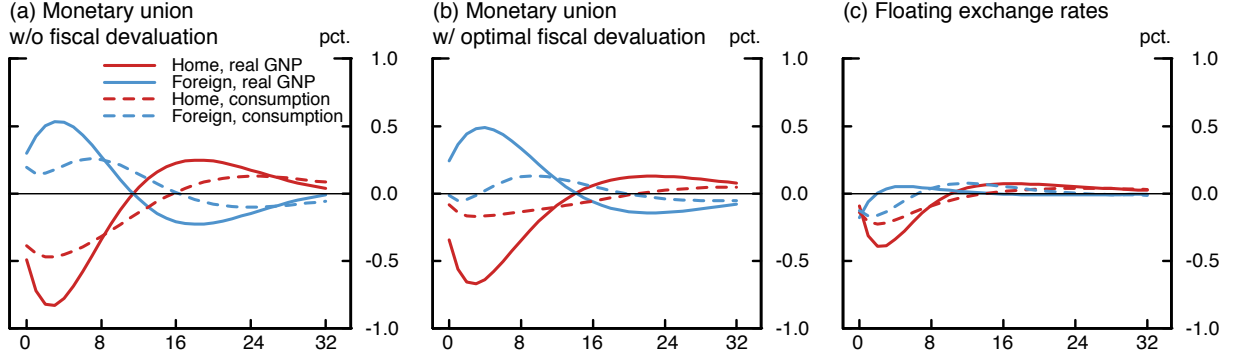
NOTE: The lines depict changes in welfare for the home and foreign countries as a function of α^{FD} , the parameter governing the size of a unilateral fiscal devaluation by the home country (see the text for details). Welfare differentials are measured relative to a baseline of no fiscal devaluation—that is, $\alpha^{FD} = 0$.

household in the home country. Figure 11 traces out the implications of this exercise on the welfare of the two countries. According to these calculations, the welfare of the home country is maximized with the size of a fiscal devaluation given by $\alpha^{FD} = -0.9$. Importantly, the welfare of the foreign country—as a function of α^{FD} —is still increasing at that point, which implies that the foreign country has an incentive to help pay for the unilateral fiscal devaluation in the home country.

The macroeconomic stabilization properties of this “optimal,” from the perspective of the home country, fiscal devaluation are shown in Figure 12, which compares the dynamics of real GNP (solid lines) and consumption (dashed lines) in response to an asymmetric financial shock in the home country in three different situations: monetary union without a fiscal devaluation (panel (a)); monetary union with the optimal unilateral fiscal devaluation by the home country (panel (b)); and a floating exchange rate regime (panel (c)). According to panel (b), the adoption of a unilateral fiscal devaluation by the home country results in a significant reduction in the volatility of real output and consumption in both countries, especially when compared with the benchmark monetary union simulation shown in panel (a). Judging by this metric, the efficacy of this policy is such that the dynamics of consumption in response to an asymmetric shock are very similar to those under a floating exchange rate regime (panel (c)).

This striking result reflects the fact that the interaction of customer markets and financial frictions creates an important pecuniary externality in our model: When foreign firms aggressively cut prices at the time when home country firms are experiencing financial distress, they treat the

FIGURE 12 – An Asymmetric Financial Shock



NOTE: The solid lines depict the model-implied responses of real GNP to an adverse financial shock in the home country in period 0 under the baseline calibration of the model, while the dashed lines show the corresponding responses of consumption.

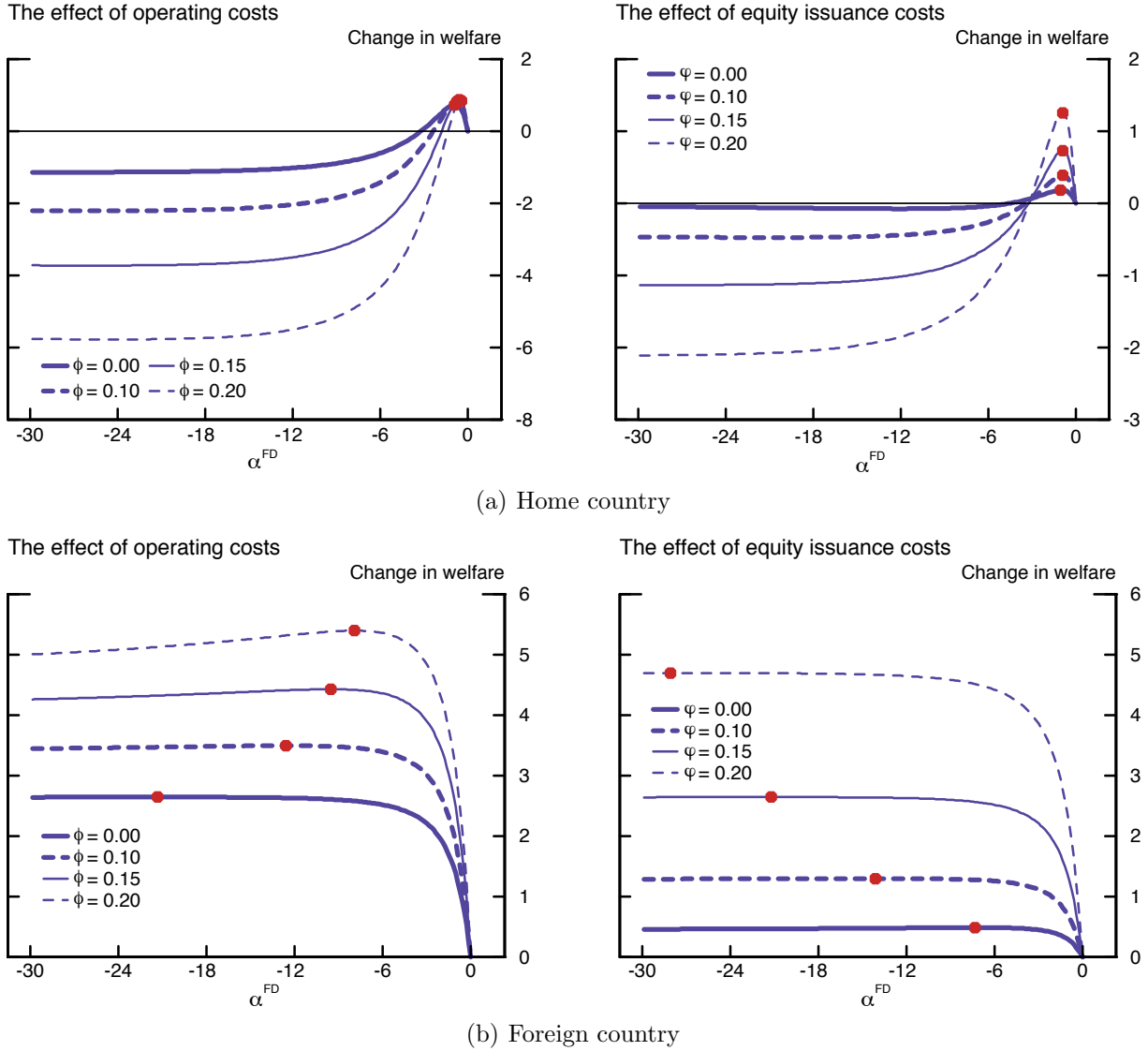
general price level as given—that is, they do not internalize the effects of their pricing behavior on the real exchange rate. Consequently, foreign firms reduce markups to excessively low levels, behavior that is, of course, individually rational, but one that does not take into account the fact that driving out their home country competitors will have an adverse effect on aggregate demand. As shown by [Farhi and Werning \(2016\)](#), a distortionary taxation can make private agents internalize pecuniary externalities in those circumstances, and a fiscal devaluation provides just such a mechanism in our model.

To highlight this aspect of the model, Figure 13 shows how varying the strength of the pecuniary externality affects the welfare of the representative household in the foreign country. The left panel considers versions of the model where we progressively decrease the operating efficiency of home country firms by increasing the size of fixed operating costs (that is, the parameter ϕ). The right panel, in contrast, considers versions of the model with progressively greater degree of financial market distortions in the home country, as measured by the increase in the steady-state value of equity dilution costs (that is, the parameter $\bar{\varphi}$). In each version of the model, the remaining parameters are kept at their benchmark values. The different lines trace out the welfare differentials for the foreign country as a function of the parameter α^{FD} , which governs the size of a unilateral fiscal devaluation carried out by the home country.

Consistent with the above discussion, the potential welfare gains for the foreign country resulting from such a policy move by the home country increase steadily as the pecuniary externality becomes more severe. This result holds regardless of whether we expose the home country firms to greater liquidity risk by lowering their operating efficiency, which increases the shadow value of internal funds for a given volatility of the financial shock (left panel); or if we directly increase the volatility of financial shocks hitting the home country (right panel).³³ Moreover, as indicated by the leftward

³³Because the financial shock is modeled as $\varphi_t = \varphi f_t$, with $\ln f_t = 0.90 \ln f_{t-1} + u_t$, increasing the steady-state value of equity dilution costs φ directly raises the variance of the shock.

FIGURE 13 – Pecuniary Externalities and Fiscal Devaluations in a Monetary Union



NOTE: The left panels depict the changes in welfare as a function of α^{FD} , the parameter governing the size of a unilateral fiscal devaluation by the home country, for different values of fixed operating costs (ϕ). The right panels depict the changes in welfare—again as a function of α^{FD} —for different values of equity dilution costs (ψ) in the home country; in each case, the remaining parameters are kept at their baseline calibration values (see the text for details). Welfare differentials are measured relative to a baseline of no fiscal devaluation—that is, $\alpha^{FD} = 0$. The dots correspond to the values of α^{FD} that maximize the welfare of the specified country.

movement of the solid circles, the size of the unilateral fiscal devaluation carried out by the home country that maximizes foreign welfare—as measured by the corresponding absolute values of α^{FD} —increases as the pecuniary externality induced by the interaction of customer markets and financial frictions becomes more acute. Thus according to our model, a unilateral fiscal devaluation by a country experiencing financial distress offers an effective macroeconomic stabilization tool, which, in principle, should not invoke a retaliatory response from the other union members.

7 Conclusion

In this paper, we present a dynamic multi-country general equilibrium model and use it to analyze the business cycle and welfare consequences of forming a monetary union among countries with different degrees of financial market distortions, which interact with the firms' pricing decisions because of customer markets considerations. We show that in such an environment, firms from the country with relatively undistorted financial markets have an incentive to expand their market share at home and abroad by undercutting prices charged by their competitors from the country marked with a high degree of financial frictions, especially when the latter are experiencing financial distress. Firms located in the country with distorted financial markets, in contrast, increase markups during the crisis in an effort to maintain cashflows, even though doing so means forfeiting some of their market share in the near term.

When applied to the financial crisis that engulfed the euro area between 2009 and 2013, the interaction of customer markets and financial frictions helps explain several phenomena that are difficult to reconcile using conventional open-economy macro models. First, the pricing mechanism implied by this interaction is consistent with our empirical evidence, which shows that the acute tightening of financial conditions in the euro area periphery during this period significantly attenuated the downward pressure on prices arising from the emergence of substantial and long-lasting economic slack. And second, this tightening of financial conditions is strongly associated with a significant increase in price markups in the periphery. Hence our framework can explain why the periphery countries have managed to avoid a debt-deflation spiral in the face of massive and persistent economic slack and how the price war between the core and periphery has impeded the adjustment process through which the latter economies have been trying to regain their external competitiveness.

In our model, the pricing behavior of firms in the core in response to a financial shock in the periphery implies a real exchange rate depreciation vis-à-vis the periphery, which causes a small export-driven boom in the core countries and a deepening of the recession in the periphery. The one-size-fits-all aspect of monetary policy—an inherent feature of a monetary union—is especially ill-suited to address such economic imbalances. According to our simulations, when union members are experiencing different economic conditions, common monetary policy charged with stabilizing inflation and output fluctuations leads to an endogenous increase in macroeconomic volatility that is double that implied by a floating exchange rate regime. This translates into a welfare loss for the union as a whole, with the loss borne disproportionately by the periphery.

To overcome limitations of common monetary policy, we consider two fiscal policy alternatives: a fiscal union and a unilateral fiscal devaluation by the periphery. We show that a complete risk-sharing arrangement among union members—or equivalently, a fiscal union—can significantly improve welfare in the periphery. However, our simulations indicate that forming a fiscal union would involve large transfers of wealth from the core to the periphery. Given the likely lack of political appetite for such cross-border transfers, we then consider the macroeconomic effects of a unilateral fiscal devaluation by the periphery. Our results indicate that such a unilateral policy

action offers an effective macroeconomic stabilization tool that can be beneficial even to the core. This finding reflects the fact that when firms in the core countries cut prices to expand their market shares, they do not internalize the pecuniary externality, whereby driving out their foreign competitors by reducing markups to an excessive degree can also reduce demand for their own products. A distortionary taxation in the form a unilateral fiscal devaluation by the periphery helps firms from the core internalize this externality, leading to an improvement in the union's overall welfare.

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Appendices – For Online Publication

A Model Appendix

[To be completed.]

TABLE A-1 – Baseline Calibration

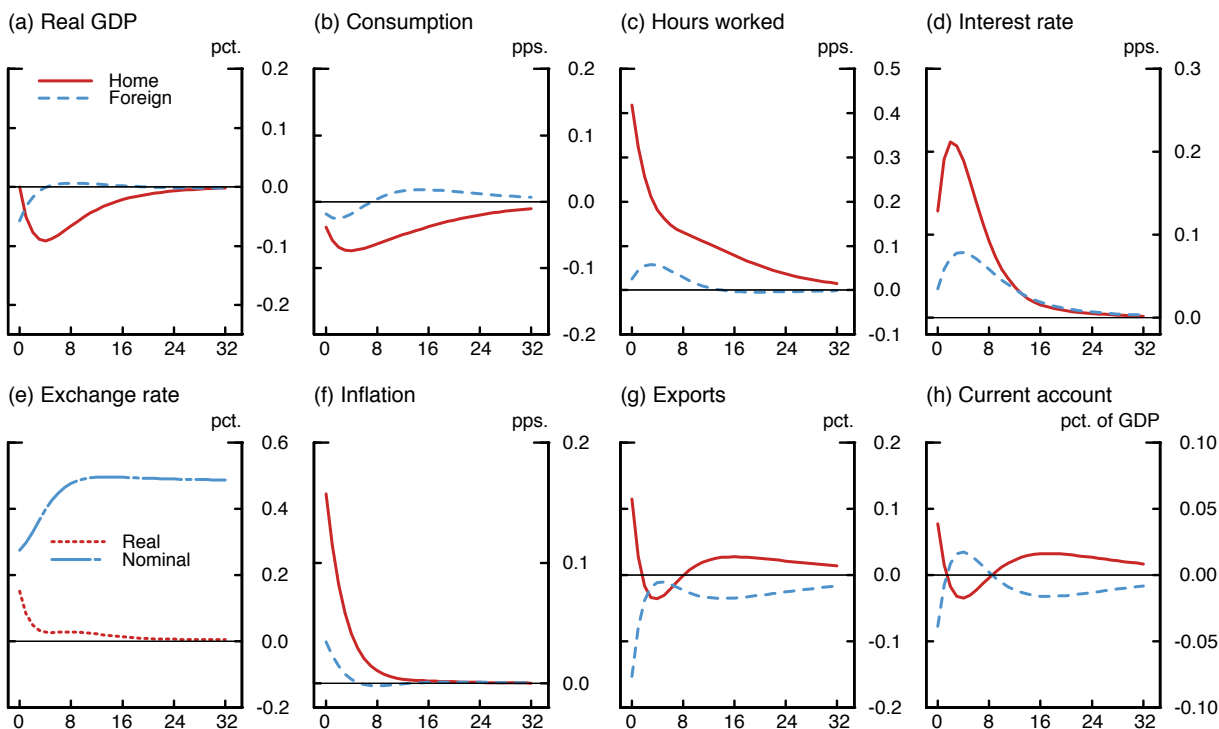
| Model Parameters | Value |
|---|--------------|
| <i>Preferences</i> | |
| time discount factor (δ) | 0.995 |
| constant relative risk aversion (γ_x) | 2.00 |
| elasticity of labor supply ($1/\gamma_h$) | 0.30 |
| strength of deep habits (θ) | −0.86 |
| persistence of deep habits (ρ) | 0.85 |
| elasticity of substitution between goods (η) | 2.00 |
| Armington elasticity (ε) | 1.50 |
| home bias (Ξ_h^ε) | 0.60 |
| <i>Technology</i> | |
| returns-to-scale (α) | 1.00 |
| fixed operating costs (ϕ) | 0.10 |
| std. deviation of idiosyncratic cost shock (σ) | 0.20 |
| persistence of aggregate technology shocks (ρ_A) | 0.90 |
| std. deviation of aggregate technology shocks, (σ_A) | 0.04 |
| <i>Nominal rigidities</i> | |
| price adjustment costs (γ_p, γ_p^*) | (10.0, 10.0) |
| wage adjustment costs (γ_w, γ_w^*) | (30.0, 30.0) |
| <i>Financial frictions</i> | |
| equity dilution costs (φ, φ^*) | (0.20, 0.02) |
| <i>Monetary policy</i> | |
| interest-rate smoothing (ψ_r) | 0.85 |
| inflation gap coefficient (ψ_π) | 1.50 |
| output gap coefficient (ψ_y) | 0.25 |

NOTE: The entries in the table denote the values of the model parameters used in the baseline calibration; see the text for details.

B The Impact of Technology Shocks

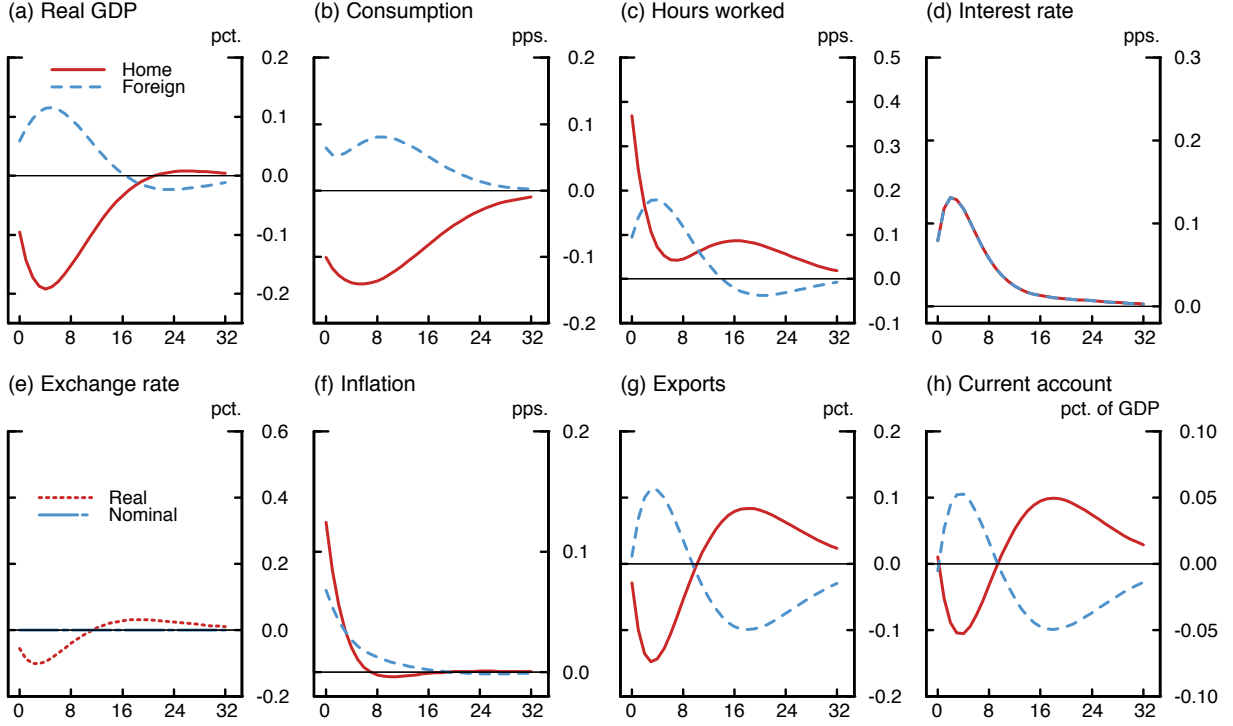
In this section, we examine the model dynamics in response to aggregate technology shocks under different institutional frameworks. Figure B-1 depicts the dynamics of selected macroeconomic variables in response to an adverse technology shock in the home country under floating exchange rates. Figure B-2, by contrast, shows the dynamics of the same variables in the case when the two countries are in a monetary union.

FIGURE B-1 – An Asymmetric Technology Shock: Floating Exchange Rates



NOTE: The panels of the figure depict the model-implied responses of selected variables to an adverse technology shock in the home country in period 0 (see the text for details). Unless noted otherwise, the solid lines show responses of variables in the home country, while the dashed lines show those of the foreign country. Exchange rates (panel (e)) are expressed as home currency relative to foreign currency.

FIGURE B-2 – An Asymmetric Technology Shock: Monetary Union



NOTE: The panels of the figure depict the model-implied responses of selected variables to an adverse technology shock in the home country in period 0 (see the text for details). Unless noted otherwise, the solid lines show responses of variables in the home country, while the dashed lines show those of the foreign country. Exchange rates (panel (e)) are expressed as home currency relative to foreign currency.

C The Boom-Bust Cycle

In this section, we show how an economically plausible sequence of shocks can generate external adjustment patterns in the home country that closely resemble those experienced by the periphery countries in the period surrounding the European sovereign debt crisis. As discussed in the main text, periphery countries borrowed heavily in the years preceding the crisis, primarily to finance domestic consumption and housing investment. As a result, real exchange rates in the eurozone periphery appreciated significantly, eroding these countries' competitiveness. These developments also produced large trade deficits among periphery countries, which in the years leading to the crisis were easily financed by foreign capital inflows, facilitated by the convergence in domestic interest rates across the euro area.

To capture the buoyant economic sentiment that prevailed in the eurozone periphery prior to the crisis, we introduce demand shocks in our model by modifying the preferences of household j in the home country (see equation 4 in the main text) as

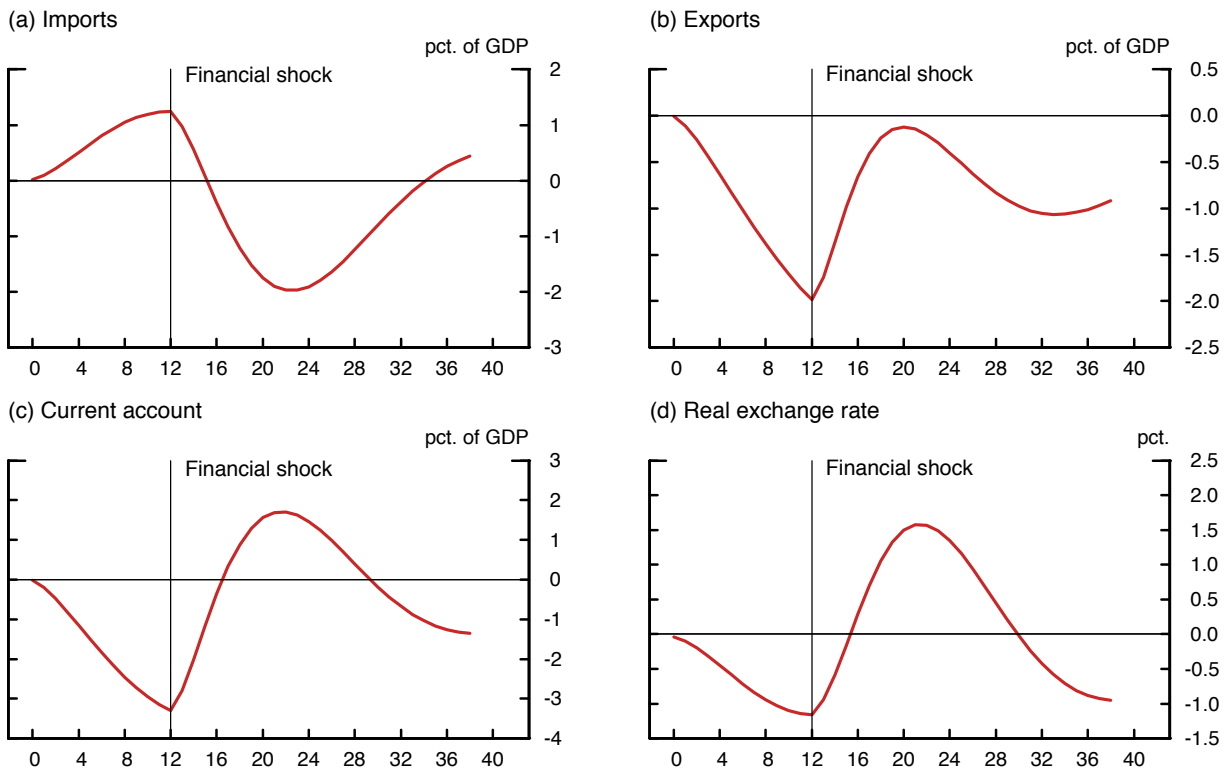
$$\mathbb{E}_t \sum_{s=0}^{\infty} \delta^s U(x_{t+s}^j - \omega_t, h_{t+s}^j); \quad (0 < \delta < 1), \quad (\text{C-1})$$

where ω_t denotes a disturbance that alters the marginal utility of current consumption. In this

context, we consider an experiment under our baseline calibration, whereby the home country first experiences a sequence of gradually increasing positive demand shocks—the pre-crisis economic boom—which is then followed by an asymmetric financial shock. Specifically, in calibrating this scenario, we assume a sequence of demand shocks in periods $0, 1, \dots, 11$, such that ω_t gradually increases to 5 percent of its steady-state value; in period 12, we hit the economy with our standard financial shock.

As shown in Figure C-1, this sequence of events generates external adjustment patterns in the home country that correspond closely with those experienced in the eurozone periphery in the period surrounding the crisis. In the years immediately preceding the financial shock, imports-to-GDP (panel (a)) increase notably, while exports-to-GDP (panel (b)) fall, trade dynamics that are consistent with the erosion in the home country’s competitiveness as evidenced by the appreciation of the real exchange rate during this period (panel (d)). When the home country is hit by the financial shock, these patterns are abruptly reversed: With imports falling and exports rising, the current account deficit (panel (c))—which reached about 3 percent of GDP at the eve of the crisis—begins to shrink immediately. Thus with an economically plausible sequence of shocks, the model is able to replicate the kind of current account reversal dynamics experienced by the eurozone periphery during the crisis.

FIGURE C-1 – The Boom-Bust Cycle in the Home Country



NOTE: The solid lines depict the model-implied responses of selected variables in the home country, when the country experiences a sequence of positive demand shocks in periods $0, \dots, 11$ and in period 12 is hit by a one-time financial shock. The real exchange rate is expressed as home currency relative to foreign currency. See the text for details.