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## DOES A CURRENCY UNION NEED A CAPITAL MARKET UNION? RISK SHARING VIA BANKS AND MARKETS

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## Abstract

We compare risk sharing in response to demand and supply shocks in four types of currency unions: segmented markets; a banking union; a capital market union; and complete financial markets. We show that a banking union is efficient at sharing all domestic demand shocks (deleveraging, fiscal consolidation), while a capital market union is necessary to share supply shocks (productivity and quality shocks). Using a calibrated model we provide evidence of substantial welfare gains from a banking union and, in the presence of supply shocks, from a capital market union.

JEL Classification: F45, E44, F36

Keywords: Risk Sharing, Currency Union, Banking Union, capital market union, incomplete markets

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# Does a Currency Union Need a Capital Market Union?

# Risk Sharing via Banks and Markets

Joseba Martinez, Thomas Philippon, and Markus Sihvonen*

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**Abstract**

We compare risk sharing in response to demand and supply shocks in four types of currency unions: segmented markets; a banking union; a capital market union; and complete financial markets. We show that a banking union is efficient at sharing all domestic demand shocks (deleveraging, fiscal consolidation), while a capital market union is necessary to share supply shocks (productivity and quality shocks). Using a calibrated model we provide evidence of substantial welfare gains from a banking union and, in the presence of supply shocks, from a capital market union.

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Failures of risk sharing lie at the heart of many economic crises, including the one that recently threatened the survival of the Eurozone. A comparison of macro-economic dynamics in Europe to those of the United States reveals the importance of risk sharing. Private leverage cycles are volatile and heterogeneous across U.S. states, just as they are volatile and heterogenous across E.U. countries. They affect output and employment in similar ways. In Europe, however, private leverage cycles are amplified by sudden stops and spreads in funding costs between countries. As the spreads widen, the weaker countries sink deeper into recession. These are clear signs of inefficient risk sharing.

The creation of a banking union is a deliberate response to these issues. Focusing on banks is a natural step because banks intermediate most of European financial flows. The funding cost of banks has a direct impact on the credit conditions of households and firms. The main purpose of the banking union is to guarantee that funding conditions remain the same across regions within Europe, and in particular that they are not directly affected by domestic sovereign risk. There is broad agreement that some form of banking union is necessary to ensure the stability of the currency union, even as disagreement persists about its required features, such as deposit insurance, bail-ins, and the funding of resolution.

A capital market union, on the other hand, can improve risk sharing via financial markets - i.e., equity and fixed income flows apart from cross-border bank flows. There is no agreement, and little academic analysis, of the gains from adding a capital market union to a banking union. This raises two questions that we aim to answer in this paper. First, what are the gains from building a banking union? Second, are there additional gains from building a capital market union in addition to a banking union?

We model a currency union with nominal (wage) rigidities under four degrees of financial integration: (i) segmented markets as observed during the Eurozone crisis; (ii) a banking union where funding costs are equalized across regions; (iii) a capital market union with optimal cross-border equity holdings; and (iv) a complete markets economy. We then ask how these four model economies respond to two types of shocks: domestic-demand shocks (triggered by public or private deleveraging) and other shocks (TFP shocks, quality shocks, and foreign demand shocks).

We take a resolutely macro-economic perspective on what constitute a banking union and capital market union. We study the consequences of an *ideal* banking union. In our model, a banking union is an institution that guarantees that (risk-adjusted) private funding costs remain the same in all regions irrespective of the shocks that hit these regions. In an ideal banking union private funding costs depend neither on the health of the domestic sovereign – a no-doom-loop condition – nor on the health of local banks – a no-sudden-stop condition. It is important to understand that this assumption captures precisely the stated policy goals of the banking union. It is, in fact, the *definition* of an ideal banking union that local banking conditions do not matter. This is not as counter-intuitive as it sounds: it is just like saying that the details of financial intermediaries are not necessary to compute the complete market allocation. Similarly, we can study the macro-economic gains from an ideal banking union without actually modeling the banks. Modeling banks explicitly would of course be required if we wanted to estimate the relative importance of various features of an *imperfect* banking union. We would then need to take a stand on the details of deposit insurance (EDIS), the funding of resolution (MREL, TLAC, ESM back-up, required bail-in ratios), the composition of sovereign exposures in banks' portfolios (which are strongly time-varying), the implicit guarantees on retail products sold by banks (a first order issue in Italy), and the capital requirements for sovereign exposures (a new and complicated debate).[1] These are issues of first order importance for the design of a banking union, but they are not necessary to answer the questions we have posed, and they would obscure the key macroeconomic insights.

We model a capital market union as a market structure that allows frictionless sharing of risk to the market value of private capital. In our model claims to the value of capital most closely resemble traded corporate equity. In reality, the trading of private credit instruments (corporate bonds, securitized loans, etc) plays a crucial role in most proposals related to the capital market union. Just like in the case of an ideal banking union, however, we can study an ideal capital market union without taking a stand on the details of risky debt versus equity. The key point is that negative shocks cause equity and risky debt to fall in value. We could allow our firms to issue debt and equity, or we could repackage their claims, without changing our macro-economic insights. In other words, we can assume a form of Modigliani-Miller theorem (Modigliani and Miller, 1958) at the firm level and study the macroeconomic consequences of risk sharing across countries. Finally, it is important to note that we consider a particular definition of complete markets: each country in the currency union is populated by borrowers and savers. Our borrowers are subject to credit constraints, and by complete markets we mean that the marginal utilities of consumption of *savers* are equalized across borders.

We then ask whether such a banking union or a capital market union can replicate a complete markets economy, and we show that the answer depends on the types of shocks under consideration.

[1] See Véron (2007) for a prescient analysis of the role of banking union and Schnabel and Véron (2018) for a discussion of EDIS.

| | Definition | Demand Shocks | Supply Shocks |
|---|---|---|---|
| Segmented Markets (SM) | $R_{j,t} \neq R_t$ | $<$ BU | $<$ BU |
| Banking Union (BU) | $R_{j,t} = \bar{R}_t$ | $=$ COMP | $<$ CMU |
| Capital Market Union (CMU) | Foreign equity share $\varphi$ | $=$ COMP | $=$ COMP |
| Complete Markets (COMP) | Backus-Smith condition | Agg. D. Externalities | Pecuniary Ext. |
| Pareto Efficient (EFF) | Planner's solution | See Farhi and Werning (2017). | |

Table 1: Summary of Results

We find that a banking union is enough to deal with leveraging/deleveraging shocks, both public and private. However, a capital market union is necessary to attain (or approximate) the complete markets outcome when there are supply shocks.

For deleveraging shocks we find that the banking union provides the same level of risk sharing as a complete markets economy. Deleveraging has real consequences: it creates an aggregate drag on the economy, and it affects output and employment. One of our main findings is that borrowing and lending across regions allows an efficient sharing of the burden of adjustment created by the deleveraging.

This result is based on a surprising symmetry in the demand effects induced by deleveraging. In our model, deleveraging initially lowers the labor income of savers. However, the lower debt burden of borrowers leads to higher demand in the future, which increases the future income of savers. How do these two effects add up? We show that in the benchmark small open economy model with Cole-Obstfeld preferences these two effects exactly offset each other so that neither the net present value of savers income nor their consumption expenditure changes. We show this that result holds approximately in more general models. However, it crucially requires that some banking union type institution guarantees that funding costs are equalized across regions.

We find that a capital market union is necessary for the efficient sharing of other shocks (supply shocks). These shocks have a first order effect on market values of assets and can only be shared with cross-border claims on private capital. This also underscores the limitations of a banking union: even a perfect banking union cannot share supply shocks. Moreover, we also show numerically that part of the welfare gains of a CMU are not properly internalized because of aggregate demand externalities induced by nominal rigidities similar to those in Farhi and Werning (2017), but also because of pecuniary externalities. Greater risk sharing by savers stabilizes the economy and implies welfare gains also for borrowers. Table 1 summarizes our results.

Existing papers in international macroeconomics, such as those in the sudden stop literature (e.g., Mendoza and Smith (2006)), focus on modeling net foreign flows. Our two agent setting instead accounts for both domestic and external credit flows. This also allows us to study how borrower specific deleveraging shocks affect the behavior of savers. Our paper is a step forward in extending the borrower-saver model and, more generally, two agent New Keynesian models (TANK) (see e.g. Bilbiie (2008)) to an open-economy framework.

Finally, while our baseline model assumes a fixed stock of capital, in an extension we include investment and capital accumulation. After estimating the model, we find that it does a good job in describing the key data moments. We use this extended model to quantitatively evaluate the welfare benefits of a banking and capital market union. We find that a banking union clearly lowers consumption volatility, especially during a crisis period. A capital market union can also bring substantial welfare benefits through more efficient allocation of ownership of capital.

**Related Literature** Our paper is related to several lines of research in international macroeconomics as well as studies of the causes and consequences of the Eurozone crisis. The optimal currency area pioneered by Mundell (1961) recognized the importance of a risk sharing mechanism. Kenen (1969) argued that such risk sharing should be organized through interregional fiscal transfers. However, Mundell (1973) notes that sophisticated financial markets might provide full insurance.

Cole and Obstfeld (1991) analyze a two-country, two-good endowment economy with flexible prices and show that adjustments to the terms of trade provide insurance against country specific shocks. Heathcote and Perri (2002) analyze production economies and find that models with asset market segmentations match cross-country correlations better than the complete markets model. Kehoe and Perri (2002) endogenize the incompleteness of markets by introducing enforcement constraints that require each country to prefer the allocation it receives by honoring its liabilities rather than living in autarky from any given time onward.

Obstfeld and Rogoff (1995) introduce nominal rigidities in the style of New Keynesian business cycle models into the open economy framework. Ghironi (2006) provides a discussion of this literature and emphasizes the difficulties in modeling market incompleteness. Gali and Monacelli (2008) circumvent the issue by assuming complete asset markets. This is also the approach followed by Blanchard et al. (2014) who model the Eurozone as a two-country (core and periphery) model.

There is a large literature on risk sharing in currency unions. Bayoumi and Masson (1995) discuss the issue of risk sharing and fiscal transfer before the creation of the Euro, and Asdrubali et al. (1996) provide evidence for the US. The Eurozone crisis spurred interest in this topic. Lane (2012) provides a detailed account of the principal drivers of the Eurozone crisis; the specific role of the boom/bust cycle in capital flows is analyzed by Lane (2013) and Gourinchas and Obstfeld (2012). Martin and Philippon (2017) provide a framework and an identification strategy to study the Eurozone crisis. They decompose each country's dynamics into three components: private leverage cycles, sovereign risks, and sudden stops/banking crises. They find that credit spreads play an important role in exacerbating the Eurozone crisis. We extend their analysis to study analytically what type of market integration is necessary for the efficient sharing of different types of shocks. We also enhance their analysis by modeling aggregate demand spillovers and monetary policy. Bolton and Jeanne (2011) analyze the transmission of sovereign debt crises through the banking systems of financially integrated economies. Hepp and von Hagen (2013) provide evidence from Germany. Allard and Brooks (2013) summarize the existing evidence. Schmitt-Grohe and Uribe (2016) emphasize the role of downward wage rigidity. Farhi and Werning (2017) analyze risk sharing in a currency union in a model with nominal rigidities. They show that fixed exchange rates increase the value of risk sharing and that complete markets do not lead to constrained efficient risk sharing. Using a similar model, Auray and Eyquem (2014) argue that complete markets can lead to lower welfare than financial autarky. Hoffmann et al. (2018) find that the introduction of the euro led to a more integrated interbank market, yet had little effect on cross-border bank-to-firm lending.

A common thread in both IRBC and NOE research is that the composition of financing flows is not discussed in detail beyond distinguishing between complete markets and non-contingent bond economies, as explained in Devereux and Sutherland (2011b) and Coeurdacier and Rey (2012). The authors provide a simple approximation method for portfolio choice problems in general equilibrium models that are solved using first-order approximations around a non-stochastic steady state. A few papers address specifically one of the enduring puzzles in open economy macroeconomics, the home equity bias puzzle. Coeurdacier and Gourinchas (2016) solve jointly for the optimal equity and bond portfolio in an environment with multiple shocks. In Heathcote and Perri (2013), home bias arises because endogenous international relative price fluctuations make domestic assets a good hedge against labor income risk. Sihvonen (2018) studies the aggregate effects of equity home bias in a model that features nominal rigidities and fixed exchange rates. Fornaro (2018) and Benigno and Romei (2014) study the effect of deleveraging shocks in open economies with nominal rigidities. Fornaro (2018) compares the consequences of a tightening of the exogenous borrowing limit in Bewley economies with and without nominal rigidities and fixed exchange rates. Benigno and Romei (2014) consider a two-country model in which one country is a net debtor and the other is a creditor. They analyze the effect of a tightening in the borrowing limit. The literature on sudden stops in emerging markets (Mendoza and Smith (2006); Mendoza (2010); Chari et al. (2005)) focuses on the imposition of an external credit constraint. These models are couched in representative agent frameworks and do not account for domestic credit flows. On the other hand, the borrower-saver models, (see e.g. Eggertsson and Krugman (2012)), and more generally the two agent New Keynesian models (Bilbiie (2008), Debortoli and Gali (2017)) lack the international dimension. Our paper instead presents a model that can account for both domestic and external capital flows, which is important for our results.

# 1 Model

We consider a currency union composed of several regions, each of which is populated by a (potentially different) measure of infinitely lived households. Each region produces a tradable domestic good and households consume both domestic and foreign goods. As in Gali and Monacelli (2008), we assume a continuum of small countries. However, as highlighted in the proofs, the appendix and the numerical section, many of our results extend to the finite country case.

Following Mankiw (2000) and Eggertsson and Krugman (2012), we assume that within each region, households are heterogeneous in their degree of time preference. Specifically, in each region there is a fraction $\chi$ of impatient households and $1-\chi$ of patient ones. Patient households (indexed by $i = s$ for savers) have a higher discount factor than borrowers (indexed by $i = b$ for borrowers): $\beta \equiv \beta_s > \beta_b$. We also consider the case in which the borrower's discount rate is stochastic. We denote the regions home and foreign and indicate foreign variables and parameters with superscript $*$. The economies differ with respect to the menu of traded assets available to savers.

We leave time subscripts out of the model parameters, although we consider (anticipated or unanticipated) shocks to many of them later.

## 1.1 Preferences and technology

We introduce equilibrium conditions for the home country, but they are defined analoguously for the other countries. Households of each type derive utility from consumption and labor through Cole-Obstfeld preferences:

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta_i^t \left[\log C_{i,t} - \nu\left(N_{i,t}\right)\right], \text{ for } i = b, s,$$

where $C_{i,t}$ is a composite good that aggregates goods produced by the home $(C_h)$ and foreign $(C_f)$ countries

$$\log C_{i,t} = (1-\alpha)\log\left(C_{h,i,t}\right) + \alpha \log\left(C_{f,i,t}\right),$$

and $\alpha < \frac{1}{2}$ is a measure of the openness to trade of the economy; equivalently, $1-\alpha$ measures home bias in consumption.[2] The home good is a composition of intermediate goods produced and aggregated into the final consumption home good using the following constant elasticity of substitution technologies:

$$C_{h,i} = \left[\int_0^1 c_i\left(j\right)^{\frac{\epsilon-1}{\epsilon}} \, \mathrm{d}j\right]^{\frac{\epsilon}{\epsilon-1}}.$$

The foreign good is a composition of goods produced in the different countries and aggregated into a final good via the technology

$$C_{f,i} = exp \int_0^1 log(C_{k,i}) \, \mathrm{d}k.$$

Similarly to the home good, each such foreign good is in turn a composite of intermediate goods:

$$C_{k,i} = \left[\int_0^1 c_{k,i}\left(j\right)^{\frac{\epsilon-1}{\epsilon}} \, \mathrm{d}j\right]^{\frac{\epsilon}{\epsilon-1}}.$$

With these preferences, the home consumption-based price index (CPI) is

$$P = \left(P_h\right)^{1-\alpha}\left(P_f\right)^{\alpha}.$$

Here the domestic producer price index is

$$P_h = \left[\int_0^1 p\left(j\right)^{1-\epsilon} \, \mathrm{d}j\right]^{\frac{1}{1-\epsilon}},$$

where $p(j)$ are prices of intermediate goods and

$$P_f = exp \int_0^1 log(P_k) \, \mathrm{d}k.$$

Moreover, for each foreign country the producer price index is

[2] With discount rate shocks the borrowers problem is

$$\mathbb{E}_t \sum_{t=0}^{\infty} \prod_{k=0}^{t} \beta_{b,k} \left[\log C_{b,t} - \nu\left(N_{b,t}\right)\right]$$

.

$$P_k = \left[ \int_0^1 p_k(j)^{1-\epsilon} \, \mathrm{d}j \right]^{\frac{1}{1-\epsilon}}.$$

The production of intermediate goods is linear in labor $AN$, where $A$ is total factor productivity. In Section 4 we introduce capital into the production function.

### 1.2 Wages and prices

We ration the labor market uniformly across households. This assumption simplifies the analysis because we do not need to keep track separately of the labor income of patient and impatient households within a country. Not much changes if we relax this assumption, except that we lose some tractability.[3] We assume a flexible form for the wage setting function $W_t = g(z^t)$, where $z^t$ denotes the history of state variables up to time $t$. Since the precise form is immaterial to the theoretical results, we defer specifying a particular function to Section 4. In the numerical section we assume sticky wages, which is important for the quantitative results. However, the theoretical results go through with flexible wages. Still the precise adjustment mechanisms to shocks are somewhat different absent nominal rigidities.

We assume prices are flexible though many of the results hold also with fixed prices. The monopolistically competitive intermediate goods producers set their prices flexibly every period. It follows that:

$$p_t(j) = P_{h,t} = \mu \frac{W_t}{A}, \ \forall j, t,$$

where $\mu \equiv \epsilon / (\epsilon - 1)$ is a markup over the marginal cost $\frac{W_t}{A}$. Since intermediate goods producers charge a markup over marginal cost, they earn profits

$$\Pi_t = (A P_{h,t} - W_t) N_t = (\mu - 1) W_t N_t.$$

### 1.3 Borrowers' budget constraint

The budget constraint of impatient households (borrowers) in each country is given by

[3] In response to a negative shock, impatient households would try to work more. The prediction that hours increase more for credit constrained households appears to be counter-factual however. One can fix this by assuming a low elasticity of labor supply, which amounts to assuming that hours worked are rationed uniformly in response to slack in the labor market. Assuming that the elasticity of labor supply is small (near zero) also means that the natural rate does not depend on fiscal policy. In an extension we study the case where the natural rate is defined by the labor supply condition in the pseudo-steady state $\nu'(n_i^\star) = (1 - \tau_j) \frac{w_j}{x_{i,j}}$. We can then ration the labor market relative to their natural rate: $n_{i,j,t} = \frac{n_i^\star(\tau)}{\sum_i n_i^\star(\tau)} n_{j,t}$ where $n_i^\star(\tau)$ is the natural rate for household $i$ in country. This ensures consistency and convergence to the correct long run equilibrium. Steady state changes in the natural rate are quantitatively small, however, so the dynamics that we study are virtually unchanged. See Midrigan and Philippon (2010) for a discussion.

$$\frac{B_{t+1}}{R_t} + W_t N_t - T_t^b = P_t C_{b,t} + B_t.$$

Where $B_t$ is the face value of debt issued in period $t-1$ by borrowers, $R_t$ is the nominal interest rate between $t$ and $t+1$, and $T_t$ are lump sum taxes. Borrowing is denominated in units of the currency of the monetary union and is subject to an exogenous limit $\bar{B}$:

$$B_{t+1} \leq \bar{B}.$$

In the numerical calibrations we assume that the borrowers are impatient enough that they always borrow up to the constraint, so $B_{t+1} = \bar{B}$. However, this assumption is not required for most of the theoretical results.

## 1.4 Monetary and fiscal policy

The precise form of the monetary policy rule $\bar{R}_t(z^t)$, given a history of state variables $z^t$, is not important for the theoretical results. However, we assume that the policy rate does not react to purely domestic shocks facing a small open economy. That is $\bar{R}_t(z^t) = \bar{R}_t(\tilde{z}^t)$, where $\tilde{z}^t$is a history of aggregate state variables. The government budget constraint is:

$$\frac{B_{t+1}^g}{R_t} = P_{h,t} G_t - T_t + B_t^g. \tag{1}$$

The rate on government debt is $R_t$ and tax receipts are $T_t = \chi T_t^b + (1-\chi) T_t^s$. We assume away from state-contingent fiscal transfers between countries; on fiscal unions see for example Farhi and Werning (2017).

## 1.5 Savers' budget constraint in each of the economies

**Segmented Markets (SMU) and Banking Union (BU)** Savers save at the rate $R_t$. The savers' budget constraint is

$$S_t + W_t N_t - T_t^s + \frac{\Pi_t}{1-\chi} = P_t C_{s,t} + \frac{S_{t+1}}{R_t},$$

where $\Pi_t$ are per-capita profits from intermediate good producers. Only savers in each country have claims to these profits, so $\frac{\Pi_t}{1-\chi}$ are profits per saver. Under BU, the interest rate at home is always equal to the interest rate in the union: $R_t = \bar{R}_t$ for all $t$. Under SMU, on the other hand, we can have

$R_t \neq \bar{R}_t$ and we will need to specify how $R_t$ is determined.

**Capital Market Union (CMU)** In a capital market union savers can additionally trade a continuum of stocks. Each such stock $i$ represents a claim to the aggregate profit stream in country $i$. The savers' budget constraint in the home country is

$$S_t + W_t N_t - T_t^s + \int_i \varphi_{t,i} \left(V_{t,i} + \Pi_{t,i}\right) di = \int_i \varphi_{t+1,i} V_{t,i} di + P_t C_{s,t} + \frac{S_{t+1}}{R_t},$$

where $\varphi_{t,i}$ are the home savers' aggregate holdings of the country $i$ stocks and$V_{t,i}$ is the price of country $i$ stock. In an (ideal) CMU this stock trading is frictionless.

**Complete Markets** In the complete markets economy, savers have access to a full set of state contingent securities. We denote purchases at time $t$ of securities paying off one unit of currency at time $t+1$ contingent on the realization of state $z_{t+1}$ following history $z^t$ by $D_{t+1}(z_{t+1}, z^t)$; this security has a time $t$ price $Q_t(z_{t+1}, z^t)$:

$$S_t + W_t N_t - T_t^s + \frac{\Pi_t}{1-\chi} + \int_{z_{t+1}} Q_t\left(z_{t+1}, z^t\right) D_{t+1}\left(z_{t+1}, z^t\right) dz_{t+1} = D_t\left(z^t\right) + P_t C_{s,t} + \frac{S_{t+1}}{R_t}.$$

## 1.6 Key equilibrium conditions

Demand functions for the home and foreign consumption bundles by savers and borrowers are given by

$$P_{h,t} C_{i,t} \quad = \quad (1-\alpha) P_t C_{i,t}, \text{ for } i = b, s. \tag{2}$$

Savers are unconstrained and their consumption is determined by their Euler equation and budget constraint (which differs depending on which assets are available, as discussed in Section 1.5):

$$\frac{1}{P_t C_{t,s}} = \beta_s R_t \mathbb{E}_t \left[\frac{1}{P_{t+1} C_{t+1,s}}\right]. \tag{3}$$

When borrowers are unconstrained their consumption is characterized by a similar Euler equation. Market clearing in goods is given by

$$AN_t = \int_i \left(\chi_i c_{i,h,b,t} + (1-\chi_i)\, c_{i,h,s,t}\right) di + G_t \tag{4}$$

here $c_{i,h,b,t}$ and $c_{i,h,s,t}$ are country $i$'s consumptions of home goods by borrowers and savers. Finally, market clearing for borrowing requires

$$\int_i \left((1-\chi_i)\, S_{t+1,i}\right) di = \int_i \left(\chi_i B_{t+1,i}\right) di + \int_i B^g_{t+1,i} di, \tag{5}$$

and (if available) that for stocks $\int_i (1-\chi_i)\, \psi_{t+1,i} di = 1$ and for Arrow-Debreu securities $\int_i (1-\chi_i)\, D_{t,i}\left(z_{t+1}, z^t\right) di = 0$ for all $z_{t+1}$.

## 2 Banking Union

In this section we study demand shocks under BU: specifically, shocks that come from private borrowing or fiscal policy. Our key theoretical result shows analytically that an ideal BU provides perfect risk sharing with respect to these shocks. Later we argue that this result is robust to various alternations of the model structure.

Under BU, the funding cost is the same in all regions. Let us first define the $k$-period discount rate from the savers' perspective as $R_{t,k} \equiv R_t \times .. \times R_{t+k-1}$, with the convention $R_{t,0} = 1$. We also define $\tilde{Y}_t \equiv P_{h,t} N_t - T_t$ as private disposable income and $F_t$ as nominal exports.

The first step is to write the current account equilibrium in market values. We then have the following Lemma:

**Lemma 1.** *The inter-temporal current account condition (for each country) is*

$$\alpha \left( (1-\chi)\, S_t - \chi B_t + \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}} (z^t) \right) = (1-\chi)\, S_t - \chi B_t - B^g_t + \sum_{k=0}^{\infty} \frac{F_{t+k}}{R_{t,k}} (z^t) \tag{6}$$

*for each history $z^t$.*

*Proof.* See Appendix. □

On the left we have the net present value of all future imports, which is a share $\alpha$ of private wealth, which itself equals financial wealth plus the value of disposable income. On the right we have net foreign assets plus the present value of exports ($F_t$). The key point here is that the inter-temporal current-account condition pins down the NPV of disposable income as a function of current assets and foreign demand. With unit demand elasticity (log-preferences) nominal exports are exogenous to the small open economy.

The next step is to consider the program of the savers. With log-preferences, we can write the savers' problem as

$$\max \mathbb{E}_t \textstyle\sum_{t\geq 0} \beta_s^t \log\left(P_t C_{s,t}\right)$$
$$s.t.\ P_t C_{s,t} + \tfrac{S_{t+1}}{R_t} = S_t + \tilde{Y}_t^s.$$

The inter-temporal budget constraint of savers is

$$\frac{P_{t+k} C_{s,t+k}}{R_{t,k}}(z^t) = S_t + \sum \frac{\tilde{Y}_{t+k}^s}{R_{t,k}}(z^t), \tag{7}$$

where $\tilde{Y}_t^s = W_t N_t - T_t^s + \frac{\Pi_t}{1-\chi}$ is the disposable income of savers. Savers have a claim on corporate equity and might face different taxes than borrowers who earn $\tilde{Y}_t^b = W_t N_t - T_t^b$. To derive our first result, we need to make a connection between the disposable income of savers $\tilde{Y}_t^s$ that enters Equation (7) and the average disposable income $\tilde{Y}_t = (1-\chi)\tilde{Y}_t^s + \chi \tilde{Y}_t^b$ that enters Equation (6). If taxes are arbitrary, there is of course very little that we can say. Therefore, we restrict our attention to a class of fiscal policies where the following condition holds:

**Condition 1.** For each history $z^t$ , the present value of savers' income is a differentiable function of that of average disposable income[4]

$$\sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}^s}{R_{t,k}}(z^{t+k}) \sim \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}}(z^{t+k}).$$

Condition 1 imposes some restrictions on fiscal policy, but it holds in many natural settings and all the applied models that we have studied. The simplest example is uniform flat taxation of all income at rate $\tau_t$, i.e., $T_t^b = \tau_t W_t N_t + T_t^{b,LS}$ and $T_t^s = \tau_t \left(W_t N_t + \frac{\Pi_t}{1-\chi}\right) + T_t^{s,LS}$and the assumption that for the lump-sum taxes $\sum_{k=0}^{\infty} \frac{T_t^{b,LS}}{R_{t,k}}(z^t) \sim \sum_{k=0}^{\infty} \frac{T_t^{s,LS}}{R_{t,k}}(z^t)$. For example when the lump-sum taxes are zero $\tilde{Y}_t^b = (1-\tau_t) W_t N_t$ and $\tilde{Y}_t^s = (1-\tau_t)\left(W_t N_t + \frac{\Pi_t}{1-\chi}\right) = (1-\tau_t) W_t N_t \left(1 + \frac{\mu-1}{1-\chi}\right)$. Therefore, all taxes, income and profits are proportional to $W_t N_t$. In particular, $\tilde{Y}_t = \mu (1-\tau_t) W_t N_t$, and therefore

[4]Now $x \sim y$ ensures that when $y$ does not change x does not change and vice versa.

$\tilde{Y}_t^s = \frac{1}{\mu}\left(1+\frac{\mu-1}{1-\chi}\right)\tilde{Y}_t$. All disposable incomes are directly proportional, period-by-period. This is stronger than what we need for Condition 1. Note that markups are constant: we will return to this issue in the next section.

If we combine Lemma 1 and Condition 1, we obtain the following result.

**Lemma 2.** *Under Condition 1 and log-preferences, nominal spending by savers ($P_t C_{s,t}$) does not react to private credit shocks ($\bar{B}_{t+1}$), to borrowers' discount rate shocks ($\beta_{b,t}$) or to fiscal policy (neither $G_t$ nor $T_t$). Spending only reacts to interest rate and foreign demand shocks.*

*Proof.* Lemma 1 shows that the net present value of disposable income is a function of exactly four variables:

$$\sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}}(z^{t+k}) \equiv \Omega\left(S_t, B_t, B_t^g, \sum_{k=0}^{\infty}\frac{F_{t+k}}{R_{t,k}}(z^{t+k})\right),$$

where the first three variables (saving, household debt, public debt) are predetermined at time $t$ and the last one (exports in euros) is exogenous given a unit demand elasticity. Therefore, equation (7) is, in fact,

$$\sum_{k=0}^{\infty} \frac{P_{t+k}C_{s,t+k}}{R_{t,k}}(z^t) \sim S_t + \Omega_t.$$

So in equilibrium the current spending of savers only depends on $\Omega_t$ and the path of interest rates. In particular, for given $\Omega_t$ and interest rates, it cannot depend on contemporaneous or future private credit, borrowers' discount rate, or fiscal policy. □

Lemma 2 clarifies the behavior of savers. Their nominal spending reacts neither to credit shocks nor to fiscal shocks. Such deleveraging shocks affect the savers in two ways. First, if this debt was held by domestic savers, deleveraging results in repayments of debt. However, the savers can substitute these repayments by lending more to foreign countries. The fact that this direct effect does not affect the *net present value* of savers income and therefore their spending is perhaps not surprising.

However, deleveraging also lowers the demand of borrowers which creates a bust in the country. This lowers the labor income and profits received by savers. Intuitively, the consumption expenditure of savers should therefore fall. But the lower debt of borrowers increases their demand in future periods, which increases the savers' future income. What is surprising is that for any distribution of deleveraging shocks this future increase in income exactly offsets the initial fall so that the NPV of savers income does not change. As a result, patient agents keep their nominal spending constant.

The exact theoretical result relies on our assumption of Cole-Obstfeld preferences (Cole and Obstfeld, 1991). In our simulations, however, we find that the theory provides a good prediction even when the demand elasticity differs from one as explained in the appendix. Moreover, it holds approximately in a finite country model in which the central bank reacts to deleveraging by lowering the policy rate. Finally, it is worth emphasizing that our results refer to expenditures, not real consumption. Even when expenditures remain constant, real consumption moves with inflation. In realistic settings, inflation responses are relatively small and our theoretical benchmark is quite accurate. We can now state our first main result.

**Proposition 1.** *The Banking Union achieves the Complete Markets allocation subject to (an arbitrary cross-sectional distribution of) country-specific private and public demand shocks ($\bar{B}_{t+1}$, $\beta_{b,t}$, $G_t$, $T_t$) using dynamic cross-country borrowing.*

*Proof.* Under BU, the interest rate is the same in all regions and is independent of idiosyncratic shocks to the SOE. Given interest rates, savers' spending $P_t C_{s,t}$ is constant. On the other hand, the complete markets outcome is characterized by the Backus-Smith condition, which, with log preferences, takes the form

$$\frac{C_{s,t,j}}{C_{s,t}} \sim \frac{P_t}{P_{t,j}},$$

for arbitrary foreign country $j$. Since shocks to an SOE do not affect foreign prices or quantities, it follows that the complete markets condition is also that $P_t C_{s,t}$ remains constant. Hence, in response to deleveraging shocks coming either from a change in the borrowers' credit constraints or the discount rate, the BU replicates the complete markets economy. These shocks can occur simultaneously. Moreover because the shocks are idiosyncratic, a shock facing a small foreign country does not affect the home country. □

Proposition 1 shows that a banking union is sufficient to deal with any cross-sectional distribution of debt deleveraging and fiscal shocks in a currency union. Martin and Philippon (2017) show that segmented markets, in contrast, can be very inefficient. They find that spreads go up during episodes of private deleveraging, mostly because of stress in the banking sector. This leads savers (or firms under Q-theory) to cut spending precisely when the economy is in recession, exacerbating the downturn. We quantity the welfare gains from BU in Section 4.

Proposition 1 is different from previous hedging results in the international macroeconomics literature, such as those in Coeurdacier and Gourinchas (2016) and Coeurdacier et al. (2010). They consider two country models with trading in two real bonds as well as equity claims. They find that countries can share risks using static positions in the real bonds. In contrast, we effectively consider a setting with trading in one nominal bond with a common interest rate. We show that countries can share risks using an essentially dynamic cross-country borrowing strategy with this bond. Our result also differs from the results in Engel and Matsumoto (2009), who show that agents can hedge risks through a static forward position in foreign exchange.

**Remark:** By Proposition 1 the government cannot affect the nominal consumption of savers. If there are no borrowers, the result implies that the government cannot affect nominal household consumption. This result is stronger than Ricardian equivalence and obtains because Cole-Obstfeld preferences imply a nominal fiscal consumption multiplier of zero. This implication can be seen as a version of the Cole and Obstfeld (1991) result and is also discussed in Lemma 3. In simple economic terms this is because: i) the interest rate does not react due to the small open economy assumption, ii) nominal exports do not react due to Cole-Obstfeld preferences, i.e. there is (no "leakage"). Note that the *real* fiscal consumption multiplier, a statistic studied for example by Farhi and Werning (2013), is generally not zero.

Figure 1 plots the impulse responses to a domestic deleveraging shock (credit shock). Deleveraging affects borrowers' spending and initially creates a recession. Savers smooth this fall in income by borrowing more from foreign countries. After the first period, this deleveraging has a small positive effect on output, wages and profits as borrowers' lower interest expenses boost demand. This additional income offsets the lower interest rate income received by savers who now hold a smaller stock of savings. As implied by Proposition 1, savers' nominal expenditure does not react to these changes. This is because the negative and positive income effects of deleveraging exactly offset each other so that the NPV of savers' income does not change.

# 3 Capital Market Union

In this section we focus on the benefits of a capital market union above an ideal banking union. We pay special attention to technology shocks in the form of "quality" shocks to the goods sold by firms. Formally, we model these shocks as changes to quality parameters $\alpha_i$ (possibly correlated across countries). These shocks alter the relative profitability of firms in different countries. The banking union will not be able to share this kind of risk, but the capital market union could, at least in principle. The following proposition characterizes the types of shocks that can be shared efficiently in a CMU.

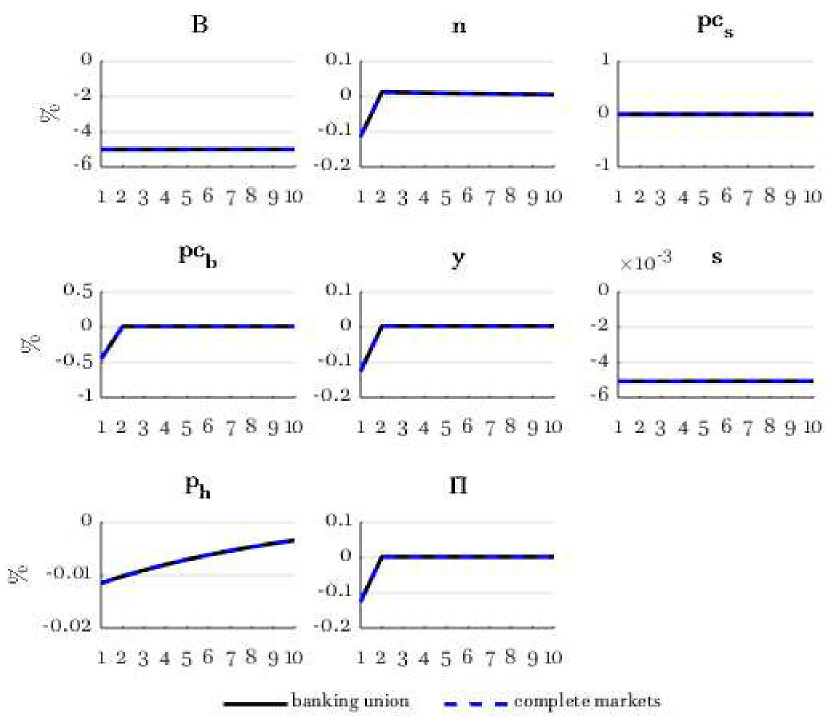


Figure 1: Private Deleveraging

Note: Impulse responses to permanent -5% shock to $\bar{B}_t$. $y_t$is nominal GDP.

**Proposition 2.** *Assume borrowers are impatient enough to borrow up to the borrowing constraint. Using static equity positions and no-cross country borrowing, it is possible to replicate the complete markets allocation in a capital market union subject to (an arbitrary cross-sectional distribution) of quality ($\alpha_t$), TFP ($A_t$), monetary policy, and various preference shocks (that can be correlated across countries).*

*Proof.* To highlight that the result does not depend on the assumption of a small open economy we show it in an $I$ country version of the model from which we can see that it holds also when $I \to \infty$.[5] The equilibrium conditions for this version of the model are very similar to those with a continuum of countries. Here the mass of each country is $\frac{1}{I}$. We assume symmetric countries but relax this in the appendix. Given symmetric countries and log preferences the complete markets condition is $P_t C_{s,t,i} = P_t C_{s,t,j}$. Imposing symmetric and constant stock positions as well as constant taxes, government spending and borrowing, and borrowing limits, the savers' budget constraints in countries $i$ and $j$ are

$$P_{t,i}C_{s,t,i} =$$
$$\bar{B}(1 - \frac{1}{R_t}) + W_{t,i}N_{t,i} + \varphi\frac{(\mu-1)W_{t,i}N_{t,i}}{1-\chi} + \sum_{j\neq i}\frac{(1-\varphi)}{I-1}\frac{(\mu-1)W_{t,j}N_{t,j}}{1-\chi},$$

where we used the assumption for the production function and the fact that taxes and transfers cancel assuming no new borrowing by government. Moreover, to simplify expressions in this case of symmetric countries, but without loss of generality, we here choose a different normalization of stock supply. Namely, each unit of the home stock entitles a saver to a dividend of $\frac{\Pi_t}{1-\chi}$. Deducting the conditions for two countries $i$ and $j \neq i$ we obtain

$$P_{t,i}C_{s,t,i} - P_{t,j}C_{s,t,j} =$$
$$W_{t,i}N_{t,i} - W_{t,j}N_{t,j} + \varphi\frac{(\mu-1)W_{t,i}N_{t,i} - (\mu-1)W_{t,j}N_{t,j}}{1-\chi}$$
$$-(\mu-1)\frac{W_{t,i}N_{t,i} - W_{t,j}N_{t,j}}{1-\chi}\frac{1-\varphi}{I-1} = (W_{t,i}N_{t,i} - W_{t,j}N_{t,j})\left(1 + \varphi\frac{\mu-1}{1-\chi} - \frac{1-\varphi}{I-1}\frac{\mu-1}{1-\chi}\right).$$

Imposing the complete markets condition and ignoring the indeterminacy case (discussed in the ap-

[5] In the limit there is a countable infinity of countries instead of a continuum of countries. However, the limiting model is effectively equivalent to a continuum economy, see Sihvonen (2019) for a discussion. Moreover, we could prove all the results by imposing a continuum of countries a priori.

pendix), we need

$$1+\varphi\frac{\mu-1}{1-\chi}-\frac{1-\varphi}{I-1}\frac{\mu-1}{1-\chi}=0. \tag{8}$$

From this one can solve

$$\varphi=\frac{1}{I}-\frac{I-1}{I}\frac{1-\chi}{\mu-1}. \tag{9}$$

With these stock positions the complete markets condition holds for arbitrary labor income realizations. The complete markets condition also ensures that the Euler equations for stocks and borrowing hold. Therefore, the above stock positions and no-cross country borrowing constitute an equilibrium that replicates the complete markets outcome. In the small open economy limit $I\to\infty$, a saver should hold $-\frac{1-\chi}{\mu-1}$ home stocks and $1+\frac{1-\chi}{\mu-1}$ foreign stocks split equally. □

To efficiently share quality shocks, savers should underweight home stocks. In practice various frictions might lead savers to do the opposite and overweight home stocks. This type of capital market union with partially segmented equity markets is able to share some but not all of the risks associated with the shocks.

Note that the proposition holds for various different types of shocks, including quality shocks, TFP shocks and monetary policy shocks. It also holds for all types of preference shocks that do not alter the complete markets condition. This includes shocks to the disutility of labor that typically affects the relationship between labor supply and wages. Moreover, the number of shocks can be higher than the number of assets; this is in contrast to the usual finiding that obtaining the complete markets outcome requires at least as many assets as shocks (see e.g. Coeurdacier and Gourinchas (2016)). The exact theoretical result hinges on log-preferences as well as the assumed form of the production function. However, it does not require a unit elasticity of substitution or a continuum of countries. [6]

The assumption that the borrowers borrow up to the constraint rules out cases in which a supply shock would indirectly induce leveraging or deleveraging. We relax this assumption in Proposition 3.

Figure 2 shows the outcomes of a home quality shock in a banking union, a partial capital market union (with equal weights on home and foreign stocks), and complete markets (equivalently, a CMU with optimal weights). With complete markets savers' spending reacts neither in the home country nor in the foreign countries. Proposition 2 shows that if stock positions are chosen correctly, the capital market outcome coincides with the complete markets case. With equal weights on home and foreign

[6] The production function implies a perfect correlation between dividends and labor income. The result would also hold in a model with a fixed capital stock but not in a model with investment. However, it holds approximately in a model with investment with realistic investment adjustment costs.

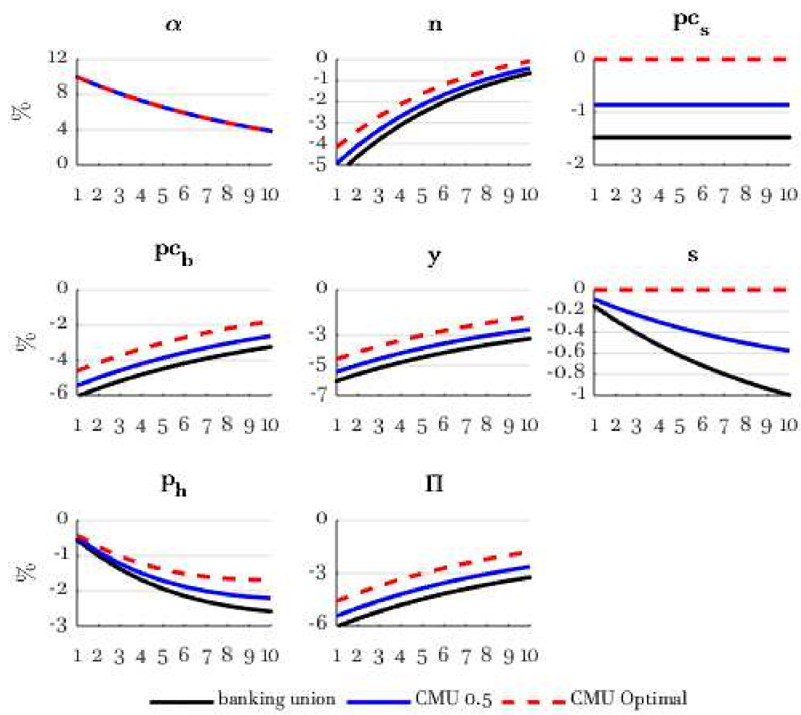


Figure 2: Quality Shocks in BU and CMU

Notes: Impulse responses to 10% shock to $\alpha$. CMU 0.5 has an exogenous weight of 0.5 on the home stock and a weight of 0.5 on foreign stocks split equally. Complete markets is equivalent to a CMU with optimal weights, as explained in Proposition 2. BU is CMU with zero weight on foreign stocks.

stocks, savers' spending in the home country increases. This increase, however, is smaller than in a banking union without cross-border equity claims.

Note in an optimal CMU cross-border equity holdings provide full insurance against supply shocks and savers' have no incentives for cross-country borrowing. However, in a partial CMU savers also borrow more from foreign countries to gain additional smoothing.

Note that our definition of a banking union implies perfect home bias in equity, whereas we define a capital market union as featuring optimal cross-border holdings of equity. We have in mind a situation in which some friction prevents savers from optimally diversifying their equity holdings, and a capital market union can be thought of as the removal of this friction. We do not explicitly model such frictions in this paper; for more elaborate micro-foundations of equity home bias and related discussions see, for example, Coeurdacier and Rey (2013) and Sihvonen (2018).

**Simultaneous Supply and Demand Shocks** Proposition 1 shows that by using dynamic borrowing a banking union is able to share demand shocks. Proposition 2 argues that by using static equity positions a capital market union can share quality shocks. In a first-order approximation these results add up in a fairly straightforward way. In our framework we also obtain the following exact result:

**Proposition 3.** *Using static equity positions and dynamic cross-country borrowing it is possible to replicate the complete markets allocation in a capital market union subject to (an arbitrary cross-sectional distribution of) (country specific) private deleveraging as well as arbitrary foreign quality, productivity, monetary policy, and various preference shocks.*

Proof: See Appendix.

**Shocks that Can Be Shared Neither in BU or CMU** We have provided results for the types of shocks that can be shared perfectly either in a BU or CMU. We have covered a broad array of shocks including credit, discount rate, taxation, government spending, quality, productivity, monetary policy and disutility of labor shocks. Are there shocks, then, that cannot be shared in an ideal CMU? Generally, the answer is yes, especially if one insists on perfectly replicating the complete markets outcome. The key counterexample would be a redistributive shock such as a mark-up shock that alters the relative share of labor and dividend income. In case of such shocks one can show that neither a BU nor a CMU exactly obtains the complete markets outcome.

# 4 Numerical Welfare Gains

In this section, we extend the model to include physical capital. We use this extended model to quantitatively assess the welfare benefits of a banking and capital market union. Adding capital does not alter the key results of the paper but it affects the welfare benefits of a banking and capital market union. This occurs partly because investment lowers the correlation between dividends and labor income, which reduces the hedging benefits of foreign equity. Moreover, we now specify the monetary policy rule and the relationship between wages and labor supply.

## 4.1 Model Structure

**Final goods producers** As before, competitive final goods producers produce the consumption good using a CES technology that aggregates intermediate goods:

$$Y_t = \left( \int_0^1 Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}.$$

**Intermediate goods producers** Intermediate goods, however, are produced by monopolistically competitive firms using a Cobb-Douglas technology with labor and capital as inputs:

$$Y_{j,t} = A_t N_{j,t}^{1-\theta} K_{j,t}^{\theta}.$$

Where $A_t$ is an aggregate, country-specific productivity shock. Intermediate goods producers are owned by shareholders in the home and foreign country and maximize dividend payoffs to shareholders ($d_{j,t}$), discounted using the average discount factor ($\bar{m}_{0,,t}$) of savers in the two countries

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \bar{m}_{t,t+s} d_{j,t+s}$$

The weights for the discount factors are given by the stock positions. For example if home savers hold most of the equity of home firms, home firms put more weight on the discount factor of home savers. The firms can transfer the aggregate consumption good into capital through investment. Dividends are:

$$d_{j,t} = P_{j,t} Y_{j,t} - W_t N_{j,t} - P_t I_{j,t} - P_t f(I_{j,t}).$$

Where $I_{j,t}$, $P_{j,t}$, $N_{j,t}$ and $Y_{j,t}$ are intermediate producer $j$'s investment, price, employment and output at time $t$ and $W_t$ is the wage rate in the country. Moreover, $f(I_{j,t})$is the investment adjustment cost. Here we set

$$f(I_{j,t}) = \frac{\zeta}{2} \left( \frac{I_{t,j}}{I_{t-1,j}} - 1 \right)^2.$$

Firm $j$'s capital evolves according to:

$$K_{j,t+1} = (1-\delta) K_{j,t} + I_{j,t}.$$

And it faces a downward sloping demand curve from producers of the final good:

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_{h,t}}\right)^{-\epsilon} Y_t.$$

Intermediate goods producers set prices flexibly. It follows that they all set the same price, labor demand and investment level.

$$N_t = N_{j,t},\ I_t = I_{j,t},\ P_{h,t} = P_{j,t},\ K_t = K_{j,t}.$$

Optimal investment is determined by the following equation:

$$P_t + P_t\zeta\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)\frac{1}{I_{j,t-1}} = \mathbb{E}_t\bar{m}_{t,t+1}\left[P_{j,t+1}\zeta\frac{Y_{j,t+1}}{K_{j,t+1}} + P_{t+1}\zeta\left(\frac{I_{j,t+1}}{I_{j,t}} - 1\right)\frac{I_{j,t+1}}{I_{j,t}^2} + \Psi_{t+1}\right]$$

Here

$$\Psi_{t+1} = (1-\delta)\mathbb{E}_{t+1}\bar{m}_{t+1,t+2}P_{j,t+2}\zeta\frac{Y_{j,t+2}}{K_{j,t+2}} + ...$$

This can be written in recursive form as

$$P_t + P_t\zeta\left(\frac{I_{j,t}}{I_{j,t-1}} - 1\right)\frac{1}{I_{j,t-1}} = \mathbb{E}_t\bar{m}_{t,t+1}\left[P_{j,t+1}\eta\frac{Y_{j,t+1}}{K_{j,t+1}} + P_{t+1}\zeta\left(\frac{I_{j,t+1}}{I_{j,t}} - 1\right)\frac{I_{j,t+1}}{I_{j,t}^2} + \mathcal{A}_{t+1}\right].$$

Here

$$\mathcal{A}_{t+1} = (1-\delta)\left[P_{t+1} + P_{t+1}\zeta\left(\frac{I_{j,t+1}}{I_{j,t}} - 1\right)\frac{1}{I_{j,t}} - \mathbb{E}_{t+1}\bar{m}_{t+1,t+2}P_{t+2}\zeta\left(\frac{I_{j,t+2}}{I_{j,t+1}} - 1\right)\frac{I_{j,t+2}}{I_{j,t+1}^2}\right].$$

The price is a constant markup over marginal cost

$$P_{h,t} = \mu MC_t.$$

Where the markup over marginal cost $MC_t$ is given by $\mu \equiv \frac{\epsilon}{\epsilon-1}$ and $MC_t = \frac{W_t}{(1-\theta)Y_t/N_t}$.

**Monetary policy rule** For the small open economy model we assume a constant policy rate from the perspective of the home country. For the two country version considered later we assume the central bank sets the interest rate according to

$$\bar{R}_t = R_{ss} \left( \left( \frac{Y_t}{Y_{ss}} \right) \left( \frac{Y_t^*}{Y_{ss}^*} \right) \right)^{\phi_Y} \left( \left( \frac{\pi_t}{\pi_{ss}} \right) \left( \frac{\pi_t^*}{\pi_{ss}^*} \right) \right)^{\phi_\pi},$$

where $R_{ss}$, $Y_{ss}$ and $\pi_{ss}$ are the steady state interest rate, output and inflation.

**Wages and labor supply** Following Martin and Philippon (2017), wage dynamics are determined by a Phillips curve with slope $\kappa$

$$W_t = W_{t-1} \left( 1 + \kappa \left( N_t - N_{ss} \right) \right),$$

where $N_{ss}$ is steady-state employment.

## 4.2 Numerical Welfare Benefits of a Banking Union

In this section we use the model with capital to estimate the welfare benefits of a banking union. Under segmented markets, the private costs of funds are not equalized across regions. Martin and Philippon (2017) and Gourinchas et al. (2016) quantify the extent of the dispersion in funding costs during the Eurozone crisis. The simplest interpretation is that domestic banks intermediate savings and investment, and, thus, the private cost of fund is pinned down by the banking system. Formally, in log-deviations from steady state, we have

$$r_t = r_t^b$$

where $r_t^b$ is the banks' funding cost. We can then consider a small country subject to a spread shock $r_t^b$ and a private leverage shock $\bar{B}_t$ . We estimate these shocks using data from the Eurozone as in Martin and Philippon (2017). The basic idea is to model the joint dynamics of spreads and private debt. Debt is well described by an AR(2) process and spreads by an AR(1) process. The processes are correlated because negative shocks cause spread to rise and banks to cut lending. Our calibration uses data from a volatile period, the eurozone crisis, so our welfare calculations capture the value of a banking union during periods of heightened financial risks.[7]

Table 2 summarizes our quantitative results. Spread differences between countries increase consumption volatility and lower welfare. The volatilities in the segmented markets case are fairly high since the model is calibrated to a volatile period. The banking union reduces consumption volatility by equalizing interest rates between countries. Table 2 shows the volatilities of (annualized quarterly log changes) real consumption for savers and borrowers as well as for aggregate consumption. The banking union eliminates almost all of the consumption volatility of savers. This is consistent with Proposition 1, according to which the banking union attains the complete markets outcome subject to deleveraging shocks. It also suggests that the Proposition holds well in the extended model with capital. The banking union also leads to a substantial reduction in the consumption volatility of borrowers and a clear decline in the volatility of total consumption. [8]

| Consumption Volatility | Segmented Markets | Banking Union |
|---|---|---|
| Savers | 6.7% | 0.1% |
| Borrowers | 5.1% | 1.9% |
| Total | 6.1% | 0.5% |

Table 2: Consumption volatilities under segmented markets and a banking union, no supply shocks

Table 3 describes the volatilities when adding supply shocks modeled as quality and productivity shocks. The estimation of these shocks is described in the next section. Now the banking union does not lead to zero volatility for savers but still implies a clear reduction in all consumption volatilities.[9] The finding that the banking union can clearly lower consumption volatility is consistent with the message of Martin and Philippon (2017)who find that segmentation in funding costs was a major contributor to the eurozone crisis.

[7] The borrowing limit follows the process

$$\log \bar{B}_{i,t} - \log \bar{B}_{i,t-1} = -0.01 \times (\log \bar{B}_{i,t-1} - \log \bar{B}) + 0.85 \times \left(\log \bar{B}_{i,t-1} - \log \bar{B}_{i,t-2}\right) + 0.04\epsilon^b_{i,t}$$

and the spread the process

$$r^b_{i,t} = 0.9 r^b_{i,t-1} + 0.003\epsilon^r_{i,t}$$

and the correlation between the two shocks is

$$corr\left(\epsilon^b_{i,t}, \epsilon^r_{i,t}\right) = -0.3.$$

The investment adjustment cost is estimated in the next section.

[8] With log-preferences the welfare benefits of these changes are still relatively small. However, we could increase this welfare gain by raising savers' risk aversion, for example through the use of recursive preferences (Epstein and Zin (1989)).

[9] Note that the point that eliminating market segmentation improves welfare is not entirely obvious. For example Devereux and Sutherland (2011a) and Brunnermeier and Sannikov (2015) find that free bond trading can reduce welfare relative to financial autarky. However, spreads tend to increase precisely when it would be efficient for countries to smooth shocks by borrowing.

| Consumption Volatility | Segmented Markets | Banking Union |
|---|---|---|
| Savers | 7.5% | 2.7% |
| Borrowers | 6.3% | 3.7% |
| Total | 7.0% | 2.9% |

Table 3: Consumption volatilities under segmented markets and a banking union, including supply shocks

### 4.3 Numerical Welfare Benefits of a Capital Market Union

In this section we argue that the welfare gains of moving from a banking union to a capital market union can be large. As before we employ the model with capital but now with two countries. We assume three different kinds of shocks: deleveraging, quality and productivity shocks.

The benefits of CMU depend on the relative importance of these shocks. First, in line with Proposition 1, deleveraging shocks can be shared well through borrowing and saving and, therefore, require little equity market diversification. Second, due to Cole-Obstfeld preferences, TFP shocks do not create large changes in the total value of output or dividends in each country, consistent with Lemma 3. Sharing such shocks, therefore, requires fairly little equity market diversification, and consumption volatilities in each country are generally insensitive to the level of diversification. On the other hand, using such shocks only tends to lead to a counterfactually low correlation between dividends and labor income. Moreover, these shocks imply high correlations between the consumption levels in the two countries, in contrast to the low levels of international risk sharing seen in the data.

However, sharing quality shocks efficiently requires diversification in equity positions. We calibrate the model to match consumption and export data from France provided by Eurostat. We also match the relative correlation between dividends and labor income. The calibration details are given in the appendix.

We calibrate the shock processes using a stock position of $\varphi = 0.8$. That is we start from a reasonable empirical benchmark with low levels of within union cross-border equity holdings. After that we numerically solve for the optimal home stock position from an individual saver's perspective using the method described by Devereux and Sutherland (2011b). The optimal home stock position is constant up to second order and given by $\varphi = \varphi^* = 0.08$. We do not model the friction that leads agents to choose a larger-than-optimal home stock position. As in Tille and van Wincoop (2010), for example, we can think of this friction as a second-order term that affects macroeconomic conditions through its impact on stock positions. We then compare the volatility of (log first differences in) consumption under the two different levels of equity market diversification. The results are given in Table 4. Note that we have slightly modified the definition of banking union to match the empirical extent of equity home bias instead of assuming perfect home bias. Further, the numbers are not directly comparable with the previous tables because we use the two country version of the model to produce Table 4.

| Consumption Volatility | Banking Union $\varphi = 0.8$ | Capital Market Union $\varphi = \varphi^* = 0.08$ |
|---|---|---|
| Savers | 1.52% | 0.88% |
| Borrowers | 3.46% | 2.96% |
| Total | 2.04% | 0.85% |

Table 4: Consumption volatilities under a banking union and a capital market union

The first order effect of increasing equity market diversification is a 62% reduction in savers' consumption volatility. Interestingly, through general equilibrium effects, increased risk sharing by savers also leads to a reduction in the consumption volatility of borrowers, and therefore a greater reduction in aggregate consumption volatility than would be implied by a reduction in savers' volatility alone. Table 5 illustrates the positive externalities of a CMU. Savers do not internalize the gains that accrue to borrowers, so the reduction in borrowers' consumption volatility amounts to a positive externality. However, there are also positive externalities for savers. If a single saver lowers her stock position to $\varphi = 0.08$, she would face a consumption volatility of 0.94%. That is, roughly 10% of the volatility reduction gains accruing to savers are not internalized. This is due both to pecuniary and aggregate demand externalities.

| | Uninternalized Volatility Reduction | Share of Total Volatility Reduction |
|---|---|---|
| Savers | 0.06% | 10% |
| Borrowers | 0.5% | 100% |

Table 5: Positive Externalities of a CMU

**Sensitivity Analysis** The results depend on the types of shocks that we assume. Table 6 shows the results if we estimate the model with deleveraging and productivity shocks only. Because home equity provides a good hedge to shocks to labor income, stock positions are mildly biased towards home stocks even absent frictions. More specifically, the frictionless equilibrium stock position is $\varphi = 0.6$. Overall, consumption volatilities are less sensitive to equity market diversification in line with Lemma 3. We can see from the table that now the CMU brings essentially zero benefits. The deleveraging shocks can be shared through borrowing and saving. Moreover, the productivity shocks do not create large differences in the value of output in the two countries. Similar results have been found in the literature on equity home bias, where it has been shown that equilibrium stock positions can be biased towards home stocks even absent frictions (e.g. Coeurdacier and Gourinchas (2016), Heathcote and Perri (2013)). Moreover, here better diversification in stock positions can even result in a small increase in savers' consumption volatility, reminiscent of the welfare reversal result of Auray and Eyquem (2014). However, as also discussed in Section 4.3, the calibration with quality shocks matches important features of the data that cannot be matched with productivity shocks alone. Furthermore, as explained below this calibration is better in line with reduced-form evidence from the US.

| Consumption Volatility | Banking Union $\varphi = \varphi^* = 0.8$ | Capital Market Union $\varphi = \varphi^* = 0.6$ |
|---|---|---|
| Savers | 1.92% | 1.94% |
| Borrowers | 3.2% | 3.2% |
| Aggregate | 2.2% | 2.2% |

Table 6: Consumption volatilities under a banking union and a capital market union, no quality shocks

In unreported simulations we also study how the degree of wage rigidity affects these numerical results. More rigid wages seem to lead to higher consumption volatilities given any degree of capital market integration. However, changing the stickiness of wages does not lead to large differences in the relative change in consumption volatilities when moving from a BU to a CMU. On the other hand, with stickier wages a larger share of this reduction is due to aggregate demand externalities.

**Pareto Efficient Solution** Our results highlight the cases in which a BU or a CMU can replicate the complete markets outcome for savers. This equilibrium might still not be Pareto efficient, however, for two reasons. First, it does not attain the complete markets allocation between borrowers in different countries or between borrowers and savers. The allocation can therefore feature pecuniary externalities as the marginal rates of substitutions between all agents are generally not equalized.

The second reason is that we assumed that wages are sticky. This is not important for the main results of the paper. However, as explained by Farhi and Werning (2017) such rigidities can give rise to aggregate demand externalities. This can imply that even the full complete markets allocation is not Pareto efficient.

Providing an analytical solution for the Pareto efficient allocation in our setup seems infeasible.

However, using a somewhat simpler model Sihvonen (2018) shows that absent frictions the equilibrium stock positions tend to be socially optimal even despite aggregate demand externalities. Numerically this property seems to hold well in our model. In the baseline model, the frictionless equilibrium stock position is 0.08. Aggregate consumption volatility is minimized with a stock position of -0.18. However, this volatility is fairly flat in the region of the socially optimal stock position so that the equilibrium stock position attains 94% of the total volatility reduction gains. This suggests that the complete markets/equilibrium stock positions are close to the socially optimal ones in a setting where all stock market frictions have been removed (a CMU).

We also show numerically that a BU and a CMU tends to improve welfare. Moreover, we numerically evaluate the positive externalities of a CMU. Here we find that these externalities are fairly large. That is a substantial part of the gains from moving from an equilibrium given frictions to a frictionless equilibrium are uninternalized.

**On the Empirical Plausibility of the Estimate of the Benefit of CMU** According to table 4 a perfect CMU would be able to more than halve aggregate consumption volatility relative to a banking union. As discussed this estimate is somewhat sensitive to model assumptions. For example calibrating the model with productivity shocks only lowers the benefit of CMU. However, a relatively large estimate is consistent with reduced form evidence from the US.

Asdrubali et al. (1996) provides a method for estimating risk sharing gains from regional capital market integration. They measure this using the regression slope coefficient

$$\beta_K = \frac{Cov(\Delta log(grp) - \Delta log(ri), \Delta log(grp))}{Var(\Delta log(grp))},$$

where $grp$ is gross regional product and $ri$ is regional income. Here the difference between the two measures reflects dividend, interest and rental payments. A coefficient of one implies that such capital market transfers perfectly offset variation in regional income; when it is zero there is no such counteracting effect. Asdrubali et al. (1996) estimate that between US states $\beta_K^{US} \approx 39\%$ with a number close to 50% in the later part of the sample. On the other hand, Afonso and Furceri (2008) estimate that between eurozone countries $\beta_K^{EUR} \approx 8\%$. While these measures are based on somewhat different sample periods, capital market integration in the US seems to increase the measure by 30-40 percentage points. On the other hand, using our calibrated model we find simulated coefficients of $\beta_K^{BU} \approx 16\%$ and $\beta_K^{CMU} \approx 67\%$. This implies that moving from a low degree of capital market integration to perfectly integrated capital markets increases the risk sharing measure by roughly 50 percentage points. This estimate is not implausibly large given that capital markets between US states are probably not perfectly integrated. For example Coval and Moskowitz (1999) find evidence of state level home bias in US equity markets.

## 5 Conclusion

Failures of risk sharing lie at the heart of many economic crises. Such crises are particularly acute in the context of a currency union in which constituent countries are hit by large, asymmetric shocks; the Eurozone crisis of 2009-12 stands as a particularly striking example.

This paper presents two main theoretical findings. The first is that in the case of demand shocks - for example, private or public deleveraging - an idealized banking union in which borrowing costs are equalized across constituent members of the currency union provides the same level of insurance as complete markets. The second finding illustrates the limitations of this ideal banking union: in the case of supply shocks, the banking union does not provide full insurance, but an idealized capital market union, in which savers frictionlessly choose optimal portfolios, does.

Using a calibrated version of our model, we find that large reductions in consumption volatility result from moving from segmented markets to a banking union and from banking union to a capital market union. We also find that a large part of the reduction comes from uninternalized general equilibrium effects.

# Appendix

## A Proof of Lemma 1

Define the k-period ahead discount rate for $k \geq 1$ from the savers' perspective

$$R_{t,k} \equiv (1 + r_t) \mathinner{..} (1 + r_{t+k-1}),$$

and the convention $R_{j,t,0} = 1$.

Let us start from market clearing for the home good (productivity is normalized to 1):

$$P_{h,t} N_t = (1 - \alpha) (\chi P_t C_{b,t} + (1 - \chi) P_t C_{s,t}) + F_t + P_{h,t} G_t.$$

Using the budget constraints of the agents and of the government we get

$$\alpha \tilde{Y}_t = (1 - \alpha) \chi \left( \frac{B^h_{t+1}}{1 + r_t} - B^h_t \right) - (1 - \alpha) (1 - \chi) \left( \frac{S_{t+1}}{1 + r_t} - S_t \right) + F_t + \frac{B^g_{t+1}}{1 + r_t} - B^g_t.$$

Summing and rearranging the terms, we get

$$\begin{aligned} \alpha \left( \tilde{Y}_t + \frac{\tilde{Y}_{t+1}}{R_{t,1}} \right) \quad = \quad & (1 - \alpha) \chi \left( \frac{1}{R_{t,1}} \frac{B^h_{t+2}}{1 + r_{t+1}} - B^h_t \right) \\ & - (1 - \alpha) (1 - \chi) \left( -S_t + \frac{1}{R_{t,1}} \frac{S_{t+2}}{1 + r_{t+1}} \right) + F_t + \frac{F_{t+1}}{R_{t,1}} \\ & + \frac{1}{R_{t,1}} \frac{B^g_{t+2}}{1 + r_{t+1}} - B^g_t. \end{aligned}$$

to write:

$$\begin{aligned} \alpha_j \left( \tilde{Y}_{j,t} + \frac{\tilde{Y}_{j,t+1}}{R_{j,t,1}} + \frac{\tilde{Y}_{j,t+2}}{R_{j,t,2}} \right) \quad = \quad & - (1 - \alpha_j) \chi_j \left( B^h_{j,t} - \frac{1}{R_{j,t,2}} \frac{B^h_{j,t+3}}{1 + r_{j,t+2}} \right) \\ & + (1 - \alpha_j) (1 - \chi_j) \left( S_{j,t} - \frac{S_{j,t+3}}{R_{j,t,3}} \right) + F_{j,t} + \frac{F_{j,t+1}}{R_{j,t,1}} + \frac{F_{j,t+2}}{R_{j,t,2}} \\ & - B^g_{j,t} + \frac{1}{R_{j,t,2}} \frac{B^g_{j,t+3}}{1 + r_{j,t+2}}. \end{aligned}$$

Therefore for a generic horizon $K$

$$\sum_{k=0}^{K}\frac{\alpha\tilde{Y}_{t+k}}{R_{t,k}} = (1-\alpha)\left((1-\chi)S_t-\chi B_t^h\right)-B_t^g+\sum_{k=0}^{K}\frac{F_{t+k}}{R_{t,k}}$$
$$-(1-\chi)(1-\alpha)\frac{S_{t+K+1}}{R_{t,K+1}}+\frac{1}{R_{t,K}}\left(\frac{(1-\alpha)\chi B_{t+K+1}^h}{1+r_{t+K}}+\frac{B_{t+K+1}^g}{1+r_{t+K}}\right).$$

We take the limit and we impose the No-Ponzi conditions

$$\lim_{K\to\infty}\frac{S_{t+K+1}}{R_{t,K+1}}(z^{t+K}) = 0$$
$$\lim_{K\to\infty}\frac{1}{R_{t,K}}\frac{B_{t+K+1}^h}{1+r_{t+K}}(z^{t+K}) = 0$$
$$\lim_{K\to\infty}\frac{1}{R_{t,K}}\frac{B_{t+K+1}^g}{1+r_{t+K}}(z^{t+K}) = 0.$$

The inter-temporal current account condition is

$$\alpha\sum_{k=0}^{\infty}\frac{\tilde{Y}_{t+k}}{R_{t,k}}(z^{t+k}) = \sum_{k=0}^{\infty}\frac{F_{t+k}}{R_{t,k}}(z^{t+k})-(1-\alpha)\left(\chi B_t^h-(1-\chi)S_t\right)-B_t^g.$$

# B Proof of Proposition 3

We need to first extend the argument in Proposition 1 to include static equity positions. Using manipulations similar to those in the proof of Lemma 1, we can write

$$W_{t,i}N_{t,i}(\mu-(1-\alpha)(1+\varphi(\mu-1))) = F_{t,i}+(1-\chi)(1-\alpha)\left(\frac{B_{t+1,i}}{R_t}-B_{t,i}\right)$$
$$-\chi(1-\alpha)\left(\frac{S_{t+1,i}}{R_t}-S_{t,i}\right)+(1-\alpha)(1-\chi)\Gamma_{t,i}.$$

Here $\Gamma_t$ is the savers' income from foreign stocks. We also assumed away from public deleveraging and spending shocks. From this we can solve

$$W_{t,i}N_{t,i} = a_1F_{t,i}+a_2\left(\frac{B_{t+1,i}}{R_t}-B_{t,i}\right)-a_3\left(\frac{S_{t+1,i}}{R_t}-S_{t,i}\right)+a_4\Gamma_{t,i},$$

where

$$a_1 = \frac{1}{\mu-(1-\alpha)(1+\varphi(\mu-1))}, a_2 = \frac{(1-\chi)(1-\alpha)}{\mu-(1-\alpha)(1+\varphi(\mu-1))},$$

$$a_3 = \frac{\chi(1-\alpha)}{\mu-(1-\alpha)(1+\varphi(\mu-1))}, a_4 = \frac{(1-\alpha)(1-\chi)}{\mu-(1-\alpha)(1+\varphi(\mu-1))} \quad .$$

The borrowers' budget constraint is

$$S_t + W_t N_t + \varphi(\mu-1)WN_t + \Gamma_t = P_t C_{s,t} + \frac{S_{t+1}}{R_t}.$$

Plugging in the previous result and rearranging we obtain:

$$\begin{aligned} P_t C_{s,t} &= (1+\varphi(\mu-1))a_1 F_{t,i} + (1+\varphi(\mu-1))a_2 \left(\frac{B_{t+1,i}}{R_t} - B_{t,i}\right) \\ &- (1+\varphi(\mu-1))a_3 + 1)\left(\frac{S_{t+1,i}}{R_t} - S_{t,i}\right) + (1+\varphi(\mu-1))a_4 + 1)\,\Gamma_{t,i}. \end{aligned}$$

Similarly to the proof of Lemma 1, it now follows that $\sum_{k=0}^{\infty} \frac{P_{t+k}C_{s,t+k}}{R_{t,k}}(z^t)$ is only a function of $S_t$, $B_t$, $\sum \frac{F_{t+k}}{R_{t,k}}$ and $\sum_{k=0}^{\infty} \frac{\Gamma_{t+k}}{R_{t,k}}$ that do not react to domestic deleveraging shocks:

$$\sum_{k=0}^{\infty} \frac{P_{t+k}C_{s,t+k}}{R_{t,k}}(z^{t+k}) = \widehat{\Omega}\left(S_t, B_t, B_t^g, \sum_{k=0}^{\infty} \frac{F_{t+k}}{R_{t,k}}(z^{t+k}), \sum_{k=0}^{\infty} \frac{\Gamma_{t+k}}{R_{t,k}}(z^{t+k})\right)$$

This generalizes the argument of Proposition 1 to static equity positions.

**The Main Argument** Given symmetric borrowing patterns the correct stock positions perfectly share shocks affecting labor income such as quality shocks by the argument in Proposition 2. These shocks need not be idiosyncratic. Idiosyncratic deleveraging shocks do not distort symmetry and the savers' consumption expenditure stays constant by the argument in Proposition 1. While the proof assumes that the home quality stays constant it also goes through with unanticipated home quality

| Parameter | Description | Value |
|---|---|---|
| $\chi$ | Fraction of impatient | 0.5 |
| $\beta_s$ | Discount factor of savers | 0.995 |
| $\alpha$ | Openness to trade | 0.25 |
| $\kappa$ | Slope wage Phillips curve | 0.1 |
| $\epsilon$ | Elasticity domestic intermediates | 4 |
| $\theta$ | Capital share | 0.36 |
| $\delta$ | Depreciation rate | 0.015 |
| $\phi_Y$ | Taylor rule - output gap | 0.5 |
| $\phi_\pi$ | Taylor rule - inflation | 1.5 |

Table 7: Calibration of baseline parameters

shocks. Moreover, it works for preference shocks that do not alter the complete markets condition such as shocks to the disutility of labor. While this proof assumes that home quality stays constant, the Proposition also holds for unanticipated home quality shocks. Under certain further restrictions on fiscal policy, the proof can be generalized to public deleveraging.

# C Symmetric calibration of baseline parameters

Table 7 shows the calibration of baseline parameters.

# D Productivity and government spending shocks only

Due to Cole-Obstfeld preferences, price adjustments give a natural hedge against productivity and government spending shocks. This can be formalized in the following lemma that generalizes the famous Cole and Obstfeld (1991)result to a borrower-saver agent economy with rigidities. Note also the limitations of the lemma: it considers a setting with only productivity shocks and government spending shocks. That it does not hold for example in an environment with both productivity and quality shocks in which case the CMU still attains the complete markets outcome.

**Lemma 3.** ***Cole-Obstfeld 91 Result with Borrowers*** *Consider the baseline model of the paper but subject to productivity shocks only. The optimal stock positions are indeterminate and the equilibrium always attains the complete markets allocation for both borrowers and savers (absent any cross-country borrowing). The result holds also when we add idiosyncratic government spending shocks financed through (potentially distortionary) taxes absent government borrowing. This effectively implies a nominal fiscal consumption multiplier of zero.*

*Proof.* Similarly to before we perform the proof in an $I$country version of the model. For any country $i$

$A_{t,i}N_{t,i}p_{t,i} = \mu W_{t,i}N_{t,i}$.

Conjecture that the model attains the complete markets outcome for both savers and borrowers. That is for any countries $i$ and $j$:

$C_{s,t,i}P_{t,i} = C_{s,t,j}P_{t,j}$

and

$C_{b,t,i}P_{t,i} = C_{b,t,j}P_{t,j}$.

Now we have,

$\frac{A_{t,i}N_{t,i}}{A_{t,j}N_{t,j}} = \frac{(1-\alpha)\chi C_{s,t,i}P_{t,i}/p_{t,i}+(1-\alpha)(1-\chi)C_{s,t,i}P_{t,i}/p_{t,i}+\frac{\alpha}{I-1}\sum_{k\neq i}(\chi C_{s,t,k}P_{t,k}/p_{t,i}+(1-\chi)C_{s,t,k}P_{t,k}/p_{t,i})}{(1-\alpha)\chi C_{s,t,j}P_{t,j}/p_{t,j}+(1-\alpha)(1-\chi)C_{s,t,j}P_{t,j}/p_{t,j}+\frac{\alpha}{I-1}\sum_{k\neq j}(\chi C_{s,t,k}P_{t,k}/p_{t,j}+(1-\chi)C_{s,t,k}P_{t,k}/p_{t,j})}$.

Then applying the complete markets conditions, we obtain

$\frac{A_{t,i}N_{t,i}}{A_{t,j}N_{t,j}} = \frac{\chi C_{s,t,i}P_{t,i}+(1-\chi)C_{b,t,i}P_{t,i}}{\chi C_{s,t,i}P_{t,i}+(1-\chi)C_{b,t,i}P_{t,i}}\frac{p_{t,j}}{p_{t,i}} = \frac{p_{t,j}}{p_{t,i}}$.

Prices and output levels move inverse one-to-one. But this implies

$W_{t,i}N_{t,i} - W_{t,j}N_{t,j} = 0$.

Now one can see that the budget constraints support the complete markets conditions for both savers and borrowers for any symmetric stock positions. Note that $\alpha$ can be arbitrary so the result also holds with respect to symmetric quality shocks. However, it does not hold with respect to arbitrary quality shocks such as shocks that only affect some countries.

What is the intuition behind the result? Assume that markets are complete. Now due to Cole-Obstfeld preferences relative output levels and prices must move one-to-one. This means that the value of output in each country must be the same. Higher production implies lower prices. But the assumption for production technology implies that labor income is a constant fraction of the total value of output in each country. This means that total labor income in each country must be the same. Finally, this implies that the budget constraints support the complete markets allocation. The result holds also in the SOE limit $I \to \infty$.

To see that the result holds when adding idiosyncratic government spending shocks financed through current taxes (in the SOE limit) note that in the proof of lemma 1, we have the line

$$\alpha\tilde{Y}_t = (1-\alpha)\chi\left(\frac{B^h_{t+1}}{1+r_t} - B^h_t\right) - (1-\alpha)(1-\chi)\left(\frac{S_{t+1}}{1+r_t} - S_t\right) + F_t + \frac{B^g_{t+1}}{1+r_t} - B^g_t.$$

Now absent any borrowing this becomes

$$\alpha \tilde{Y}_t = F_t.$$

In SOE government spending shock does not affect $F_t$ and therefore $\tilde{Y}_t$does not react. Foreign demand solely determines income. By Condition 1 neither the borrowers' nor the savers' income reacts. By the budget constraints the nominal consumption levels do not react either. Because private consumptions do not react in any country, the total value of production in the home country must rise by the value of nominal government spending. Therefore the fiscal multiplier is one. A similar simplified argument could be used for productivity shocks, but the former proof highlights that this first result holds also in the finite country case.

**Government spending: an example** Note that if there are no borrowers, Proposition 1 implies that the nominal fiscal consumption multiplier is zero in a banking union. This holds irrespective of the financing method of the spending increase. To understand that this holds even with distortionary taxes, consider the following simple example. Now abstract away from borrowers. Assume a disutility of labor function $v(N) = \frac{N^{1+\sigma}}{1+\sigma}$ and that spending increases are financed using a contemporaneous labor tax. Now figure 3 shows the impulse responses subject to a government spending increase. Nominal spending and saving by households stays constant. Nominal GDP stays constant but higher government demand of the home good pushes down its price.

# E Asymmetries

We now generalize the results concerning equity to asymmetric initial stock positions, mark-ups and shares of savers. The complete markets condition is $P_t C_{s,t} = \lambda P_t^* C_{s,t}^*$, where $\lambda$ is the relative Pareto weight and starred values refer to the foreign country. We first show the result in a two country version of the model and then tackle the $I$ country case. The budget constraints are

$$\bar{B} + N_t W_t - T + \varphi(\mu - 1) N_t W_t + \left(\frac{1}{1-\chi} - \frac{1-\chi^*}{1-\chi}\varphi^*\right)(\mu^* - 1) N_t^* W_t^* = P_t C_{s,t} + \frac{\bar{B}}{R_t}$$

$$\bar{B} + N_t^* W_t^* - T + \left(\frac{1}{1-\chi^*} - \frac{1-\chi}{1-\chi^*}\varphi\right)(\mu - 1) N_t W_t + \varphi^*(\mu^* - 1) N_t^* W_t^* = P_t^* C_{s,t}^* + \frac{\bar{B}}{R_t}.$$

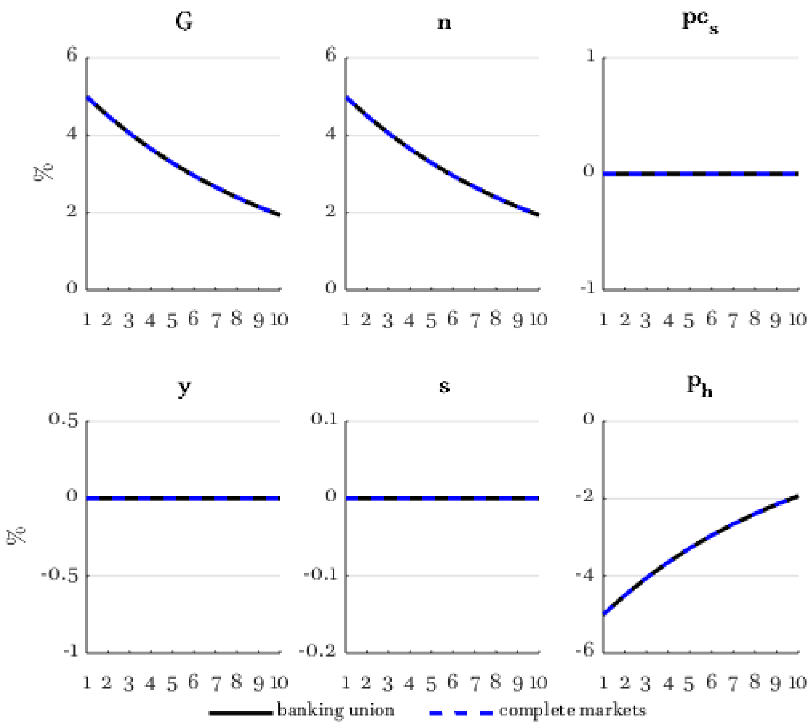


Figure 3: Government Spending Shock, No Borrowers

Note: Impulse responses to a 5% shock to $G_t$. $y_t$is nominal GDP.

Deducting the budget constraints and imposing the complete markets condition yield

$$N_t W_t \left(1 + (\mu - 1)(\varphi - \tfrac{1}{1-\chi^*} + \tfrac{1-\chi}{1-\chi^*}\varphi)\right) - N_t^* W_t^* \left(1 + (\mu^* - 1)(\varphi^* - \tfrac{1}{1-\chi} + \tfrac{1-\chi^*}{1-\chi}\varphi^*)\right) = (\lambda - 1) P_t^* C_{s,t}^*.$$

or

$$N_t W_t \left(1 + (\mu - 1)(\varphi - \tfrac{1}{1-\chi^*} + \tfrac{1-\chi}{1-\chi^*}\varphi) - \tfrac{\lambda-1}{1+\lambda}\mu\right) - N_t^* W_t^* \left(1 + (\mu^* - 1)(\varphi^* - \tfrac{1}{1-\chi} + \tfrac{1-\chi^*}{1-\chi}\varphi^*) + \tfrac{\lambda-1}{1+\lambda}\mu^*\right) = 0.$$

From this we solve

$$\varphi = \frac{1}{2-\chi-\chi^*} + \frac{\lambda-1}{1+\lambda}\frac{\mu}{\mu-1}\frac{1-\chi^*}{2-\chi-\chi^*} - \frac{1}{\mu-1}\frac{1-\chi^*}{2-\chi-\chi^*}$$

and

$$\varphi = \frac{1}{2-\chi-\chi^*} + \frac{\lambda-1}{1+\lambda}\frac{\mu}{\mu-1}\frac{1-\chi^*}{2-\chi-\chi^*} - \frac{1}{\mu-1}\frac{1-\chi^*}{2-\chi-\chi^*}.$$

The relative Pareto weight $\lambda$ depends on initial conditions and can be solved numerically. $\varphi$ is increasing in $\lambda$ and $\varphi^*$ decreasing. The result can be generalized to different tax rates. The above derivations generalize Proposition 2. Proposition 3 can be generalized similarly.

With $I$ countries the budget constraints are:

$$\bar{B} + N_{t,i} W_{t,i} + \sum \varphi_{i,k}(\mu_k - 1) N_{t,k} W_{t,k} = P_{t,i} C_{s,t} + \frac{\bar{B}}{R_t}, i = 1, .., I.$$

The complete market condition is$P_{t,i} C_{s,t,i} = \lambda_{i,j} P_{t,j} C_{s,t,j}$. Deducting the budget constraints and using this condition we obtain:

$$\begin{aligned} &N_{t,i} W_{t,i}(1 + \varphi_{i,i}(\mu_i - 1)) - N_{t,j} W_{t,j}(1 + \varphi_{i,j}(\mu_j - 1)) \\ &+ \textstyle\sum_{k \neq i,j} (\varphi_{i,k} \text{-} \varphi_{j,k})(\mu_k - 1) N_{t,k} W_{t,k} = (\lambda_{ij} - 1) P_{t,i} C_{s,t,i}, j \neq i. \end{aligned}$$

Using the fact that value of total consumption equals value of total output as well as the complete market conditions:

$$N_{t,i}W_{t,i}(1+(\varphi_{i,i}-\varphi_{j,i})(\mu_i-1))-N_{t,j}W_{t,j}(1+(\varphi_{i,j}\text{-}\varphi_{j,j})(\mu_j-1))$$
$$+\sum_{k\neq i,j}(\varphi_{i,k}\text{-}\varphi_{j,k})(\mu_k-1)N_{t,k}W_{t,k}=(\lambda_{ij}-1)\frac{\sum_k \mu_k W_{t,k}N_{t,k}}{1+\sum_{k\neq j}\lambda_{jk}}, j\neq i.$$

We need to set the multiplier on each $N_{t,k}W_{t,k}$to zero, which gives a well-defined problem. For each $j$ we get $I$ restrictions in total. There are $I-1$ such equations. Together with the stock market clearing conditions we have $I \times I$ equations and unknows and can now solve for the static equity positions replicating the complete market outcome. The result holds also in the small open economy limit $I \to \infty$.

# F Proposition 1 in a Two Country Model

Consider now the case of deleveraging shocks hitting a large economy. Proposition 1 is exactly correct in a small open economy; with two economies, foreign demand depends (partly) on domestic demand and, therefore, on domestic deleveraging. In addition, the central bank reacts by changing the risk free rate.

In spite of these differences we find that the result of Proposition 1 remains essentially correct. The intuition is as follows. First, we know that savers do not react in a SOE. With two countries, foreign demand is endogenous, but this effect is small because it depends on two consecutive cross-border spillovers: the pass-through of domestic demand onto foreign income and then from foreign income back to foreign demand for home goods. The spillover is quantitatively small. Proposition 1 is also approximately correct for reasonable values of the elasticity of substitution other than one.

The second important difference is the Taylor rule. Of course, the reaction of the monetary authority has a direct impact on the dynamics of the currency union. But the key point is that this impact is the same under BU and under complete markets. Why? Because savers face the same interest rate in both countries.

Figure 4 depicts the impulse responses to a domestic deleveraging shock (credit shock) in each of the two regions of the currency union. The responses of all variables except $S_t$ are virtually the same under BU and under complete markets. Domestic savings $S_t$ need to adjust more in the BU than in the complete markets economy because of the lack of explicit state contingent contracts.

The aggregate (currency union-wide) response to a deleveraging shock obviously depends on how monetary policy reacts. Our results show that, irrespective of the central bank's reaction, the BU and complete markets economies behave in virtually identical ways after the deleveraging shock. One

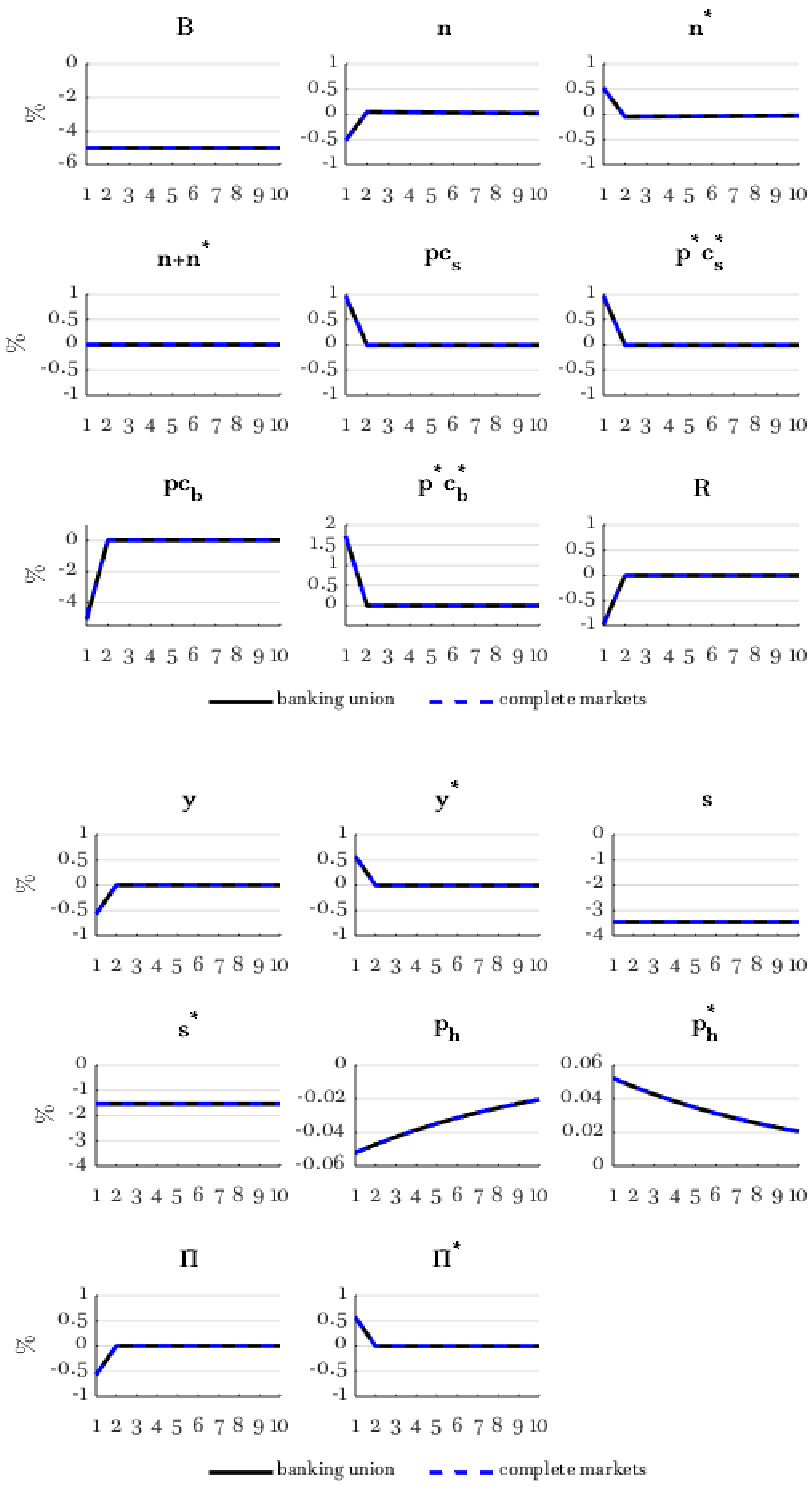


Figure 4: Private Deleveraging in 2-Country Model
Note: Impulse responses to permanent -5% shock to $\bar{B}_t$.

might wonder, however, if this result could be over-turned if the central bank was constrained by the zero lower bound. We find that this is not the case: our result also holds when the ZLB binds. Figure 5 depicts impulse responses to a deleveraging shock large enough to make the ZLB bind. Naturally, when the ZLB binds the central bank is unable to lower the interest rate enough to stabilize aggregate employment in the currency union.

We conclude that an ideal banking union – a union that guarantees that funding costs are equalized across regions – is enough to deal with all domestic demand shocks, both private and public.d

# G Proposition 1: Beyond Cole-Obstfeld

Similarly to for example Gali and Monacelli (2008), Heathcote and Perri (2013) and Martin and Philippon (2017) our framework assumes Cole-Obstfeld preferences. That is we assume log-preferences and a unit elasticity of substitution between home and foreign goods.

However, our key results such as Proposition 1 hold approximately with more general preferences. Figure 6 shows the response in savers' nominal consumption for three different values of elasticity of substitution $\xi = 0.9, 1, 1.1$. One can see that the results are virtually identical for these different values. The results are also similar beyond log-utility. That is the equilibrium approximately attains the complete market outcome for reasonable values of the risk aversion parameter. However, when risk aversion is different from one, complete markets do not predict that nominal consumption stays constant. However, when risk aversion is approximately one, savers' nominal consumption stays approximately constant.

# H Benefits of CMU: Calibration

As explained in the text, our baseline model for the CMU assumes quality, productivity and deleveraging shocks. Most of the parameters take standard values (see Appendix C). However, we calibrate the quality and deleveraging shock volatilities and persistences to match consumption and export data from France obtained from Eurostat. We also match the correlation between relative dividends and labor income (Home - Foreign values, $Corr(W_tN_t - W_t^*N_t^*, d_t - d_t^*)$). We take the persistence of the productivity shocks from Heathcote and Perri (2013) but estimate their volatility. Following e.g. Auray and Eyquem (2014) and Heathcote and Perri (2013) we assume home and foreign shocks are uncorrelated, largely because uncorrelated shocks can be used to match the data. These parameter

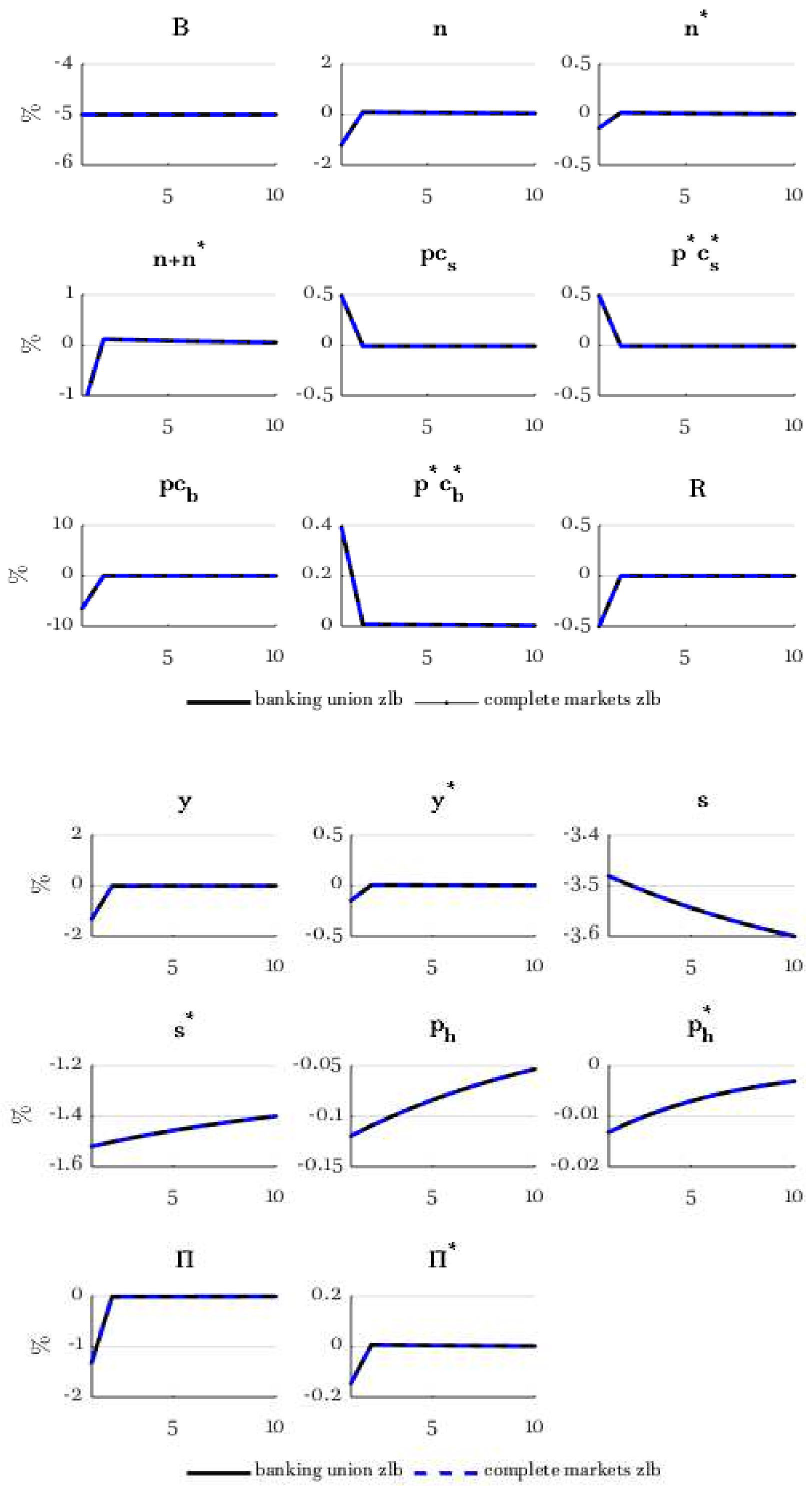


Figure 5: Private Deleveraging in 2-Country Model with ZLB

Note: Impulse responses to permanent -5% shock to $\bar{B}_t$.

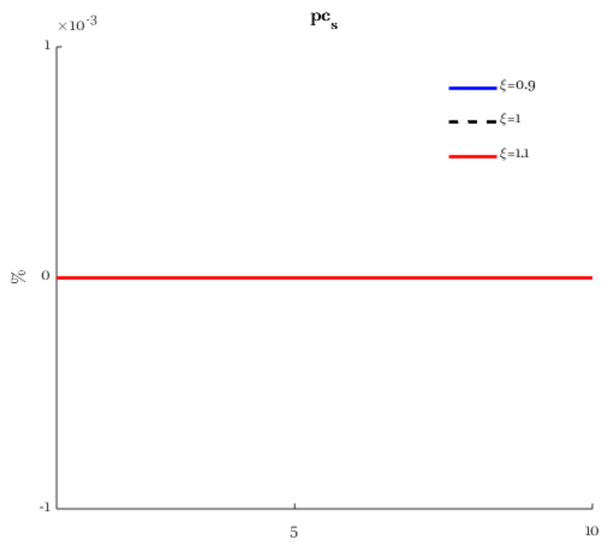


Figure 6: Effects of a deleveraging shock for different values of elasticity of substitution
Note: Impulse response to permanent -5% shock to $\bar{B}_t$.

| Parameter | Value |
|---|---|
| Quality shock ($\alpha_t$) volatility | 3.64% |
| Quality shock ($\alpha_t$) persistence | 0.995 |
| TFP shock ($A_t$) persistence (Heathcote and Perri (2013)) | 0.91 |
| TFP shock ($A_t$) volatility | 0.75% |
| Deleveraging shock ($\bar{B}_{t+1}$) volatility | 0.7% |
| Deleveraging shock ($\bar{B}_{t+1}$) persistence | 0.90 |
| Investment adjustment cost ($\zeta$) | 1.95 |

Table 8: Rest of the parameters

values are given in Table 8. Moreover, Table 9 compares the key model simulated moments to those seen in the data.

As explained in the text, we calibrate the model with a home stock position of 0.8 and then later solve for the frictionless equilibrium home stock position. The implied correlation between relative dividends and labor income is roughly 0.8, which is close to that for France as well as close to the average number for EU countries calculated by Coeurdacier et al. (2010). If we match a smaller correlation value, the welfare benefit of a CMU is somewhat lower but still significant. The model is solved using perturbation methods.[10]

[10] To give a well-defined portfolio choice problem, it is important to approximate the Euler equations at least up to 2nd order. However, otherwise higher order approximations lead to fairly small changes relative to a first order approximation. Note that all of our theoretical results are exact.

| Statistic | Model | Data |
|---|---|---|
| Volatility of consumption growth | 2.0% | 2.1% |
| Volatility of export growth | 5.2% | 5.0% |
| Dividend-labor income correlation | 0.80 | 0.77 (Coeurdacier et al. (2010)) |

Table 9: Key simulated and empirical moments

# I On Empirical Tests of Model Predictions

We have argued that our numerical estimate for the benefit of CMU is consistent with reduced-form evidence from the United States. However, this paper has also provided exact theoretical results about the types of shocks that can be shared efficiently either in BU or CMU. How could these results be tested empirically?

First note that these predictions are mostly counterfactual exercises. For example, according to Proposition 1 an idealized BU, in which funding costs are fully equalized, could efficiently share deleveraging shocks. However, actual deleveraging episodes such as those observed during the eurozone crisis tend to be associated with segmentation in funding costs. Perhaps the best way to test this proposition would be to consider a region such as US that is closer to a banking union type arrangement with smaller regional differences in state level funding costs. If the eurozone is also able to implement a well-functioning banking union, future deleveraging periods could also be used for such tests. However, note that this would still require carefully identifying a deleveraging shock.

Similarly, Proposition 2 could be tested using a region with a high level of capital market integration such as the US. Again, this would require identifying supply shocks. However as argued before, our calibration for CMU roughly matches the empirical amount of risk sharing through capital markets between US states.

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