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.

Keywords: risk sharing, banking union, capital market union, incomplete markets.

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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)	$R_{j,t} \neq \bar{R}_t$	$<$ BU	$<$ BU
Banking Union (BU)	$R_{j,t} = \bar{R}_t$	$=$ COMP	$<$ CMU
Capital Market Union (CMU)	Foreign equity share φ	$=$ 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. These two effects exactly offset each other so that neither the net present value of savers income nor their consumption expenditure changes as long as funding costs remain equalized.

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. 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 spillovers across countries, by modeling aggregate demand spillovers and monetary policy, and to analyze the desirability of capital market integration within a currency union. 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 (2013) 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 (2011) 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. Coeurdacier et al. (2010) emphasize trade in stocks and bonds: domestic equity hedges labor income risk while terms of trade shocks are hedged using domestic and foreign bonds. Sihvonen (2018) studies the aggregate effects of equity home bias in a model that features nominal rigidities and fixed exchange rates. Fornaro (2014) and Benigno and Romei (2014) study the effect of deleveraging shocks in open economies with nominal rigidities. Fornaro (2014) 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. However, 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 (2011)), 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. We will consider two main specifications: one with two regions, home and foreign, as in standard models of international trade; and another with a continuum of countries, each one of which is small relative to the union, as in Gali and Monacelli (2008). Some results are easier to establish in one setup than in the other.

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 χ 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 that affect savers' budget constraints.[2]

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

Households of each type and in each region derive utility from consumption and labor:

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

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

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

[2]For ease of exposition the equations presented below are valid when the two regions' populations are of equal measure; we consider different country sizes in the appendix.

and $\alpha < \frac{1}{2}$ is a measure of the openness to trade of the economy; equivalently, $1-\alpha$ measures home bias in consumption.[3] With these preferences, the home consumption-based price index (CPI) is

$$P_t = \left(P_{h,t}\right)^{1-\alpha} \left(P_{f,t}\right)^{\alpha},$$

where $P_{h,t}$ and $P_{f,t}$ are the time t producer price indices (PPI) in the home and foreign countries, respectively. Assuming the law of one price, the foreign price index is $P_t^* = \left(P_{f,t}^*\right)^{1-\alpha} \left(P_{h,t}^*\right)^{\alpha}$. The home and foreign goods, in turn, are compositions of intermediate goods produced in each of the countries; intermediate goods are aggregated into the final consumption goods using the following constant elasticity of substitution technologies:

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

The PPIs in each region are therefore:

$$P_{h,t} = \left[\int_0^1 p_t\left(j\right)^{1-\epsilon} \,\mathrm{d}j\right]^{\frac{1}{1-\epsilon}},$$

where $p_t(j)$ are prices of intermediate goods. The production of intermediate goods is linear in labor AN_t, where A is total factor productivity.

1.2 Wage setting

We assume that wages are sticky and 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.[4] Wage dynamics are determined by a Phillips curve with slope

[3] With discount rate shocks the borrowers problem is

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

[4] 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 essentially boils down 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 $\nu'\left(n_i^\star\right) = \left(1-\tau_j\right)\frac{w_j}{x_{i,j}}$. 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.

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

where N_{ss} is steady-state employment. The assumption that wages are sticky is not important for the theoretical results, but it matters for the numerical welfare benefits of BU and CMU. 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

$$\Pi_t = \left(AP_{h,t} - W_t\right) N_t = \left(\mu - 1\right) W_t N_t.$$

1.3 Borrowers' budget constraint

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

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

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 monetary policy rule is not important for the theoretical results. However, in the calibrations we assume that it takes the form of a Taylor rule. That is, the nominal interest rate in the currency union

$\bar{R}$ is set by the central bank 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 π_{ss} are the steady state interest rate, output and inflation, respectively. 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 $T_t = \chi T_t^b + (1-\chi)\, T_t^s$.

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 Π_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 trade a non-contingent bond, a home stock and a foreign stock. The savers' budget constraints in the home region is

$$S_t + W_t N_t - T_t^s + \varphi_t\left(V_t + \frac{\Pi_t}{1-\chi}\right) + (1-\varphi_t^*)\left(V_t^* + \frac{\Pi_t^*}{1-\chi}\right) = \varphi_{t+1}V_t + \left(1-\varphi_{t+1}^*\right)V_t^* + P_t C_{s,t} + \frac{S_{t+1}}{R_t}.$$

Similarly, abroad we have

$$S_t^* + W_t^* N_t^* - T_t^{s,*} + \varphi_t^*\left(V_t^* + \frac{\Pi_t^*}{1-\chi}\right) + (1-\varphi_t)\left(V_t + \frac{\Pi_t}{1-\chi}\right) = \varphi_{t+1}^* V_t^* + (1-\varphi_{t+1})\, V_t + P_t^* C_{s,t}^* + \frac{S_{t+1}^*}{R_t},$$

where φ_t are the home savers' aggregate holdings of the home stock and φ_t^* are the foreign savers' holdings of the foreign stock. Moreover, V_t and V_t^* are the prices of the home and foreign stock, respectively, that represent claims to the aggregate profit streams in the countries.

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 s_{t+1} following history s^t by $D_{t+1}(s_{t+1}, s^t)$; this security has a time t price $Q_t(s_{t+1}, s^t)$:

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

1.6 Equilibrium conditions

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

$$\begin{aligned} P_{h,t} C_{h,i,t} &= (1-\alpha) P_t C_{i,t} \\ P_{f,t} C_{f,i,t} &= \alpha P_t C_{i,t}. \end{aligned} \tag{2}$$

Savers are unconstrained and their consumption is determined by their Euler equation and budget constraint (which differs across economies, as presented in section 1.5):

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

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

$$A N_t = \chi C_{h,b,t} + (1-\chi) C_{h,s,t} + \chi^* C^*_{h,b,t} + (1-\chi^*) C^*_{h,s,t} + G_t,$$

where G_t is spent on home goods only. Substituting in for demand functions and expressing in nominal terms, nominal output is

$$P_{h,t} A N_t = (1-\alpha)\left(\chi P_t C_{b,t} + (1-\chi) P_t C_{s,t}\right) + \alpha^* \left(\chi^* P_t^* C^*_{b,t} + (1-\chi^*) P_t^* C^*_{s,t}\right) + P_{h,t} G_t. \tag{4}$$

Finally, market clearing for bonds requires

$$(1-\chi) S_{t+1} + (1-\chi^*) S^*_{t+1} = \chi B_{t+1} + \chi^* B^*_{t+1} + B_t^g + B_t^{g*}, \tag{5}$$

and (if available) for Arrow-Debreu securities $D_t(s_{t+1}, s^t) = D_t^*(s_{t+1}, s^t)$ for all s_{t+1}.

2 Banking Union

2.1 Small Open Economies in a BU

In this section we study demand shocks under BU: specifically, shocks that come from private borrowing or fiscal policy. We first derive analytical results for the impact of these shocks on a small open economy. We then study the case of two regions. Finally, we also study the effect of a deleveraging shock large enough to make the zero lower bound on the nominal interest rate binding.[5]

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 (in the case of two regions this is simply $F_t = \alpha^* P_t^* C_t^*$).

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 country j is*

$$\alpha\left((1-\chi) S_t - \chi B_t + \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}}\right) = (1-\chi) S_t - \chi B_t - B_t^g + \mathbb{E}_t \sum_{k=0}^{\infty} \frac{F_{t+k}}{R_{t,k}}. \tag{6}$$

Proof. See Appendix. □

On the left we have the net present value of all future imports, which is a share α 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

[5] To solve the model when the ZLB occasionally binds we use Guerrieri and Iacovello OccBin toolbox; see Guerrieri and Iacovello (2014) for details.

savers' problem as

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

The inter-temporal budget constraint of savers is

$$\mathbb{E}_t \sum_{k=0}^{\infty} \frac{P_{t+k} C_{s,t+k}}{R_{t,k}} = S_t + \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}^s}{R_{t,k}}, \tag{7}$$

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. The present value of savers' income is a simple function (linear, affine, etc.) of that of average disposable income

$$\mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}^s}{R_{t,k}} \sim \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}}.$$

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 τ_t, i.e., $T_t^b = \tau_t W_t N_t$ and $T_t^s = \tau_t \left(W_t N_t + \frac{\Pi_t}{1-\chi}\right)$. In that case, $\tilde{Y}_t^b = (1-\tau_t) W_t N_t$ 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 $\tilde{Y}_t^s = \frac{1}{\mu}\left(1 + \frac{\mu-1}{1-\chi}\right)\tilde{Y}_t$. 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:

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

where the first three variables (saving, household debt, public debt) are predetermined at time t and the last one (exports in euros) is exogenous under log preferences. Therefore, equation (7) is, in fact,

$$\mathbb{E}_t \sum_{k=0}^{\infty} \frac{P_{t+k} C_{s,t+k}}{R_{t,k}} \sim S_t + \Omega_t.$$

So the current spending of savers only depends on Ω_t and the path of interest rates. In particular, for given Ω_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 log-preferences as in 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. 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. *For a small open economy subject to private and public demand shocks ($\bar{B}_{t+1}$, $\beta_{b,t}$, G_t, T_t), the Banking Union achieves the Complete Markets allocation.*

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

$$\frac{C^*_{s,t}}{C_{s,t}} \sim \frac{P_t}{P^*_t},$$

for arbitrary foreign country. 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. Moreover, these shocks can occur simultaneously. □

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 (2011) 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 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.

2.2 Two Countries and ZLB

Our next task is to study the case of 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 1 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 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 2 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.

3 Capital Market Union

In this section we focus on the benefits of a capital market union above and beyond an ideal banking union. We pay special attention to technology shocks in the form of "quality" shocks to the goods sold by domestic firms. Formally, we model these shocks as a change to α^*, or the preference of foreigners for domestic goods. In response to these shocks, domestic firms become more profitable, while foreign firms become less profitable. 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

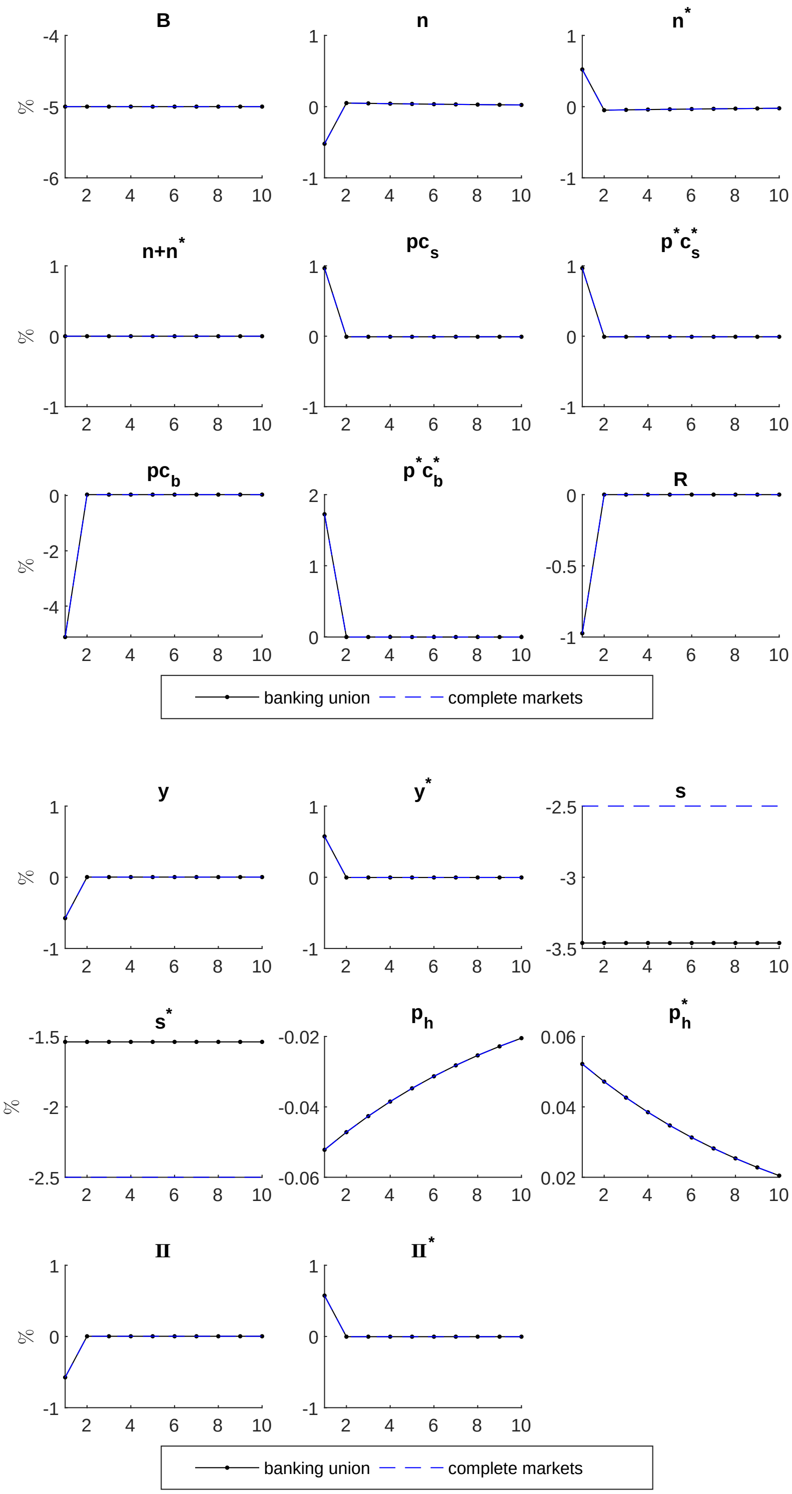

Figure 1: Private Deleveraging in 2-Country Model

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

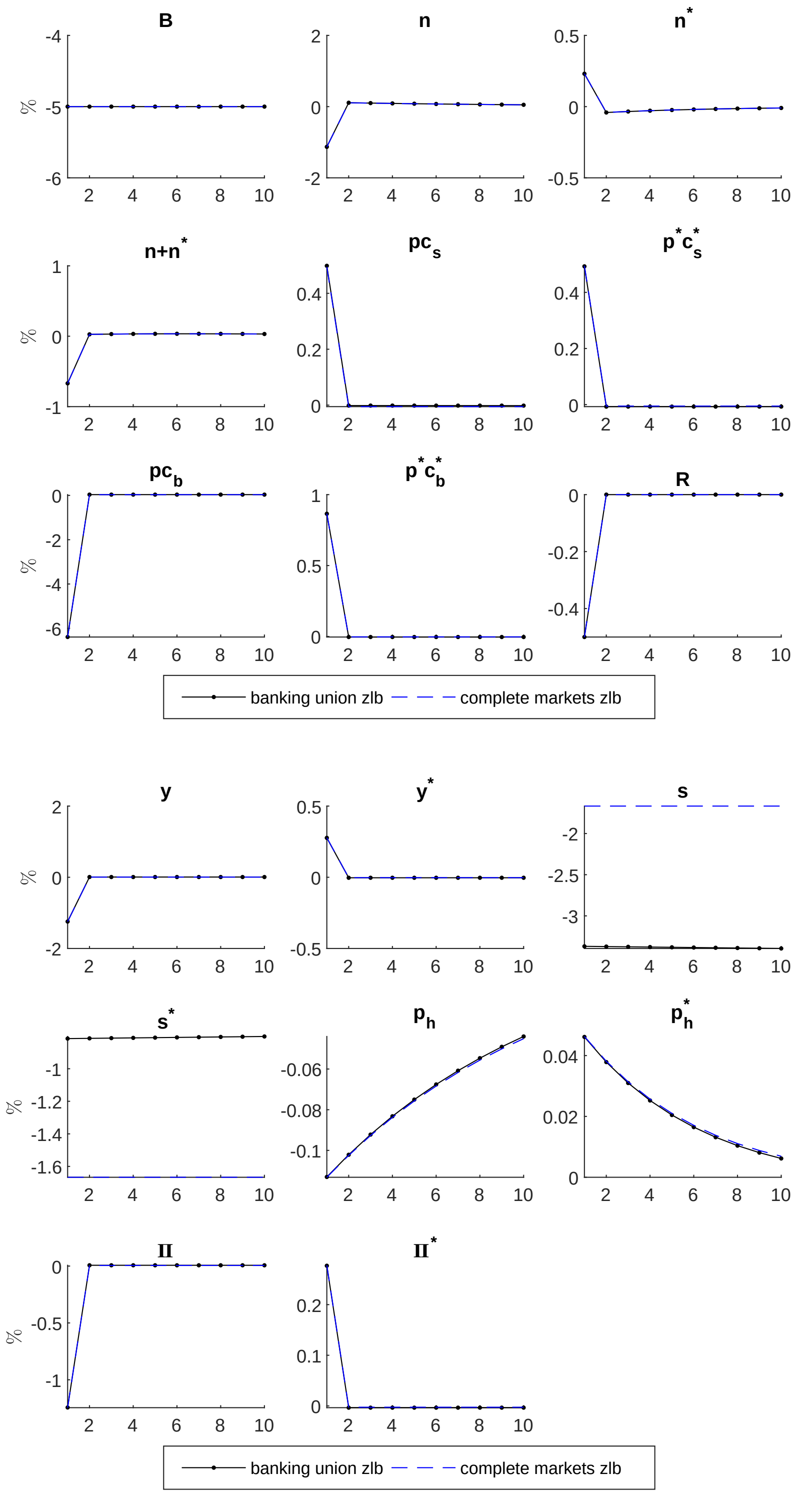

Figure 2: Private Deleveraging in 2-Country Model with ZLB

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

shocks that can be shared efficiently in a CMU.

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 (home or foreign) quality* (α_t, α_t^*)*, TFP* (A_t, A_t^*)*, monetary policy* $(\phi_{\pi,t}, \phi_{\pi,t}^*, \phi_{Y,t}, \phi_{Y,t}^*)$*, and various preference shocks.*

Proof. Given symmetric countries and log preferences the complete markets condition is $P_t C_{s,t} = P_t^* C_{s,t}^*$. Imposing symmetric and constant stock positions as well as constant taxes and borrowing limits, the savers' budget constraints are

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

and

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

Quality shocks affect firm profits and labor income. Subtracting the borrowing constraints, imposing the complete markets condition, and using the production function yields

$$(W_t N_t - W_t^* N_t^*)\left(1 + \frac{(2\varphi - 1)(\mu - 1)}{1-\chi}\right) = 0$$

We can then simply solve

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

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 bonds hold. Therefore, the above stock positions and no-cross country borrowing constitute an equilibrium that replicates the complete markets outcome. □

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 could affect the Phillips curve for 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. As with Proposition 1, the exact theoretical result hinges on Cole-Obstfeld preferences as well as the assumed form of the production function.[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 3 shows the outcome to a 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 in the two countries is equalized. 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 stocks, savers' spending in the home country increases relative to that in the foreign country. This increase, however, is smaller than in a banking union without cross-border equity claims.

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. *When each country is small, 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 (idiosyncratic) deleveraging as well as arbitrary foreign quality, productivity, monetary policy, and various preference shocks.*

[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.

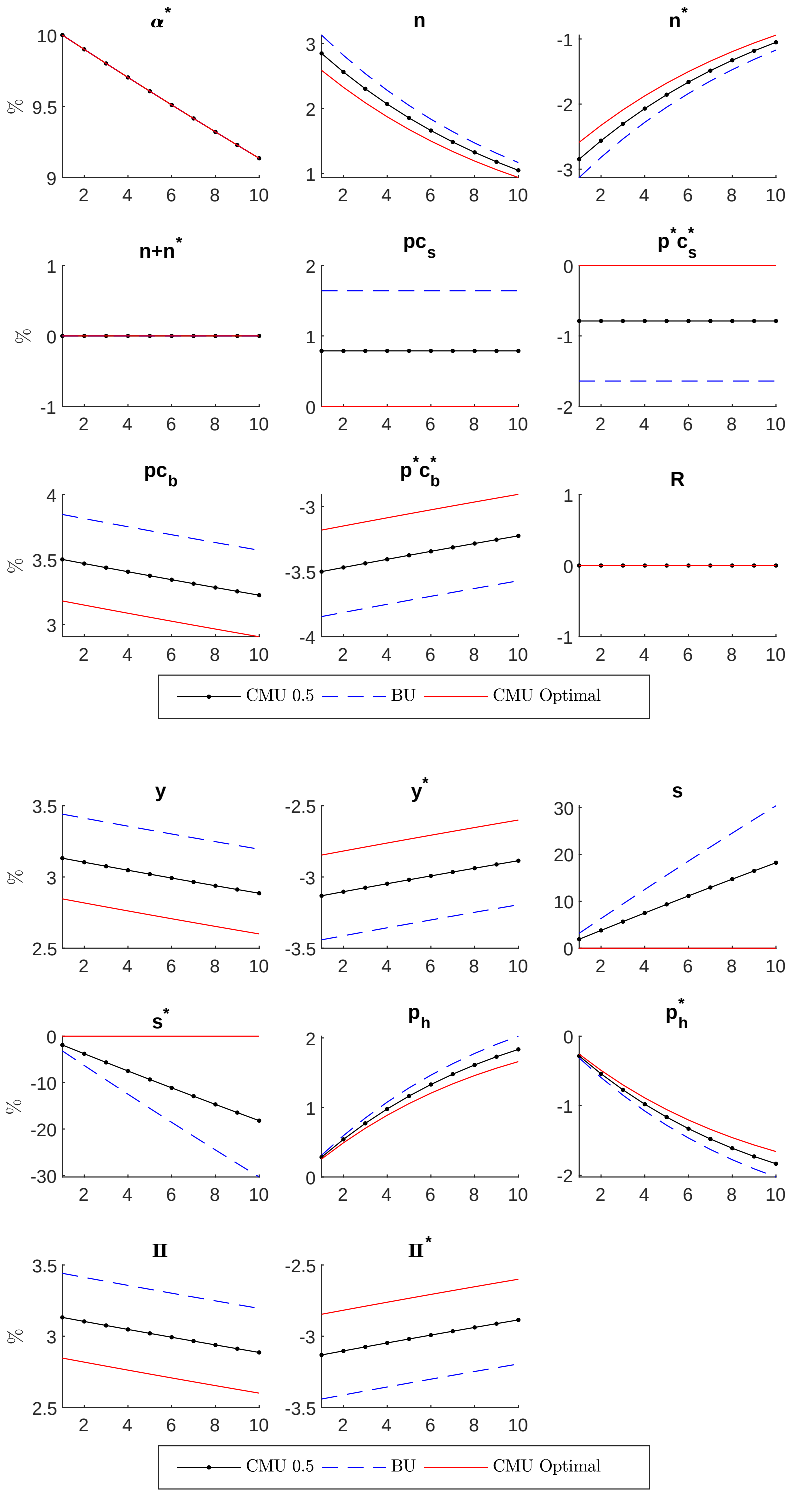

Figure 3: Quality Shocks in BU and CMU

Notes: Impulse responses to 10% shock to α^*. CMU 0.5 has exogenous equal weights on home and foreign stocks. Complete markets is equivalent to a CMU with optimal weights, as explained in Proposition 2. BU is CMU with zero weight on foreign stocks.

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.

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 $MC_t = \frac{W_t}{(1-\theta)Y_t/N_t}$.

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 island 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) 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]

[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 CRRA 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 using a bond 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 estimate the model with consumption and export data from France provided by Eurostat. We also match the relative correlation between dividends and labor income. The estimation details are given in the appendix.

We estimate the shock processes using a stock position of $\varphi = 0.8$. 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 using the bond. 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 (2011), Heathcote and Perri (2013)). 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.

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

Finally, note that if the quality shocks are transitory rather than persistent, they can also be partially shared using the bond. However, the estimation implies a fairly high persistence requiring diversification in equity positions.

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.

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 Equilibrium Conditions of the Model

A.1 Home

$$P_t C_{b,t} = \frac{\bar{B}_{t+1}}{R_t} + W_t N_t - T_t - \bar{B}_t$$

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

$$P_{h,t} A_t N_t = (1-\alpha_t)\left(\chi P_t C_{b,t} + (1-\chi) P_t C_{s,t}\right) + \frac{N_{ss}^*}{N_{ss}} \alpha_t^* \left(\chi^* P_t^* C_{b,t}^* + (1-\chi^*) P_t^* C_{s,t}^*\right) + T_t$$

$$\Pi_t = \left(A_t P_{h,t} - W_t\right) N_t$$

$$P_{h,t} = \mu \frac{W_t}{A_t}$$

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

$$S_t + Y_t - T_t + \frac{(1-\phi^*)\,\Pi_t + \phi \Pi_t^* \frac{N_{ss}^*}{N_{ss}}}{1-\chi} = P_t C_{s,t} + \frac{S_{t+1}}{R_t}$$

A.2 Foreign

$$P_t^* C_{b,t}^* = \frac{\bar{B}_{t+1}^*}{R_t} + W_t^* N_t^* - T_t^* - \tilde{B}_t^*$$

$$\frac{1}{P_t^* C_{s,t}^*} = \beta R_t \mathbb{E}_t \left[\frac{1}{P_{t+1}^* C_{s,t+1}^*} \right]$$

$$P_{h,t}^* A_t^* N_t^* = (1-\alpha_t^*)\left(\chi^* P_t^* C_{b,t}^* + (1-\chi^*) P_t^* C_{s,t}^*\right) + \frac{N_{ss}}{N_{ss}^*} \alpha_t \left(\chi P_t C_{b,t} + (1-\chi) P_t C_{s,t}\right) + T_t^*$$

$$\Pi_t^* = \left(A_t^* P_{h,t}^* - W_t^*\right) N_t^*$$

$$P_{h,t}^* = \mu^* \frac{W_t^*}{A_t^*}$$

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

$$S_t^* + W_t^* N_t^* - T_t^* + \frac{(1-\phi)\,\Pi_t^* + \phi^* \Pi_t \frac{N_{ss}}{N_{ss}^*}}{1-\chi^*} = P_t C_{s,t} + \frac{S_{t+1}^*}{R_t}$$

A.3 Union-wide

$$R_t = R_{ss} \left(\left(\frac{Y_t}{Y_{ss}}\right)^{\frac{N_{ss}}{N_{ss}^* + N_{ss}}} \left(\frac{Y_t^*}{Y_{ss}^*}\right)^{\frac{N_{ss}^*}{N_{ss}^* + N_{ss}}} \right)^{\phi_Y} \left(\left(\frac{\pi_t}{\pi_{ss}}\right)^{\frac{N_{ss}}{N_{ss}^* + N_{ss}}} \left(\frac{\pi_t^*}{\pi_{ss}^*}\right)^{\frac{N_{ss}^*}{N_{ss}^* + N_{ss}}} \right)^{\phi_\pi}$$

and

$$N_{ss}\,(1-\chi)\, S_{t+1} + N_{ss}^*\,(1-\chi^*)\, S_{t+1}^* = N_{ss} \chi B_{t+1} + N_{ss}^* \chi^* B_{t+1}^*$$

B Proof of Lemma 1

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

$$R_{j,t,k} \equiv (1 + r_{j,t}) \ldots (1 + r_{s,j,t+k-1}),$$

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

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

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

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

$$\alpha_j \tilde{Y}_{j,t} = (1-\alpha_j)\,\chi_j \left(\frac{B_{j,t+1}^h}{1+r_{j,t}} - B_{j,t}^h\right) - (1-\alpha_j)(1-\chi_j)\left(\frac{S_{j,t+1}}{1+r_{j,t}} - S_{j,t}\right) + F_{j,t} + \frac{B_{j,t+1}^g}{1+r_{j,t}} - B_{j,t}^g.$$

Summing and rearranging the terms, we get

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

to write:

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

Therefore for a generic horizon K

$$\begin{aligned}
\sum_{k=0}^{K} \frac{\alpha_j \tilde{Y}_{j,t+k}}{R_{j,t,k-1}} &= (1-\alpha_j)\left((1-\chi_j)\, S_{j,t} - \chi_j B^h_{j,t} \right) - B^g_{j,t} + \sum_{k=0}^{K} \frac{F_{j,t+k}}{R_{j,t,k}} \\
&\quad - (1-\chi_j)\,(1-\alpha_j)\, \frac{S_{j,t+K+1}}{R_{j,t,K+1}} + \frac{1}{R_{j,t,K}} \left(\frac{(1-\alpha_j)\,\chi_j B^h_{j,t+K+1}}{1+r_{j,t+K}} + \frac{B^g_{j,t+K+1}}{1+r_{j,t+K}} \right).
\end{aligned}$$

We take the limit and we impose a No-Ponzi condition

$$\begin{aligned}
\lim_{K\to\infty} \mathbb{E}_t \left[\frac{S_{j,t+K+1}}{R_{j,t,K+1}} \right] &= 0 \\
\lim_{K\to\infty} \mathbb{E}_t \left[\frac{1}{R_{j,t,K}} \frac{B^h_{j,t+K+1}}{1+r_{j,t+K}} \right] &= 0 \\
\lim_{K\to\infty} \mathbb{E}_t \left[\frac{1}{R_{j,t,K}} \frac{B^g_{j,t+K+1}}{1+r_{j,t+K}} \right] &= 0.
\end{aligned}$$

The inter-temporal current account condition is

$$\alpha_j \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{j,t+k}}{R_{j,t,k}} = \mathbb{E}_t \sum_{k=0}^{\infty} \frac{F_{j,t+k}}{R_{j,t,k}} - (1-\alpha_j)\left(\chi_j B^h_{j,t} - (1-\chi_j)\, S_{j,t} \right) - B^g_{j,t}.$$

C Proof of Proposition 3

Step 1: Extending Propositions 1-2 To begin, we need to extend some of the earlier results. First we extend Proposition 2 to include multiple symmetric countries. Given that there are I symmetric countries, the complete markets condition is $C_{t,s,i}P_{t,i} = C_{t,s,j}P_{t,j}, i, j = 1, ..., I$. With symmetric stock positions and uniform tax rate on labor and capital income, the budget in each country is

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

Deducting the conditions for two countries i and $j \neq i$ we obtain

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

Imposing the complete markets condition and ignoring the indeterminacy case, 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

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

Savers in each country should invest $\frac{1}{I} - \frac{I-1}{I}\frac{1-\chi}{\mu-1}$ in home stocks and $\frac{1}{I} + \frac{1}{I}\frac{1-\chi}{\mu-1}$ in the stocks of each foreign country. Savers should overweight foreign stocks. Next we need to extend proposition 1 to include static equity positions. Using manipulations similar to those in the proof of Lemma 1, we can write

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

Here Γ_t is the savers' income from foreign stocks. For simplicity assume labor income as well as home and foreign capital gains are all taxed at the same rate τ and that the government does not take new debt. From this we obtain

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

From this it is possible to write labor income as a function of exogenous variables. Then one can write the value of savers' spending as a function of exogenous variables S_t, B_t, B^g_t , $\mathbb{E}_t\sum_{k=0}^{\infty}\frac{F_{t+k}}{R_{t,k}}$ and $\mathbb{E}_t\sum_{k=0}^{\infty}\frac{\Gamma_{t+k}}{R_{t,k}}$ as in the proof of Lemma 1. This generalizes proposition 1.

Step 2: The Main Argument Given symmetric borrowing patterns the above stock positions perfectly share shocks affecting labor income such as quality shocks. These shocks need not be idiosyncratic. Idiosyncratic deleveraging shocks do not distort symmetry. This is because the savers hold a constant amount in non-contingent savings. If borrowers pay back debt, the savers can substitute this by lending more to foreign countries. While the proof assumes that the home quality stays constant it also goes through with unanticipated home quality shocks. Moreover, it works for preference shocks that do not alter the complete markets condition such as shocks to the disutility of labor that might affect the Phillips curve for wages. While this proof assumes that home quality stays constant, the Proposition also holds for unanticipated home quality shocks.

D Symmetric calibration of baseline parameters

Table 7 shows the calibration of baseline parameters.

E Only Productivity Shocks

Due to Cole-Obstfeld preferences, price adjustments give a natural hedge against productivity 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. 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

Parameter	Description	Value
χ	Fraction of impatient	0.5
β_s	Discount factor of savers	0.995
α	Openness to trade	0.25
κ	Slope wage Phillips curve	0.1
ϵ	Elasticity domestic intermediates	4
θ	Capital share	0.36
δ	Depreciation rate	0.015
ϕ_Y	Taylor rule - output gap	1.5
ϕ_π	Taylor rule - inflation	0.5

Table 7: Calibration of baseline parameters

markets outcome.

Lemma 3. ***Cole-Obstfeld 91 Result with Borrowers*** *Consider a symmetric two country economy similar to that in the baseline model but subject to productivity shocks. The optimal stock positions are indeterminate and the equilibrium always attains the complete markets allocation for both borrowers and savers.*

Proof. The production functions for the intermediate goods are A_tN_t and $A_t^*N_t^*$. Firms set prices $\mu\frac{W_t}{A_t}$and $\mu\frac{W_t^*}{A_t^*}$. In this model

$y_tp_t = A_tN_tp_t = \mu W_tN_t$

and

$y_t^*p_t^* = A_t^*N_t^*p_t^* = \mu W_t^*N_t^*$.

Moreover, firm profits are as before. Conjecture that the model attains the complete markets outcome for both savers and borrowers. That is

$C_{s,t}P_t = C_{s,t}^*P_t^*$

and

$C_{b,t}P_t = C_{b,t}^*P_t^*$.

Now we have,

$\frac{y_t}{y_t^*} = \frac{(1-\alpha)C_{s,t}P_t/p_t+\alpha C_{s,t}^*P_t^*/p_t+(1-\alpha)C_{b,t}P_t/p_t+\alpha C_{b,t}^*P_t^*/p_t}{(1-\alpha)C_{s,t}^*P_t^*/p_t^*+\alpha C_{s,t}P_t/p_t^*+(1-\alpha)C_{b,t}^*P_t^*/p_t^*+\alpha C_{b,t}P_t/p_t^*}$.

Then applying the complete markets conditions, we obtain

$\frac{y_t}{y_t^*} = \frac{C_{s,t}P_t+C_{b,t}P_t}{C_{s,t}P_t+C_{b,t}P_t}\frac{p_t^*}{p_t} = \frac{p_t^*}{p_t}$.

That is prices and output levels moves inverse one-to-one. But this implies

$W_tN_t - W_t^*N_t^* = 0$.

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 α 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 the foreign country.

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.

F Asymmetries

We now generalize the results concerning equity to asymmetric initial stock positions, mark-ups, shares of savers and country sizes. The complete markets condition is $P_tC_{s,t} = \lambda P_t^* C_{s,t}^*$, where λ is the relative Pareto weight. The budget constraints are

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

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

Deducting the budget constraints and imposing the complete markets condition yields

$$N_tW_t\left(1+\frac{(2\varphi-1)(\mu-1)}{1-\chi}\right) - N_t^*W_t^*\left(1+\frac{(2\varphi^*-1)(\mu^*-1)}{1-\chi^*}\right) = (\lambda-1)P_t^*C_{s,t}^*$$

or

$$N_tW_t\left(1+\frac{(2\varphi-1)(\mu-1)}{1-\chi}\right) - N_t^*W_t^*\left(1+\frac{(2\varphi^*-1)(\mu^*-1)}{1-\chi^*}\right) = \frac{\lambda-1}{1+\lambda}(\mu N_tW_t + \mu^*N_t^*W_t^*)$$

From this we can solve

$$N_tW_t\left(1+\frac{(2\varphi-1)(\mu-1)}{1-\chi}\right) - N_t^*W_t^*\left(1+\frac{(2\varphi^*-1)(\mu^*-1)}{1-\chi^*}\right) = \frac{\lambda-1}{1+\lambda}(\mu N_tW_t + \mu^*N_t^*W_t^*)$$

or

$$N_tW_t\left(1+\frac{(2\varphi-1)(\mu-1)}{1-\chi} - \frac{\lambda-1}{1+\lambda}\mu\right) - N_t^*W_t^*\left(1+\frac{(2\varphi^*-1)(\mu^*-1)}{1-\chi^*} + \frac{\lambda-1}{1+\lambda}\mu^*\right) = 0$$

From this we solve

$$\varphi = \frac{1}{2} - \frac{1}{2}\frac{1-\chi}{\mu-1} + \frac{1}{2}\frac{(\lambda-1)\mu(1-\chi)}{(1+\lambda)(\mu-1)}$$

and

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

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

Parameter	Value
Quality shock (α_t) volatility	3.64%
Quality shock (α_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 (ζ)	1.95

Table 8: Rest of the parameters

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

G 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 D). 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. These parameter 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.

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