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Does a Currency Union Need a Capital Market Union?

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`Preliminary and incomplete.`

Abstract

We study financial linkages and risk sharing in the context of the Eurozone crisis. We consider four types of currency unions: a currency union with (potentially) segmented markets; a banking union; a capital market union; and a currency union with complete financial markets. We then analyze how these economies respond to deleveraging shocks and to technology shocks. We find that a banking union is enough to deal with public and private deleveraging shocks, but a capital market union is necessary to approximate the complete market allocation when there are shocks that affect productivity or the terms of trade.

Risk sharing problems are at the heart of the Eurozone crisis. Martin and Philippon (2014) show that the Eurozone crisis can be decomposed into three components: a private leverage crisis, a fiscal crisis and a sudden stop. What changes from one region to the next is the relative importance of each component. In most countries, we see clear private leveraging/deleveraging cycles with associated booms and busts in GDP and employment. This private cycle also exists across U.S. regions and it plays out in the same way as in Europe. In Europe however, unlike in the U.S., the private leverage crisis was followed by fiscal crises and sudden stops, as interest rates spreads widened across countries and capital flows reversed.

The creation of a banking union was a deliberate answer to the issues that arose in this second stage of the Eurozone crisis. The Eurozone is heavily dependent on banking intermediation. The funding conditions of banks have a direct impact on the funding conditions of households and firms. As the costs of fund diverged between countries within the Eurozone, the weaker countries sunk deeper into recession. The main purpose of the banking union is to guarantee that funding conditions remain the same across regions within the Eurozone. There is broad agreement that this is necessary to ensure the stability of the currency union.

If we agree on the necessity of a banking union, the open question then becomes: What other features are necessary for a successful currency union? Considering the U.S. experience, two such features immediately come to mind: fiscal union and capital market union. A fiscal union improves risk sharing via net fiscal transfers across regions. A capital market union improves risk sharing via financial markets, i.e. equity and fixed income flows apart from cross-border bank flows.

Our goal in this paper is to study the desirability of a capital market union to improve the efficiency of a currency union. We consider four model economies: (i) segmented markets; (ii) a banking union where funding costs are equalized across regions; (iii) a capital market union with significant cross border equity holdings; and (iv) a complete market economy.

We then ask how these four model economies respond to two types of shocks: demand shocks (triggered by public or private deleveraging), and productivity shocks (TFP, terms of trade, etc.). We find that a banking union is enough to deal with leveraging/deleveraging shocks, both public and private. We also find, however, that a capital market union is necessary to approximate the complete market outcome when there are productivity shocks.

The starting point of our analysis is Martin and Philippon (2014), who provide a framework and an identification strategy to study country dynamics within the Eurozone. Our contribution is to extend their analysis to study spillovers across countries, in particular by modeling aggregate demand spillovers and monetary policy, and to analyze the desirability of capital market integration within a currency union. Martin and Philippon (2014) disentangle the shocks that hit the Eurozone and quantify the relative importance of fiscal policy, private leverage and financial spreads. For instance, they find that fiscal policy was very important for Greece. The implications for the design of fiscal rules are clear, and the issue of cross-border fiscal multipliers is addressed in Blanchard et al. (2014).

We focus on the financial side. Martin and Philippon (2014) find that credit spreads play an important role in exacerbating the Eurozone crisis. They run counterfactuals where spreads are capped and they find that this would significantly reduced the recession in the eurozone periphery. We think of a banking union as an institution that guarantees than bank (risk-adjusted) funding costs remain the same in all regions irrespective of the shocks that hit these regions. In particular, bank funding costs are not directly affected by the health of their sovereigns. Since banks are the main source of private funds for households and firms, we model the banking union as a currency union were the private sector costs of funds are equalized across regions. We ask whether such a banking union is sufficient to replicate a complete market economy, and we show that it depends on the shocks. For deleveraging shocks, public or private, we find that the banking union is enough. Note that deleveraging create an aggregate drag on the economy in any case, but borrowing and lending across regions allows an efficient sharing of the burden of adjustment created by the deleveraging. For productivity shocks, however, capital market integration is needed because the wealth shocks need to be shared.

Finally, we study two extension of the (relatively) simple model. First, we study the implications of allowing borrowers to default. This amounts to a transfer from savers to borrowers. In the class of model that we consider, default can be ex-post efficient. In an open economy setting, an interesting questions arises: who bears the cost of default? We show that this depends on the ultimate ownership of claims and, in particular, of bank equity. The second extension is to introduce physical capital, which is technically challenging in this class of model.

Related Literature Our paper is related to several lines of research in open economy macroeconomics and macroeconomics models in the New Keynesian tradition: (i) cross-border risk sharing through inter-temporal trade, (ii) open economy models featuring nominal rigidities, including fixed exchange rates, (iii) models of financial deleveraging shocks.

In a two-country, two-good endowment economy with fully flexible prices, Cole and Obstfeld (1991) show that the welfare gain from allowing trading of assets across borders is small, since adjustments in the terms of trade provide insurance against country specific fluctuations. Heathcote and Perri (2002) find that in a similar setup but with endogenous production a framework in which countries are in asset market autarky matches cross-country correlations much better than the complete markets model. The analysis in Kehoe and Perri (2002) goes a step further in that it endogenizes the incompleteness of markets by introducing enforcement constraints that require each country to prefer the allocation it receives by honoring it's liabilities than living in autarky from any given time onward. The model goes some way towards explaining cross-country correlations observed in data, but at the cost of generating counterfactually low cross-border investment.

In contrast to studies which preserve the basic structure of the real business cycle model (the IRBC literature), studies in the new open economy (NOE) literature, following Obstfeld and Rogoff (1995), introduce nominal rigidities in the style of New Keynesian business cycle models as well as market incompleteness into the open economy framework. Schmitt-Grohe and Uribe (2012) emphasize the role of downward wage rigidity in the Eurozone recession. An important shortcoming of models in this tradition is that they are unable to pin down a unique, endogenously determined steady state, and are inherently non-stationary. Ghironi (2006) provides a succinct discussion of the evolution of this literature and attempts to deal with these issues. More recent studies, for example Gali and Monacelli (2008), circumvent the issue entirely by assuming complete asset markets. This is the approach followed, for example, in Blanchard et al. (2014) who model the Eurozone as a two-country (core and periphery) version of Gali and Monacelli (2008).

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 (2011) 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. An exception to this theme are papers which specifically address 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.

Following Bernanke and Gertler (1989), many macroeconomic papers introduce credit constraints at the entrepreneur level (Kiyotaki and Moore (1997), Bernanke et al. (1999), or Cooley et al. (2004)). In all these models, the availability of credit limits *corporate* investment. As a result, credit constraints affect the economy by affecting the size of the capital stock. Curdia and Woodford (2009) analyze the implication for monetary policy of imperfect intermediation between borrowers and lenders. Gertler and Kiyotaki (2010) study a model where shocks that hit the financial intermediation sector lead to tighter borrowing constraints for entrepreneurs. We model shocks in a similar way. The difference is that our borrowers are households, not entrepreneurs, and, we argue, as Mian and Sufi (2010), that this makes a difference for the model's cross-sectional implications. In particular, a striking feature of the data is the strong correlation between household leverage and employment across regions and over time, as documented in Midrigan and Philippon (2010) for the US.[1] Our framework builds on the tradition of Campbell and Mankiw (1989), that feature impatient and patient consumers. This type of models has been used by Gali et al. (2007) to analyze the impact of fiscal policy on consumption and by Eggertsson and Krugman (2012) to analyze macroeconomic dynamics during the Great Recession.

Fornaro (2014) and Benigno and Romei (2014) study the effect of deleveraging shocks in open economies with nominal rigidities. Fornaro (2014) compare 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 where one country is a debtor and the other a creditor in the steady state, and analyze the effect of a tightening in the borrowing limit. In contrast to these studies, we analyze a model where each country is populated by both borrowers and savers. This is an important distinction because we know from the extensive research on the US experience that deleveraging in a closed economy (or in an open economy without sudden stop) can already create a recession.

1 Model

The economies we study consist of two regions, each of which is populated by a (potentially different) measure of infinitely lived households. Each region produces a tradable domestic good and households in both regions consume both the domestic and the foreign goods. Following Mankiw (2000) and more recently 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 denote the regions home and foreign, and indicate foreign variables and parameters with superscript $*$. The economies differ only with respect to the menu of traded assets, which affect only savers' borrowing constraints, so we first describe their common structure.[2]

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[1] For instance, Mian and Sufi (2010) find that the predictive power of household borrowing remains the same in counties dominated by national banks. It is also well known that businesses entered the recession with historically strong balanced sheets and were able to draw on existing credit lines Ivashina and Scharfstein (2008).

1.1 Preferences and technology

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

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

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

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

where $\alpha \geq \frac{1}{2}$ is a measure of the openness to trade of the home economy. With these preferences, the home and foreign consumption based price indices (CPI) are:

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

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

Where $P_{h,t}$ and $P_{f,t}$ are the time t producer price indices (PPI) in the home and foreign countries, respectively. The home and foreign goods are in turn compositions of intermediate goods produced in each of the countries, which are aggregated into the final consumption goods using the following constant elasticity of substitution technologies:

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

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[2] For ease of exposition the equations presented below are valid when the two regions' populations are of equal measure; we relegate the general model to the appendix.

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

The PPIs in each region are therefore:

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

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

Where $p_t(j)$ are prices of intermediate goods. The production of intermediate goods is linear in labor N_t, so the marginal cost of production for each intermediate produce is simply the wage rate W_t.

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 loose some tractability.[3]

1.2 Price setting

We assume that wages are determined by a Phillips curve:

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

Where κ is a parameter that governs the steepness of the wage Phillips curve and N_{ss} is steady-state employment. The monopolistically competitive intermediate goods producers set their prices flexibly every period. It follows that:

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

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[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 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.

where $\mu \equiv \sigma / (\sigma - 1)$ is a markup over the marginal cost W_t. Since prices are fully flexible and the exchange rate is fixed, the law of one price holds,

$$P_{h,t} = P^*_{f,t} \ \forall \ t$$

$$P_{f,t} = P^*_{h,t} \ \forall \ t$$

But if $\alpha > \frac{1}{2}$, the CPI in each country will in general differ. Since intermediate goods producers charge a markup over marginal cost, they earn (per capita) profits:

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

1.3 Monetary and fiscal policy

Monetary policy follows a Taylor rule:

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

where R_{ss}, Y_{ss} and π_{ss} are the steady state interest rate, output and inflation, respectively.

We do not focus on fiscal policy, but our model has implication for public and private deleveraging. The government budget constraint in country is:

$$\frac{B^g_{t+1}}{R_t} = G_t + T_t + B^g_t, \tag{1}$$

We consider various degrees of financial market integration, so $\tilde{R}$ is the policy rate, R the rate at home, and R^* the foreign interest rate. When markets are fragmented, we will allow these rates to differ. Conversely, we interpret the banking union as a way to enforce $R_t = \tilde{R}_t = R^*_t$.

1.4 Borrowers' budget constraint

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

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

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 $\tilde{B}_{t+1}$:

$$B_{t+1} \leq \tilde{B}_{t+1}$$

We will assume throughout that borrowers are impatient enough that they always borrow up to the constraint, so their nominal consumption is:

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

1.5 Savers' budget constraint in each of the economies

Each of the economies we study differs in the set of assets available for inter-regional trade. We study three configurations: a bond economy, a bond economy with cross-border claims to the profits of intermediate goods producers, and complete markets. The only difference between these economies is in the budget constraint of the savers.

1.5.1 Bond Economy (Banking Union, BU)

In this model only a single non-contingent, nominal bond is traded. The bond pays one unit of the currency of the union and has a time t price of $\frac{1}{R_t}$, where R_t is the nominal interest rate set by the central bank. In this economy the savers' budget constraint is:

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

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.

1.5.2 Bonds and Stocks (Capital Market Union, CMU)

In this economy only the non-contingent bond is traded, but savers in the home (foreign) region own claims on the profits of the foreign (home) intermediate goods producers. In particular home savers (in aggregate) own a fraction ϕ of claims to foreign profits (foreign savers own the complementary fraction). Savers' budget constraints in the home and foreign regions are, respectively:

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

and

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

1.5.3 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 $D_{t+1}\left(s_{t+1}, s^t\right)$; this security has a time t price $Q_t\left(s_{t+1}, s^t\right)$.

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

1.6 Equilibrium conditions

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

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

Since borrowers are always at their borrowing limit, their consumption is determined by their budget constraint:

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

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):

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

Market clearing in goods is given by:

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

Where G_t is nominal government expenditure, which is spent on home goods only. Substituting in for demand functions and expressing in nominal terms, nominal output is:

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

Finally, market clearing for bonds and (if available) Arrow-Debreu securities:

$$(1-\chi) S_{t+1} + (1-\chi^*) S^*_{t+1} = \chi B_{t+1} + \chi^* B^*_{t+1}$$

$$D_t\left(s_{t+1}, s^t\right) = D^*_t\left(s_{t+1}, s^t\right), \ \forall s_{t+1}$$

2 Deleveraging Shocks

In this section we study deleveraging shocks. We model these shocks as reductions in borrowers' exogenous borrowing limit. We first derive analytical results (Propositions 1 and 2) for the effect of a deleveraging shock on a small open economy which has the same structure as the regions in our two-country economy. We then study a linear approximation of our model around the steady state to analyze the effect of deleveraging shocks on our economy. Finally, we also study the effect of a deleveraging shock large enough to make the zero lower bound on the nominal interest rate binding.[4]

Define disposable income as

$$\tilde{Y}_t \equiv W_t N_t - T_t.$$

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 can then write the inter-temporal budget constraint of savers as

$$\mathbb{E}_t \sum_{k=0}^{\infty} \frac{P_{t+k} C_{s,t+k}}{R_{t,k}} = S_t + \mathbb{E}_t \sum_{k=0}^{\infty} \frac{\tilde{Y}_{t+k}}{R_{t,k}}. \tag{2}$$

---

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

Lemma 1. *The inter-temporal current account condition for country j is*

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

Proof. See Appendix. □

On the left we have private wealth (discounted at the savers' rate) and α is the share of wealth spent on imports. On the right we have net foreign assets plus the 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, home bias and foreign demand.

If we combine the Lemma with the inter-temporal budget constraint (2), we obtain the following proposition.

Proposition 1. *Nominal spending by savers ($P_tC_{s,t}$) does not react to private credit shocks (B_{t+1}) or to fiscal policy (G_t or T_t). It 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 four variables:

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

where the first three variables (saving, household debt, public debt) are predetermined at time t and the last one (exports) is exogenous. Therefore, equation (2) is in fact

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

So current spending of savers can only depend on V_t and the path of interest rates. In particular, for given V_t and interest rates, it cannot depend on contemporaneous or future private credit and fiscal policy. □

Proposition 1 clarifies the behavior of savers. Their spending reacts neither to G_t nor to T_t. This result is related to – but also different from – Ricardian equivalence. To understand it, one needs to focus on the budget constraint of the patient households. Clearly, shocks to interest rates will affect this budget constraint and also the Euler equation, so we know that they will affect spending $X_{s,t}$. What is surprising is that, even though changes in the borrowing constraints of impatient agents or changes in fiscal policy have a direct impact on disposable income $\tilde{Y}_t$, savers do not react. The reason is that patient agents know that higher spending today – which increases output – means higher interest payments in the future – which decreases spending and output. The key result is that the *net present value* of disposable income does not change. Changes in B_t^h, G_t, T_t have no effect on the permanent income of patient agents.

Shocks to foreign demand, on the other hand, affect consumption expenditures of patient households because they affect their permanent income. Of course, even when expenditures remain constant, this does not mean that real consumption remains constant. In fact real consumption always changes because prices (wages) always react to changes in aggregate spending. These results depend on our using the preferences of Cole and Obstfeld (1991). Farhi and Werning (2013) discuss the implications of these preferences for government multipliers in currency unions.

In a small open economy, foreign demand is exogenous, so the proposition completely characterize the equilibrium behavior of savers.

Proposition 2. *Consider a small open economy subject to private and public leveraging and deleveraging shocks. The equilibrium of this economy is the same under Banking Union as under Complete Markets.*

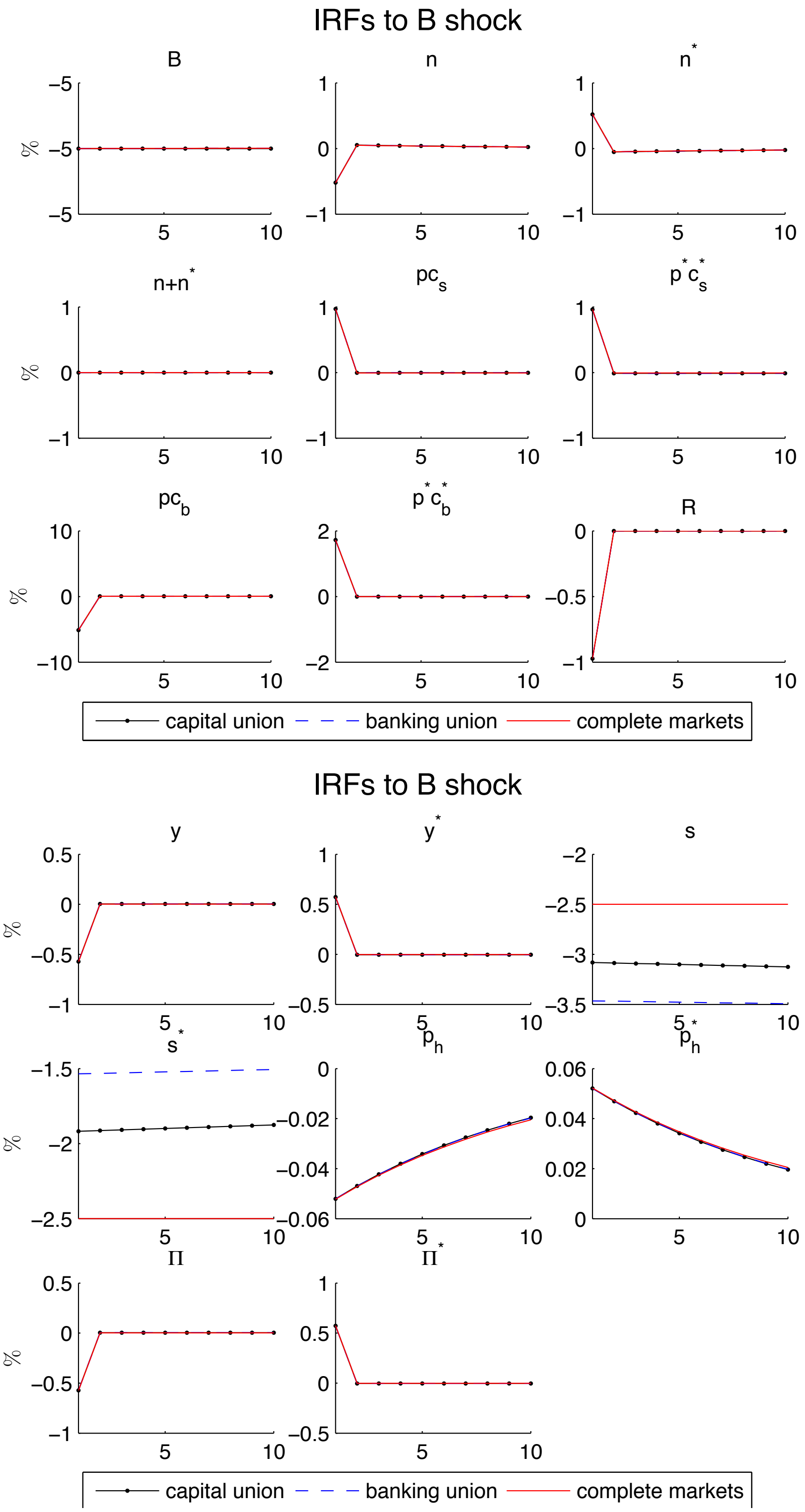
Proof. Under BU, the country interest rate is pinned down by the Taylor rule, which is exogenous from the perspective of a small economy. For given interest rates, savers spending $P_t C_{s,t}$ is constant. On the other hand, the complete market condition for a SOE (with log preferences) is

$$\left(\frac{P_{f,t}}{P_{h,t}}\right)^{1-\alpha} \frac{1}{C_{s,t}} = constant$$

Since $P_t = (P_{h,t})^{1-\alpha} (P_{f,t})^{\alpha}$ and the SOE does not affect foreign prices, it follows that the complete market condition is also that $P_t C_{s,t}$ remains constant. Hence, in response to deleveraging shocks, the BU replicates the complete market economy. □

Proposition 2 shows that banking union is enough is deal with debt deleveraging shocks. Martin and Philippon (2014) show that when spreads increase because of leverage and default risk, then savers react and this pushes the economy further into recession. So deleveraging when markets become segmented is inefficient.

Figure 1: Impulse responses to permanent -5% shock to $\tilde{B}_t$



On the other hand, when costs of funds are equalized, as they are in a Banking Union, then Proposition 2 says that a SOE will experience the complete market outcome.

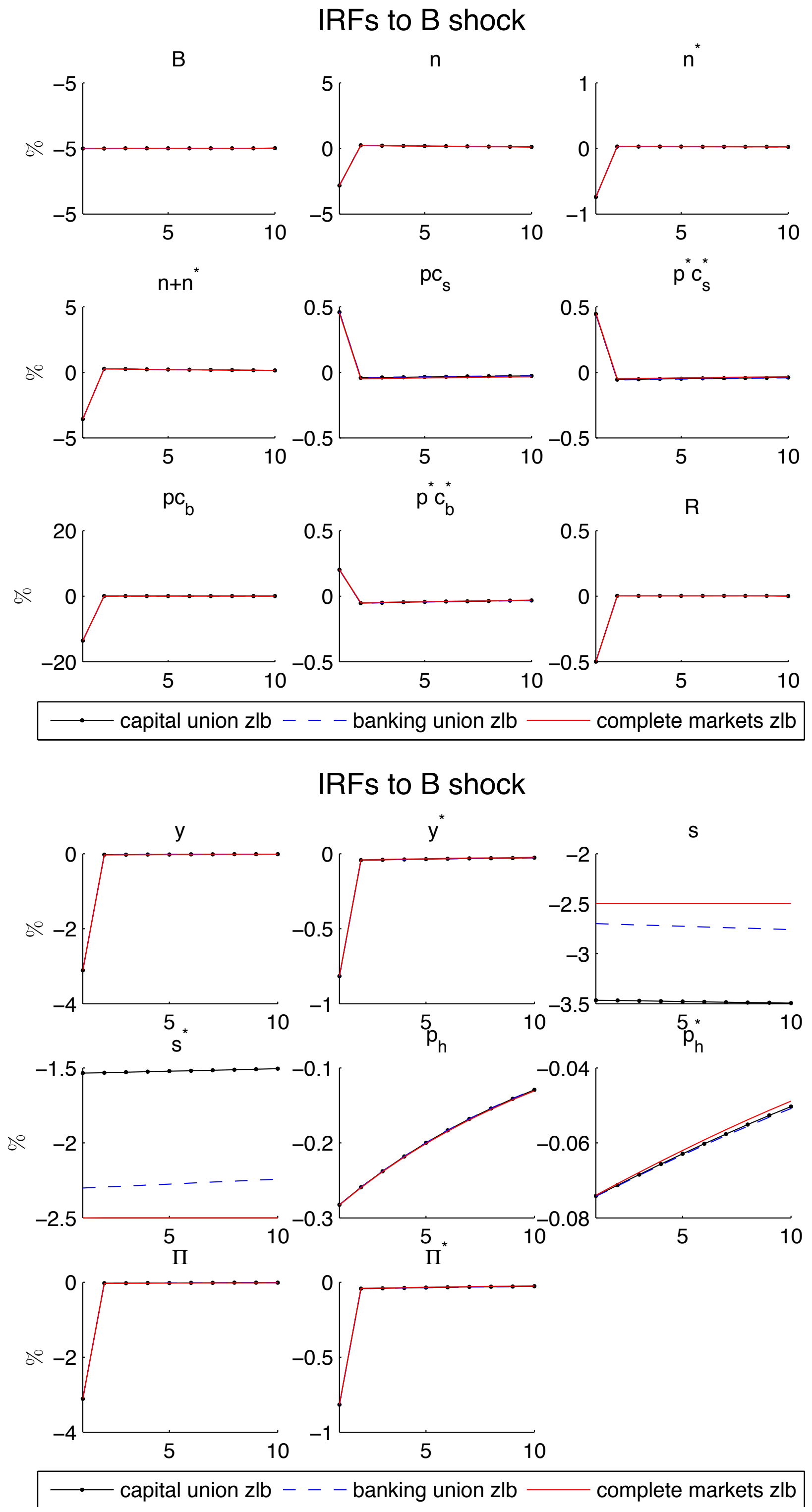
Our next task is to study the response in the general case when the shock happens in an economy of significant size. Proposition 2 is exactly correct in a SOE (i.e. a small periphery country). With two economies, then foreign demand depends (partly) on domestic demand and therefore on domestic deleveraging. In addition, the central bank is going to react by changing the risk free rate.

Yet we find that the result of Proposition 2 remains (approximately) correct. The intuition is as follows. First, we know that savers do not react in a SOE. With two countries, foreign demand F_t is endogenous, but this effect is small because it depends on two consecutive cross-border spillovers: the pass-through of domestic demand on to foreign income, and then from foreign income back to foreign demand for home goods. Because of this, the effect is quantitatively small.

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 economy. But the key point is that this impact is the same under BU and under CM. Why? Because savers face the same interest rate in both countries.

The impulse response to a domestic deleveraging shock in each of the two-region economies is depicted in figure 1. The responses of all variables except the $S_t$and S_{t+1} are virtually the same in each of the economies. The ranking of the magnitude of equilibrium adjustment in domestic savings S_t is intuitive: in the BU economy greater adjustment is required than in the CMU economy, and the complete markets economy requires the least adjustment by domestic savers.

Figure 2: Impulse responses to permanent -5% shock to $\tilde{B}_t$ with zero lower bound



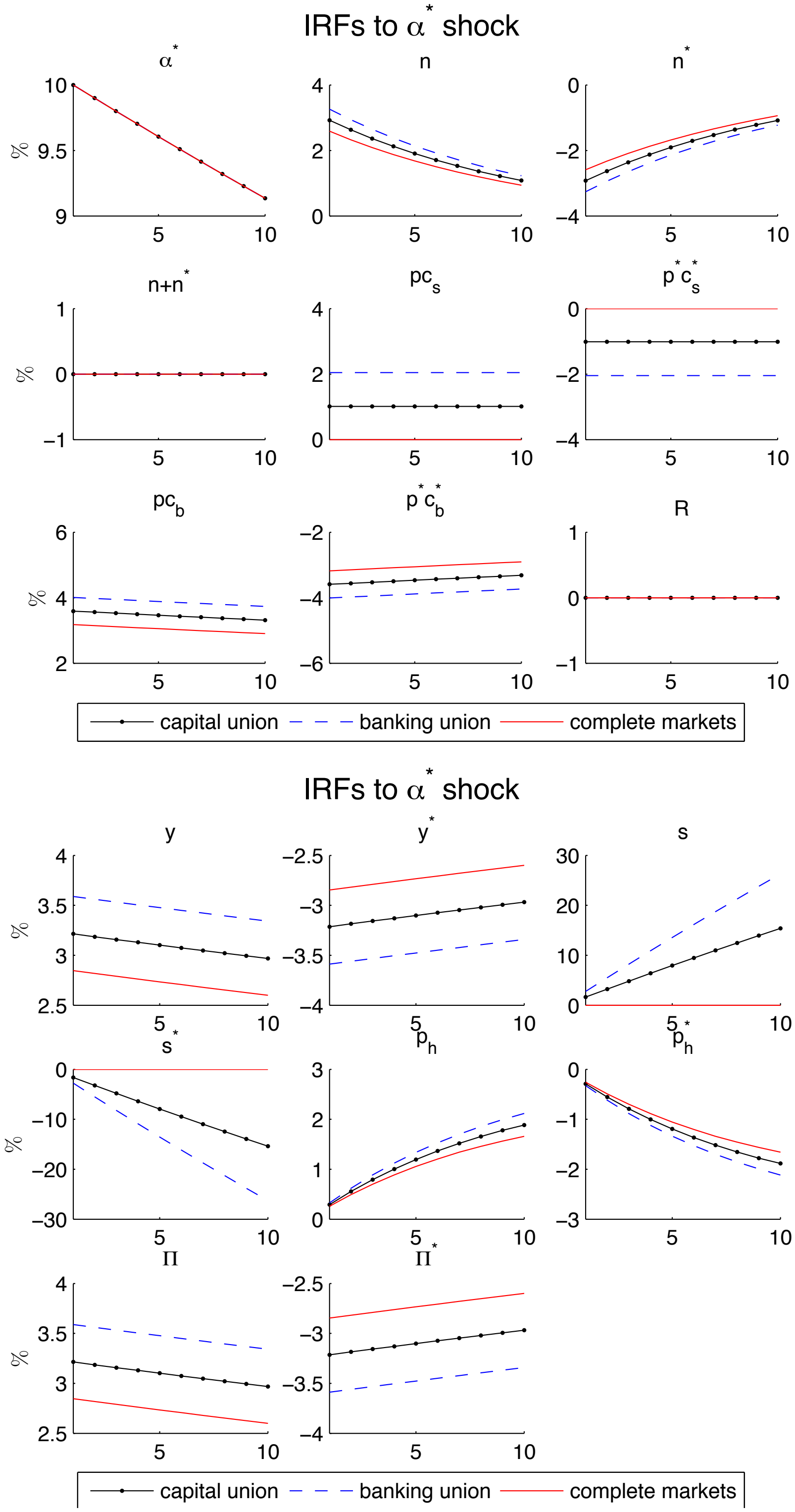
The aggregate (currency union) response to a deleveraging shock obviously depends on how monetary policy reacts. Our results show that, conditional on whatever the central bank does, the BU and complete market economies behave in virtually identical ways after deleveraging shock. One might wonder, however, if this result could be over-turned if the central bank is constrained by the zero lower bound. We find that this is not the case: our result also holds at the ZLB. 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. However, there is no difference in the relative responses to the shock in the three economies. We conclude that a successful banking union – or any union that guarantees that rates of returns are equalized across regions – is enough to deal with deleveraging shocks.

3 Foreign Demand / Quality Shocks

In this section we look at "technology" shocks in the form of "quality" shocks that shift foreign demand for home products. We model these shocks as an unanticipated change to α^*, the preference of foreigners for domestic goods. In response to these shocks, domestic firms become more profitable, while foreign firms become less profitable.

The bond economy will not be able to share this kind of risk. The capital market union, on the other hand, will be able to smooth some of it via cross-border equity holdings. Figure 3 depicts the response to a shock to α^*. Aggregate employment in the region is unaffected by the shock, which implies that the central bank does not react. The complete markets economy displays the lowest dispersion in employment across the two regions, followed by CMU, with BU the most disperse economy.

Figure 3: Impulse responses to 10% shock to α^*



Proposition 3. *Risk sharing of quality shocks leads to a clear ranking: BU<CMU<Complete Markets.*

Notice also that this result really does not depend much on monetary policy since, in the benchmark case, aggregate employment does not move in response to the shock even if rates remain constant.

4 Extensions

4.1 Technology Shocks in a model with Capital

In this section, we extend the model to include physical capital and we study the consequences of corporate capital financing. We also study standard TFP shocks. These shocks have different implications in terms of employment and inflation compared to the "quality" shocks above.

4.1.1 Production

Final goods producers As before, competitive final goods producers produce the consumption the 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:

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

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 discount factor $(m_{0,t})$ of savers in the country in which the producer is domiciled:

$$\max \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t m_t d_{j,t}$$

Dividends are:

$$d_{j,t} = P_{j,t} Y_{j,t} - W_t N_{j,t} - P_{K,t} I_{j,t}$$

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, W_t is the wage rate in the country and P_t^k is the price installed capital, which may differ from the price of the investment good due to investment adjustment costs, discussed below. The firm pays out to its shareholders a dividend which is revenue minus the wage bill and investment expenditure. 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:

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

Cost minimization yields the following input demands:

$$W_t = \frac{\epsilon-1}{\epsilon} P_{j,t}(1-\eta)\frac{Y_{j,t}}{N_{j,t}}$$

$$R_t = \frac{\epsilon-1}{\epsilon} P_{j,t}\eta\frac{Y_{j,t}}{K_{j,t}}$$

Optimal investment is determined by the following Euler equation:

$$P_{K,t} = \mathbb{E}_t\beta m_{t,t+1}\left[P_{j,t+1}\eta A_{t+1}N_{j,t+1}^{1-\eta}K_{j,t+1}^{\eta-1} + (1-\delta)P_{K,t+1}\right]$$

Intermediate goods producers set prices flexibly. It follows that they all set the same price and have the same input demands.

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

The price is set as a markup over marginal cost

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

Where

$$\mu \equiv \frac{\epsilon}{\epsilon-1}$$

$$MC_t = \frac{1}{A_t}(1-\eta)^{-(1-\eta)}\eta^{-\eta}(W_t)^{1-\eta}(R_t)^{\eta}$$

Production of capital In order to add to their capital stock, intermediate goods firms must purchase capital from installers of capital. There is a continuum of these competitive producers who purchase the investment good at price $P_{I,t}$ and sell installed capital at price $P_{K,t}$. They maximize profits given by:

$$\max_{I_t} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t m_t \left[(P_{K,t} - P_{I,t}) I_t - \frac{\psi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right]$$

The investment good itself is a composition of the home and foreign final goods:

$$I_t = (1-\alpha_I) \log \left(\frac{I_{h,t}}{1-\alpha_I} \right) + \alpha_I \log \left(\frac{I_{f,t}}{\alpha_I} \right)$$

The sequence of optimal investment flows satisfies the following inter-temporal condition:

$$P_{K,t} = P_{I,t} + \psi \left[\frac{1}{I_{t-1}} \left(\frac{I_t}{I_{t-1}} - 1 \right) - \beta \mathbb{E}_t m_{t,t+1} \frac{I_{t+1}}{I_t^2} \left(\frac{I_{t+1}}{I_t} - 1 \right) \right]$$

Demand for the home and foreign final good from installers of capital is:

$$I_{h,t} = (1-\alpha_I) \frac{P_{I,t}}{P_{h,t}} I_t$$

$$I_{f,t} = \alpha_I \frac{P_{I,t}}{P_{f,t}} I_t$$

Where the price index of the investment good is:

$$P_{I,t} = (P_{h,t})^{1-\alpha_I} (P_{f,t})^{\alpha_I}$$

4.1.2 Household problem

Preferences and demographics are as in the baseline model described above. Borrowers' problem is the same as above, but savers' budget constraint now include stocks. The supply of shares in each country is normalized to one. Denoting by $\varphi_{h,t}$ and $\varphi_{f,t}$ home households positions in home and foreign stocks respectively and by $P_{S,t}$ and $P_{S,t}^*$ the price of the home and foreign stocks, the budget constraint of home savers is:

$$X_{s,t}+\frac{S_{t+1}}{R_t}+\left(\varphi_{h,t+1}-\varphi_{h,t}\right)P_{S,t}+\left(\varphi_{f,t+1}-\varphi_{f,t}\right)P^*_{S,t}=\varphi_{h,t}d_t+\varphi_{f,t}d^*_t+S_t+W_tN_t-T_t$$

Market clearing in stock market requires:

$$\varphi_{h,t}+\varphi^*_{f,t}=1$$

$$\varphi_{f,t}+\varphi^*_{h,t}=1$$

4.2 Allowing Borrowers to Default

In this section we study deleveraging with default by some borrowers. Allowing borrowers to default can have a significant impact on deleveraging dynamics. A default is a transfer from savers to borrowers and this tends to facilitate the ex-post macroeconomic adjustment. So typically, employment falls less if we allow borrowers to default.

We study this question in the context of a capital market union with defaultable debt. The debt can be directly held, or it can be intermediated by banks. In the later case, the crucial issue becomes the equity ownership of banks. More precisely, consider a debt deleveraging shock at home, which reduces the gross debt of impatient agents. Without default, the budget constraint of an impatient agent is

$$P_tC_{b,t}=\frac{\tilde{B}_{t+1}}{R_t}+W_tN_t-T_t-\tilde{B}_t$$

We start from a steady state with constant $\tilde{B}_t=\tilde{B}_0$ and we tighten the limit to $\tilde{B}_1<\tilde{B}_0$. We let η be the fraction of deleveraging achieved through default. The budget constraint at time 0 then becomes

$$P_0C_{b,0}=W_0N_0-T_0+\frac{\tilde{B}_1}{R_0}-\left(1-\eta\right)\tilde{B}_0$$

We assume no further default from time 1 onward.

The next question is: Who bears the cost of default? In a closed economy setup credit losses must be borne by domestic savers. In an open economy it depends on who owns the debt. Let ω be the fraction of home debt owned by home savers. After the default, we have

$$S_0=\mathbb{E}_{-1}\left[S_0\right]-\omega\eta\tilde{B}_0$$

and

$$S_0^* = \mathbb{E}_{-1}\left[S_0^*\right] - (1-\omega)\,\eta\tilde{B}_0$$

The most direct interpretation of these equations is that household debt is directly held by other households. An equivalent setup is to imagine that banks intermediate household debt. Domestic banks make loans to households and finance themselves with debt and equity. Foreign households own a share $(1-\omega)$ of domestic bank equity. When borrowers default, bank equity takes a hit, and foreign household end up absorbing $(1-\omega)\,\eta\tilde{B}_0$ just as if they held the debt directly.

Lemma 2. ***Equivalence of cross-border bond funds and foreign bank equity ownership.*** *The two following economies are equivalent in their sharing of credit risk: (1)foreign households hold a fraction $1-\omega$ of bonds backed by domestic loans; or (2) domestic household borrow from domestic banks, and foreign household hold a fraction $1-\omega$ of domestic bank equity.*

The lemma makes clear that, as far as sharing default risk is concerned, different types of capital market integration are equivalent. One option is to package loans into bonds and sell them abroad. Another option is to let banks retain the loans and encourage cross-border ownership of bank equity.

We now present impulse responses to deleveraging and default shocks. Figure 4 presents impulse responses to a 5% deleveraging shock when part of deleveraging is achieved through default, for different values of η (keeping $\omega = 0.5$). For the case of deleveraging achieved completely through default ($\eta = 1$), the deleveraging shock has no effect. The effects of the deleveraging shocks are larger the smaller the fraction of deleveraging achieved through default. Figure 5 presents impulse responses to the same shock for $\eta = 1$, for different values of ω. The effect of varying ω is small but conforms with our intuition: the larger the share of default borne by foreigners, the less negative the effect on the domestic economy. For a large enough deleveraging shock, such that the zero lower bound on the nominal interest binds, deleveraging through default is especially attractive from the point of view of employment stabilization: in the most extreme case in which deleveraging occurs only through default ($\eta = 1$) and the incidence of default by domestic borrowers falls only on domestic savers ($\omega = 1$), employment is unchanged in both countries and consequently the central bank does not change its policy rate. In the polar opposite case, $\eta = 0$, full employment stabilization requires an unfeasibly large fall in the nominal interest rate. This comparison is illustrated in Figure 6 (for $\omega = 0.5$).

Figure 4: Impulse responses to permanent -5% shock to $\tilde{B}_t$ with default, varying extent of default (η), $\omega = 0.5$

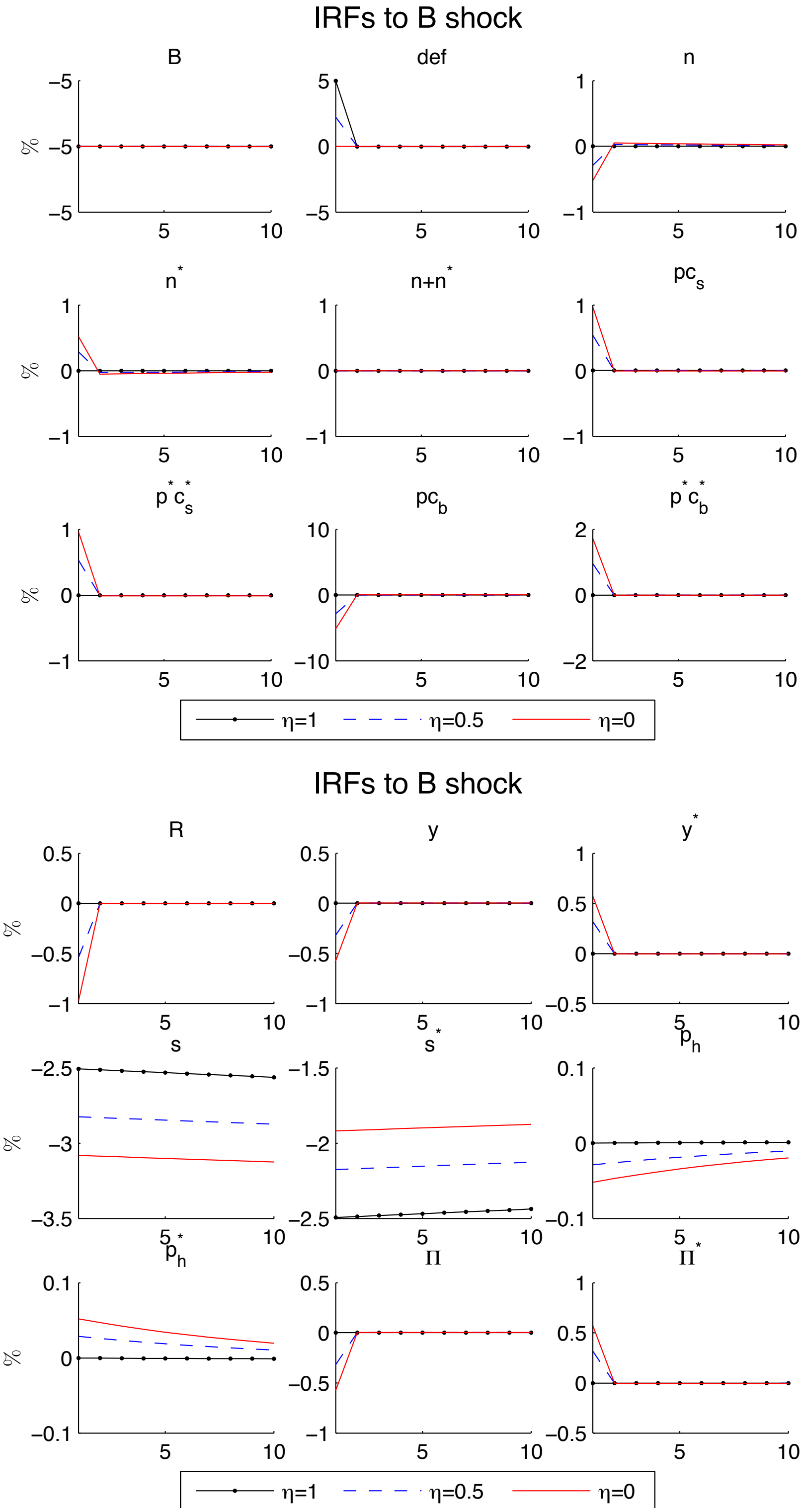


Figure 5: Impulse responses to permanent -5% shock to $\tilde{B}_t$ with default, varying incidence of default (ω), $\eta = 1$

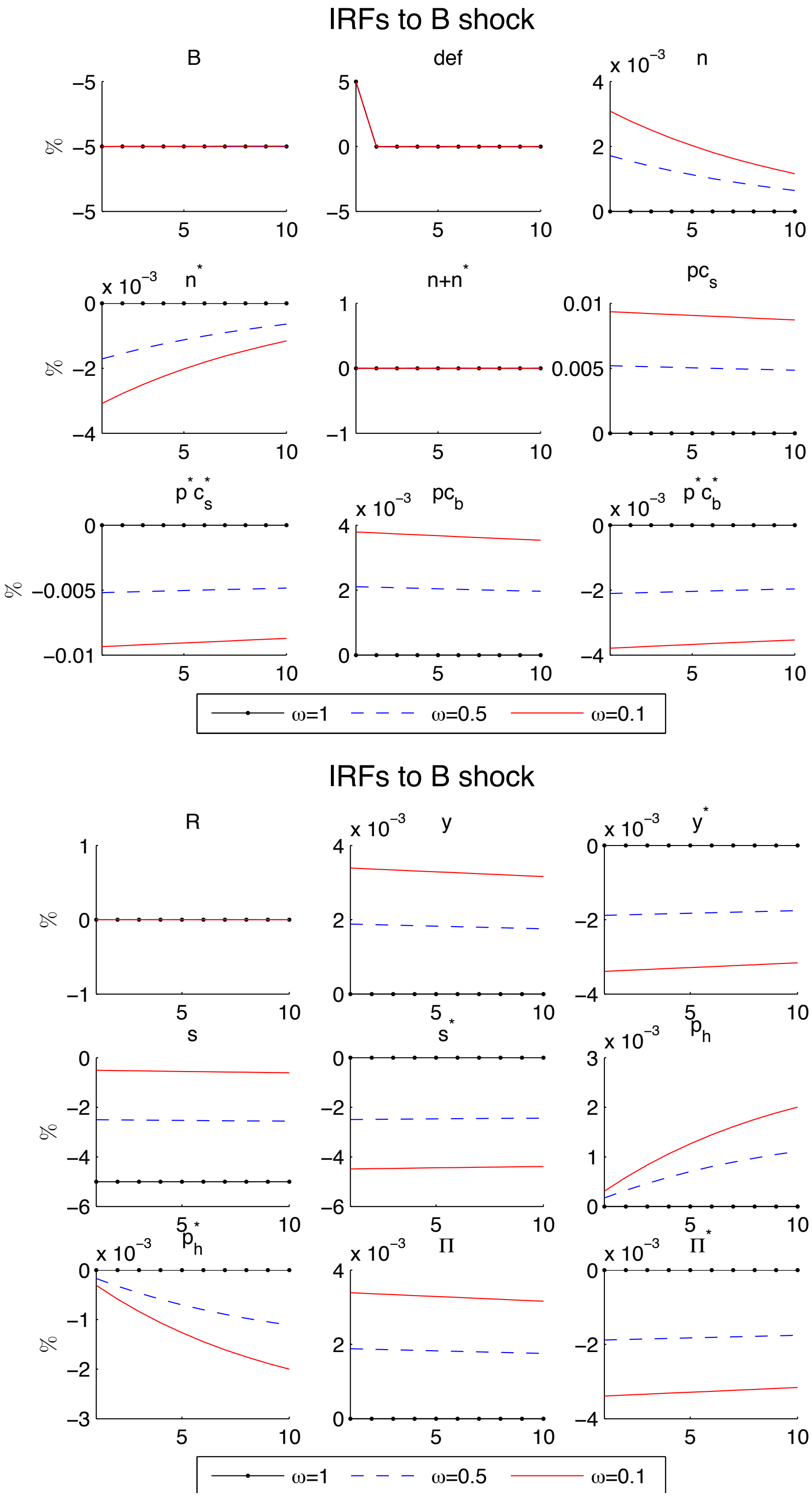
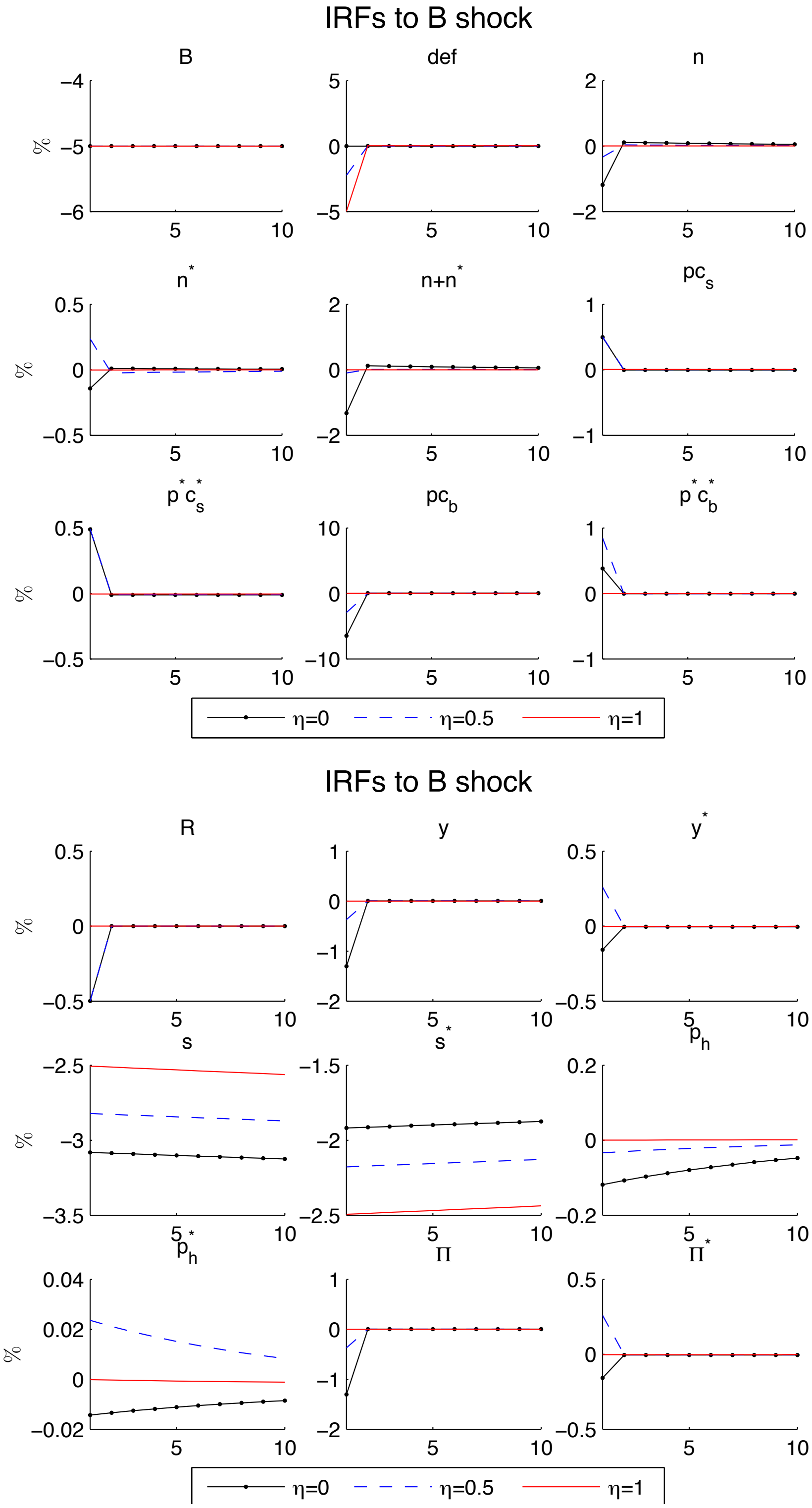


Figure 6: Impulse responses to permanent -5% shock to $\tilde{B}_t$ with default, varying extent of default (η), $\omega = 0.5$, zero lower bound



APPENDIX

A Equilibrium Conditions

A.1 Home

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

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

$$P_{h,t} N_t = \alpha \left(\chi P_t C_{b,t} + (1-\chi) P_t C_{s,t} \right) + \frac{N^*_{ss}}{N_{ss}} (1-\alpha^*) \left(\chi^* P^*_t C^*_{b,t} + (1-\chi^*) P^*_t C^*_{s,t} \right) + T_t$$

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

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

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

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

A.2 Foreign

$$P^*_t C^*_{b,t} = \frac{\tilde{B}^*_{t+1}}{R_t} + W^*_t N^*_t - T^*_t - \tilde{B}^*_t$$

$$\frac{1}{P^*_t C^*_{s,t}} = \beta R_t \mathbb{E}_t \left[\frac{1}{P^*_{t+1} C^*_{s,t+1}} \right]$$

$$Y^*_t = P^*_{h,t} N^*_t = \alpha^* \left(\chi^* P^*_t C^*_{b,t} + (1-\chi^*) P^*_t C^*_{s,t} \right) + \frac{N_{ss}}{N^*_{ss}} (1-\alpha) \left(\chi P_t C_{b,t} + (1-\chi) P_t C_{s,t} \right) + T^*_t$$

$$\Pi^*_t = \left(P^*_{h,t} - W^*_t \right) N^*_t$$

$$P^*_{h,t} = \mu^* W^*_t$$

$$W^*_t = W^*_{t-1} \left(1 + \kappa^* \left(N^*_t - N^*_{ss} \right) \right)$$

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

A.3 Union-wide

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

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

B Proof of Lemma 1

Define nominal spending of savers

$$X_{s,t} = P_t C_{s,t}$$

Savers solve

$$\begin{gathered} \max \textstyle\sum_{t \geq 0} \beta^t \log\left(X_{s,j,t}\right) \\ X_{s,j,t} + \tfrac{S_{j,t+1}}{1+r_{j,t}} = S_{j,t} + \tilde{Y}_{j,t} \end{gathered}$$

Let us integrate forward the budget constraint:

$$\sum_{k=0}^{K} \frac{X_{s,j,t+k}}{R_{j,t,k}} + \frac{S_{j,t+K+1}}{R_{j,t,K+1}} = S_{j,t} + \sum_{k=0}^{K} \frac{\tilde{Y}_{j,t+k}}{R_{j,t,k}}.$$

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

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

and the convention $R_{j,t,0} = 1$. The next step is to use the resource constraint

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

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

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

The inter-temporal budget constraint is then

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

The net present value of savers' spending depends on beginning of period net foreign assets $\left(1 - \left(1-\alpha_j\right)\chi_j\right) S_{j,t} - \chi_j \left(1-\alpha_j\right) B^h_{j,t} - B^g_{j,t}$ and the net present value of exports.

C Calibration

C.1 Symmetric calibration

Parameter	Description	Value
χ	Fraction of impatient	0.5
β	Discount factor of savers	0.995
α	Openness to trade	0.75
κ	Slope wage Phillips curve	0.1
ϵ	Elasticity domestic intermediates	4
φ	Portfolio share CMU economy	0.5
ϕ_Y	Taylor rule - output gap	1.5
ϕ_π	Taylor rule - inflation	0.5

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