Bank Capital Regulation in a Banking Union*

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Abstract

We examine the international spillovers from bank capital regulation in a model of a monetary union featuring bank default risk and cross-border banking. Capital requirement increases make domestic banks safer but entail cross-country spillovers which operate via trade as well as cross-border lending and bank solvency channels. The design of the deposit insurance scheme and the reciprocation of capital regulatory measures are two key determinants of the overall spillovers.

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Since the global financial crisis, regulatory efforts have focused on building up banks' capital buffers in order to make financial institutions more resilient and to prevent financial crises. Countries have set up macroprudential authorities to monitor risks and activate domestic bank capital measures to mitigate them. While the existing literature has provided important insights on the effectiveness of bank capital requirements in closed economies (e.g. Van Den Heuvel, 2008; Begenau, 2020; Elenev et al., 2020; Mendicino et al., 2020), our understanding of the international spillovers of capital requirements remains still limited. What are the cross-border effects of capital requirement changes in a monetary union? Which economic and institutional features affect the size of the spillovers? What are the costs and benefits of international cooperation in the setting of bank capital regulation?

This paper addresses the above questions through the lens of a monetary union with bank intermediation frictions and bank default risk. Banks in each country raise deposits domestically and invest in productive capital both at home and abroad. We show that while domestic capital requirement increases make the domestic banking sector safer, they also entail cross-country spillovers operating via both trade and financial interlinkages.

First, we characterize the cross-country spillovers in the absence of reciprocation of bank capital regulatory measures. Accordingly, bank capital requirement increases enacted in one country only apply to domestic banks and are not extended to the exposure of foreign banks.[1] Under this setting, our results highlight two channels of cross-country spillovers: trade and cross-border lending.

Capital requirements affect foreign households through *trade linkages*. Bank leverage restrictions contract the supply of domestic goods thus raising their relative price on international markets. This has a negative welfare effect on foreign buyers of domestic goods.

[1] The EU regulatory framework under Basel III imposes compulsory reciprocation of counter-cyclical buffers while the reciprocation of all other measures (e.g. risk weights, systemic risk buffers, conservation buffers) is voluntary. The vast majority of bank capital regulatory measures enacted in a particular country typically target only the financial exposures of domestic banks. Consequently, these measures do not automatically extend to the exposures of foreign financial institutions, whether held through branches in the activating country or directly across borders.

Higher capital requirements also entail *cross-border lending spillovers*. Our model features financial channels which create significant spillovers across countries through cross-border banking operations. Higher capital requirements on domestic lending has an ambiguous effect on foreign credit supply. On the one hand, banks are encouraged to shift their loan books towards foreign loans whose capital requirements have not increased. On the other hand, higher domestic capital requirements increase the average capital requirement on the entire loan book, leading to lower lending both at home and abroad. Our results show that the second effect dominates and foreign credit supply shrinks as capital requirements on domestic loans increase. Thus some of the costs of making domestic banks safer may be imposed on foreign economies. Overall, in the absence of reciprocation of bank capital requirement changes, the net cross-country spillovers of domestic capital requirement increases are always negative.

Second, we explore the role of the reciprocity framework and show that the reciprocation of capital regulatory measures significantly affects the size of the spillovers.[2] In particular, under reciprocity, capital requirement increases also entail positive *solvency spillovers*. If higher domestic capital requirements affect the riskiness of foreign banks' operations in the activating country then some of the benefits accrue to foreign deposit insurance funds which face a lower probability of having to pay out on the deposits of failed banks.

Reciprocity mitigates the negative spillovers of tighter domestic capital regulation. In particular, under reciprocity the solvency spillovers more than offset the negative trade and cross-border lending spillovers, leading to positive net spillovers and, hence, welfare benefits for the foreign economy. This also implies smaller welfare costs from non-cooperative choices. Overall, our results suggest that the reciprocation of bank capital regulatory measures is always beneficial.

[2]Although reciprocation is not always mandatory, macroprudential measures taken in one activating country are often reciprocated by other authorities to the exposures of foreign financial institutions located in that country.

Third, we show that another key determinant of the size and sign of the net spillovers is how the *deposit insurance scheme* is financed. In the baseline, the deposit insurance is paid for by national taxation within each country. We also examine the consequences of a common deposit insurance scheme that is jointly paid for by the two countries. Higher capital requirements in one country benefit other countries through a reduction in the cost of insuring the affected bank deposits.

A common deposit insurance fundamentally changes the way the costs and benefits of tighter bank capital requirements are distributed across the two countries. The enacting country suffers most the cost in terms of reduced bank intermediation, while the benefits are share with the foreign fiscal authority. This amplifies the positive cross-border spillovers of tighter regulation, leading to larger net cross-country spillovers. As a result the welfare losses from non-cooperatively chosen capital requirements are larger.

By highlighting that cross-country spillovers do matter for capital requirement choices, our results provide important policy insights. First, in the absence of reciprocation of macroprudential measures and national deposit insurance, uncoordinated capital requirement choices lead to individual country choices that are too high from a common perspective. This is because the enacting country ignores the costs imposed on other country due to reduced cross-border lending and lower supply of the goods they specialize. Secondly, by allowing for positive cross-country bank solvency spillovers, reciprocity considerably reduces the welfare cost from non-cooperative choices. Finally, once we allow for a common deposit insurance, the optimal capital requirements chosen by individual countries become too low from a common point of view. This is because individual member states ignore the larger positive spillovers of higher domestic capital requirements on other member states.

The findings of this paper have important implications for the assessment of the cost and benefits of a banking union.[3] Our results corroborate the importance of the reciprocation

[3]The European Banking Union was a powerful response to the global financial crisis based on the unprecedented decision to shift, among others, (macro)prudential responsibility to a shared level with the aim

of macroprudential measures in reducing cross-border spillovers. This helps to align single country and union-wide incentives for bank capital requirement policies within the current institutional set-up in which national regulators still play a very important role. Nevertheless, we argue that spillovers between countries remain even under reciprocity. This means that it is beneficial to move (macro)prudential policy to a shared level in order to internalize cross-country spillovers and ensure the socially optimal setting of macroprudential policy in the euro area. Finally, coordinated decision-making on bank capital requirements would become even more important if the European banking union is completed via the establishment of a European deposit insurance scheme.

Literature review. This paper belongs to the growing literature that explores the real and financial effects of changes in bank capital requirements in quantitative models (Van Den Heuvel, 2008; Clerc et al., 2015; Begenau, 2020; Mendicino et al., 2018; Begenau and Landvoigt, 2017; Elenev et al., 2020; Mendicino et al., 2020). We add to this literature by examining the effects of cross-country spillovers of bank capital requirements.

The theoretical mechanisms behind the cross-country spillovers in our model are consistent with the channels identified in the empirical literature on the international financial spillovers of (macro)prudential policy (e.g. Buch and Goldberg, 2017; Forbes et al., 2017; Bonfim and Costa, 2017; Frost et al., 2018).

A handful of papers studies the international coordination of bank capital regulation in stylized theoretical frameworks to highlight the role of regulatory competition. In particular, Dell'Ariccia and Marquez (2006) studies competition in market shares in non-reciprocal regimes, while Bahaj and Malherbe (2022) focuses on competition in bank capital for the cross-border effects of the Basel III's counter-cyclical capital buffer under the principle of

of pursuing banking integration and enhancing cross-border cooperation and coordination. With the entry into force of the Single Supervisory Mechanism Regulation in 2014, the European Central Bank has been equipped with macroprudential tools to improve the resilience of the financial system. In particular, the ECB may, instead of the national authorities, apply higher capital buffer requirements than those applied by the national authorities.

reciprocity.[4] Unlike these papers, we rely on a general equilibrium model with bank default risk to study the cross-border spillovers of capital regulation under perfect competition and uncover the importance of other real (e.g. trade) and financial (e.g. bank solvency) sources of cross-border spillovers.

Our paper also connects to the literature which studies macroprudential policy in small open economies (see e.g. Mendoza, 2010; Bianchi and Mendoza, 2011; Benigno et al., 2013; Schmitt-Grohé and Uribe, 2016; Falasconi et al., 2023). We complement existing work by focusing on the international financial spillovers of macroprudential policy, rather than on the implication for small open economies. In this respect, our paper is closer to Fornaro and Romei (2019) which study global financial policies in a tractable framework of a financially integrated world in a liquidity trap. Differently from them, we focus on the long-run spillovers of bank capital requirements in a two-country setting.

1. Model Economy

We consider a monetary union composed of two symmetric countries, Home, indexed by H and Foreign, indexed by F with equal sizes. Each country is populated by a household which provides consumption insurance to two types of members: workers and bankers, both of unitary measure. Workers supply labor to the production sector, deposit funds in the bank and hold capital. Bankers provide (inside) equity financing to the banks. In each period, with probability $1-\theta_b$ some bankers retire and become workers again and the same fraction of workers become bankers. Thus, the fraction of each type of household member remains constant. At the beginning of her activity each new banker receives an endowment from the household. Then, upon retirement the banker transfers her accumulated net worth to the

[4]Few other papers study the gain from coordination of macroprudential policy in multi-country DSGE models with cross-border banking in the absence of bank default risk (e.g. Agénor et al (2017), Darracq Paries, Kok and Rancoita (2019), Rubio (2020). San Millan (2023) instead extends the bank default model of Mendicino et al. (2018) to a two-country framework and highlights the role of the heterogeneity in the volatility of the banking sector for the cross-country setting of capital requirements.

household.

Banks invest in productive capital using the equity raised from the bankers and deposits supplied by the workers. Firms produce the final good using labor and capital using a Cobb-Douglas production function. Capital is financed by banks and by the household. The latter is however subject to a management cost which reflects a less efficient management of investment compared to the bank.

Finally, the central bank sets the short-term nominal rate following a Taylor-type rule at the monetary union level.

1.1 Households

In each country, the household maximizes the discounted future stream of utility

$$\begin{aligned} V_t = & \max_{C_t, L_t, B_{R,t}, B_{i,t}, D_t, K_{H,t}} \quad \log(C_t) - \varphi \frac{L_t^{1+\eta}}{1+\eta} + \beta_t \mathbb{E}_t \left[V_{t+1} \right], \\ \text{s.t.} \quad & C_t + (1+X_t) B_{R,t} + B_{i,t} + D_t + (q_t + p_{S,t}) K_{H,t} \\ & = R_t B_{R,t-1} + \frac{i_{t-1}}{\Pi_{t,t-1}} B_{i,t-1} + \frac{R_{D,t}}{\Pi_{t+1}} D_{t-1} + R_{K,t} q_{t-1} K_{H,t-1} + w_t L_t + T_t \end{aligned} \tag{1}$$

where where C_t denotes consumption, L_t hours worked in the production sector, w_t the real wage rate and $\Pi_{t+1} = P_{t+1}/P_t$ is the inflation rate. Households can save in bank deposits D_t that pays a gross return equal to $R_{D,t}/\Pi_{t+1}$. Households can also invest in nominal bonds $B_{i,t}$, an internationally traded asset $B_{R,t}$ at gross rate R_t, and capital $K_{H,t}$ with the real price q_t which costs the household the additional service fee in real terms $p_{S,t}$. T_t refers to the sum of all transfers which the household receives. $X_t \equiv e^{\varkappa_X (B_{R,ss} - B_{R,t})}$ is a portfolio adjustment cost. Everything is expressed in terms of the price of consumption.

Taking first order conditions

$$1 = \mathbb{E}_t \left[\Lambda_{H,t+1} R_{t+1} \right] \frac{1}{1 + X_t}, \tag{2}$$

$$1 = \mathbb{E}_t \left[\frac{\Lambda_{H,t+1}}{\Pi_{t,t-1}} \right] i_t, \tag{3}$$

$$1 = \mathbb{E}_t \left[\Lambda_{H,t+1} \tilde{R}_{D,t+1} \right], \tag{4}$$

$$1 = \mathbb{E}_t \left[\Lambda_{H,t+1} R_{K,t+1} \right] \frac{Q_t}{Q_t + P_{S,t}}, \tag{5}$$

$$W_t = \varphi L_t^{\eta} C_t, \tag{6}$$

where we define the real stochastic discount factor

$$\Lambda_{H,t} = \beta_t \frac{C_{t-1}}{C_t}. \tag{7}$$

1.1.0.1 Consumption Basket.

Both consumption and investment goods are made up of locally produced and imported goods. The relative share of local and imported goods is pinned down by minimising expenditure

$$\begin{aligned} \min_{C_{L,t}, C_{IM,t}} \quad & P_{L,t} C_{L,t} + P_{IM,t} C_{IM,t}, \\ \text{s.t.} \quad & C_t = \left[\chi^{1/\gamma} C_{L,t}^{\frac{\gamma-1}{\gamma}} + (1-\chi)^{1/\gamma} C_{IM,t}^{\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}. \end{aligned} \tag{8}$$

First order conditions give

$$C_{L,t} = \chi P_{L,t}^{-\gamma} C_t, \tag{9}$$

$$C_{IM,t} = (1-\chi) P_{IM,t}^{-\gamma} C_t. \tag{10}$$

1.2 Banking Sector

1.2.0.1 Bankers.

During their activity, bankers use their net worth (n_t) to provide equity financing (e_t) to two classes of banks j of competitive banks, that provide capital $K_{B,j,t}$ to either local firms ($j = L$) or foreign firms ($j = EX$). There is a continuum of banks in each class. Bankers can also pay dividends (dv_t) to the household by solving the following problems

$$V_{B,t} = \max_{e_{L,t}, e_{EX,t}, dv_t} \left\{ dv_t + \mathbb{E}_t \left[\frac{\Lambda_{B,t+1}}{\Pi_{t+1}} \left[(1-\theta_b)\, n_{t+1} + \theta_b V_{B,t+1} \right] \right] \right\} \tag{11}$$

subject to $e_{L,t} + e_{EX,t} + dv_t = n_t$, with

$$n_{t+1} = \frac{\int_0^\infty \rho_{L,t+1}(\omega) e_{L,t} dF(\omega) + \int_0^\infty \rho_{EX,t+1}(\omega) e_{EX,t} dF(\omega)}{\Pi_{t+1}} \tag{12}$$

and $dv_t \geq 0$, where $\rho_{t+1}(\omega)$ is the gross rate of return of the banker portfolio of equity.

By guessing that the value function is linear in net worth, (11) becomes $n_t \nu_t = \underset{e_t, dv_t}{max} \Big\{ dv_t + \mathbb{E}_t \left[\Lambda_{B,t+1} \left((1-\theta_b) + \theta_b \nu_{t+1} \right) n_{t+1} \right] \Big\}$, where $\Lambda_{B,t+1} = \Lambda_{t+1} \left(1 - \theta_b + \theta_b \nu_{t+1} \right)$ and ν_t is the shadow value of one unit of bank equity.[5]

Hence,interior equilibria in which both classes of banks receive strictly positive equity from bankers ($e_{j,t} > 0$) require the properly discounted gross expected return on equity at each class of bank to be equal to ν_t:

$$\mathbb{E}_t \left[\Lambda_{B,t+1} \rho_{L,t+1} \right] = \mathbb{E}_t \left[\Lambda_{B,t+1} \rho_{EX,t+1} \right] = \nu_t.$$

Finally, taking into account effects of retirement and the entry of new bankers, the

[5]Note that as long as $\nu_t > 1$ bankers only pay a final dividend when they retire.

evolution of active bankers' aggregate net worth can be described as:

$$n_t = \frac{(\theta_b + \chi_b 1 - \theta_b)\left(\rho_{L,t} e_{L,t-1} + \rho_{EX,t} e_{EX,t-1}\right)}{\Pi_t}. \tag{13}$$

1.2.0.2 Banks.

The representative bank of class j uses funding in the form of (inside) equity $E_{b,j,t}$ and deposits $D_{j,t}$ to purchases claims $K_{B,j,t}$ from final goods producing firms at price q_t. There are no financing frictions between firms and banks. Hence, the firm promise the bankers the realized return on a unit of capital in next period in exchange for borrowed funds today, which is $R_{K,j,t+1}$. The bank's returns on the capital is subject to an idiosyncratic shock $\omega_{j,t+1}$, such that the time $t+1$ gross return on assets is $\omega_{j,t+1} R_{K,j,t+1} q_t K_{B,j,t}$. We assume that $\omega_{j,t+1}$ follows a log-normal distribution with a mean of one and standard deviation of $\sigma_{B,j,t}$, and assume $\sigma_{B,L,t} = \sigma_{B,EX,t} \equiv \sigma_{B,t}$.

The bank operates over one period. It defaults if its terminal net worth is negative. If it is instead positive it gives it back to the bankers at the end of the period. Hence, the bank maximizes the real net present value (NPV) of the bankers' equity stake conditional on not defaulting

$$\max_{K_{B,j,t}, D_{j,t}} \mathbb{E}_t \left[\frac{\Lambda_{B,t+1}}{\Pi_{t+1}} \max \left\{ \omega_{j,t+1} R_{K,j,t+1} q_t K_{B,j,t} - R_{D,t+1} D_{j,t}, 0 \right\} \right] - \nu_t E_{j,t}$$

subject to the balance sheet constraint

$$q_t K_{B,j,t} = D_{j,t} + E_{j,t},$$

and the capital requirement constraint

$$E_{j,t} \geq \phi_j q_t K_{B,j,t}.$$

1.2.0.3 Default.

The bank receives iid shocks ω_t which are lognormally distributed $\log(\omega) \sim \mathcal{N}\left(-\frac{\sigma_{B,t}^2}{2}, \sigma_{B,t}^2\right)$. We can define the following objects

$$G_{j,t} = \int_0^{\bar{\omega}_{j,t}} \omega dF(\omega) = \Phi\left(\frac{log(\overline{\omega}_{j,t}) - \frac{\sigma_{B,t}^2}{2}}{\sigma_{B,t}}\right), \tag{14}$$

$$F_{j,t} = \int_0^{\bar{\omega}_{j,t}} dF(\omega) = \Phi\left(\frac{log(\overline{\omega}_{j,t}) + \frac{\sigma_{B,t}^2}{2}}{\sigma_{B,t}}\right). \tag{15}$$

The default threshold is then given by

$$\bar{\omega}_{j,t} = (1 - \phi_j)\frac{R_{D,t-1}}{\Pi_t R_{K,j,t}}, \tag{16}$$

and defaulting fraction of banks is

$$\Xi_t = (\bar{\omega}_{j,t} - \Gamma_{j,t} + \mu G_{j,t})/(1 - \phi_j), \tag{17}$$

where μ is a proportional repossession cost and $\Gamma_{j,t} = G_{j,t} + \bar{\omega}_{j,t}(1 - F_{j,t})$. Finally, we can define the return on equity $\rho_{j,t}$

$$\rho_{j,t} = (1 - \Gamma_{j,t})\, R_{K,j,t}/\phi_j, \tag{18}$$

where $R_{K,j,t} = (r_{K,j,t} + (1 - \delta)q_t)/q_{t-1}$ is the real return to capital.

1.2.0.4 Deposit insurance scheme.

Deposits are fully insured by a deposit insurance scheme (DIS). In the case of bank default, DIS sizes the value of bank assets after repossession costs $(1 - \mu)\omega_{t+1} R_{K,t+1} q_t K_{B,t}$ and pays insured deposits in full. Then the DIS ex-post balance its budget period-by-period by

charging lump-sum taxes to the household such that

$$T_{G,t} = -\Xi_t. \tag{19}$$

1.3 Capital Sector

1.3.0.1 Capital Basket.

Bank capital is made up of locally produced and imported capital. The relative share of local and imported good is pinned down by minimising expenditure

$$\begin{aligned} \min_{K_{L,t},K_{B,IM,t}} \quad & r_{L,t}K_{L,t} + r_{IM,t}K_{B,IM,t}, \\ \text{s.t.} \quad & K_t = \left[\chi_K^{1/\gamma} K_{L,t}^{\frac{\gamma-1}{\gamma}} + (1-\chi_K)^{1/\gamma} K_{B,IM,t}^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}} \end{aligned} \tag{20}$$

where $K_{L,t} \equiv K_{B,L,t} + K_{H,t}$. First order conditions give

$$K_{L,t} = \chi_K r_{L,t}^{-\gamma} K_t \tag{21}$$

$$K_{B,IM,t} = (1-\chi_K) r_{IM,t}^{-\gamma} K_t. \tag{22}$$

1.3.0.2 Investment Basket.

Similar to consumption and capital, the equivalent expressions for investments are

$$I_t = \left[\chi^{1/\gamma} I_{L,t}^{\frac{\gamma-1}{\gamma}} + (1-\chi)^{1/\gamma} I_{IM,t}^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{23}$$

$$I_{L,t} = \chi P_{L,t}^{-\gamma} I_t, \tag{24}$$

$$I_{IM,t} = (1-\chi) P_{IM,t}^{-\gamma} I_t. \tag{25}$$

1.3.0.3 Capital Production.

Producers of capital combine investment, I_t, with the previous stock of capital, K_{t-1}, in order to produce new capital which can be sold at nominal price Q_t.

Capital producers face adjustment costs as in Jermann (1998), such that $I_{ss} = \delta K_{ss}$ and $Q_{ss} = 1$. Hence

$$\begin{aligned} S(x) =& \frac{1}{1-1/\psi}\delta^{\frac{1}{\psi}}x^{1-\frac{1}{\psi}} - \frac{\delta}{1-\psi}, \\ S'(x) =& \delta^{\frac{1}{\psi}}x^{-\frac{1}{\psi}}. \end{aligned}$$

The law of motion of the capital stock can be written as

$$K_t = (1-\delta)K_{t-1} + S\left(\frac{I_t}{K_{t-1}}\right)K_{t-1}, \tag{26}$$

where δ is the depreciation rate of capital and aggregate capital is $K_t = K_{L,t} + K_{B,EX,t}$.

1.3.0.4 Capital management firms.

A measure-one continuum of competitive firms operating with decreasing returns to scale manage the capital directly held by households in exchange for a fee s_t per unit of capital. These firms have a quadratic cost function $\frac{\zeta}{2}K_{H,t}^2$, with $\zeta > 0$. Their profit maximization implies $P_{S,t} = \zeta K_{H,t}$.

1.4 Closing Up

The nominal bond is in zero-net supply $B_{i,t} = 0$. With cross-border trade in a bond denominated in the home currency we have the following returns

$$R_t = \frac{i_{t-1}}{\Pi_t}, \tag{27}$$

$$R_t^* = R_t \frac{RER_t^*}{RER_{t-1}^*}. \tag{28}$$

The real exchange rate adjusts to clear the market for the internationally traded bond

$$B_{R,t} + RER_t B_{R,t}^* = 0, \tag{29}$$

with

$$\frac{RER_t}{RER_{t-1}} = \frac{\Pi_t^*}{\Pi_t}, \tag{30}$$

$$RER_t = 1/RER_t^*. \tag{31}$$

Net-exports are defined as

$$NX_t = r_{EX,t} K_{B,EX,t} + P_{EX,t} CEX_t - P_{IM,t} CIM_t - r_{IM,t} K_{B,IM,t} \tag{33}$$

where imports and exports are

$$K_{B,EX,t} = K_{B,IM,t}^*, \tag{34}$$

$$IM_t = I_{IM,t} + C_{IM,t}, \tag{35}$$

$$EX_t = IM_t^*. \tag{36}$$

The law of one price holds so that

$$P_{EX,t} = P_{L,t}, \tag{37}$$

$$P_{IM,t} = RER_t P^*_{EX,t} \tag{38}$$

$$r_{IM,t} = RER_t r^*_{EX,t}. \tag{39}$$

Finally, we define the terms of trades as defined as

$$\mathcal{T}_t \equiv \frac{P_{IM,t}}{P_{EX,t}}. \tag{40}$$

2. Model Calibration

The model is calibrated using EA quarterly macroeconomic, banking and financial data for the period 2001:1–2016:4.[6]

[TABLES 1- 2 HERE]

The countries are fully symmetric and union averages are targeted. We start by setting some model's parameters in line with existing literature. See Table 1. We set the Frisch elasticity of labor supply, η, equal to 1 and the labor disutility parameter, φ, to 1 and the capital-share parameter of the production function, α, equal to 0.3. The depreciation rate of physical capital, δ, equals 0.03. The bankruptcy cost parameter, μ, is set equal to a common value of 0.30. ψ in the adjustment cost function of capital producing firms is calibrated to 2 as in CITE.[7]

[6] See Online Appendix for details on the data series used in the calibration.

[7] Calibrating the parameter ψ would require the matching of second order moments, i.e. moments that require the specification of the stochastic structure of the model. Since the analysis in this paper abstract from aggregate shocks, we borrow from the calibration in CITE, a value for the parameter which is in the middle of the range of values used in the literature.

We set the trade elasticity for consumption, investment and capital aggregators γ to 2, which is in the ballpark of the literature values. We set the home bias parameter for consumption and investment χ equal to 0.7.

We calibrate the remaining parameters simultaneously so as to match key data targets. The steady state inflation parameter, Π^*_{ss}, and the discount factor, β, directly pin down the inflation target of 1.77% per year and the yearly risk free rate of 2.32%. We calibrate the home bias for capital parameter, χ_K, to match the share of cross-border loans extended by EA banks which amounts to 10%. The capital requirement level, ϕ, is set to the reference capital requirement of 8% that characterized Basel I and II for both countries and types of banks.[8]

The parameter of the capital management cost function, ζ, is set to match the share of physical capital directly held by savers in the model with an estimate, based on EA flow of funds data, of the proportion of assets of the NFC sector whose financing is not supported by banks. The new bankers' endowment parameter, χ_b is used to make the steady state return on equity, ρ_b, equal to the average cost of equity of EA banks banks. In addition, the survival rate of bankers, θ_b, is used so that the shadow value of bank equity, ν_b, matches the average price-to-book ratio of banks. We set the standard deviation of the banks idiosyncratic shock $\sigma_{B,ss}$, to match the average probability of default of banks. As shown in Table 2, all targets are matched perfectly.

[8]Basel II featured a total regulatory capital requirement equal to 8% of "risk weighted assets". Thus calibrating ϕ to 8% implies assuming that risky capital in the model carry a full risk-weight, as it is the case for loans to unrated corporations under the standardized approach of Basel II and III.

3. Cross-Border Spillovers of Capital Requirements on Domestic Exposures

In this section we use the calibrated model to characterize the cross-country spillovers from changes in bank capital requirements. We start by assessing the effects on capital requirements on domestic exposures by domestically owned banks. Figure 1 reports the steady state comparative statics with respect to the capital requirements ϕ_H, i.e. the requirement which applies to the investment by Home banks in Home capital. In what follows we explore the implications of varying capital requirements for the Home country and the spillovers to the Foreign country.shows how key macro and financial variables change as the bank capital requirement at Home is increased.

[Figure 1 HERE]

3.1 Impact on Home Country

The black solid line in Figure 1 depicts the impact of changes in ϕ_H the impact on Home prices and quantities.

The impact of higher capital ratios at Home flow from the reduction of bank leverage which brings costs and benefits to the domestic economy. The main benefit is that the probability of bank default declines together with its associated deadweight costs. As deposits are insured and the costs of failing banks are paid by the Home fiscal authority, ultimately the Home households bears them and hence benefits from their mitigation.

The reduction in the supply of Home goods which improves the Home terms of trade, also leads to increased consumption of imported goods. This is a benefit for the Home country which is specific to an open economy framework.

The cost is that, due to the higher cost of equity relative to debt, better capitalized banks

experience an increase in their weighted average cost of capital. They pass the higher cost on to firms and households, leading to somewhat lower lending volumes, investment and GDP.

3.2 Impact on Foreign Country

We consider two countries linked via trade in goods and via cross-border bank loans but where each country's deposit insurance (DI) fund is domestically financed. Importantly, cross-border bank loans are assumed to be made through bank branches so they are financed with deposits raised from the bank's home country and covered by the home country's DI fund.

Results highlight two channels through which changes in Home capital requirements spillover over to the Foreign country: the trade channel and the cross-border lending channel. Foreign consumes a CES basket of Home and Foreign goods, the reduction in the supply of Home goods and the associated rise in the relative price of Home goods reduces Foreign consumption of imports (*negative trade spillovers*).

The red dashed line in Figure 1 also clearly demonstrates the negative cross-border lending spillovers onto the Foreign economy. While the tightening of capital requirements in the Home country, promotes cross-border lending by Foreign banks, there is a reduction in Home banks' lending to the Foreign economy. Home banks' international exposures are not directly affected by higher capital requirements at Home, there is an indirect impact that works through the higher capital requirement on the overall Home banks' portfolio forcing Home banks to contract also their investment abroad (*negative cross-border lending spillovers*).

3.3 Welfare Effects

[Figure 2 HERE]

We now use Welfare as a summary measure of the net benefits of capital requirement tightening in each country.

Overall, despite the negative effect on production, the potential net benefits of higher capital requirements for the Home economy can be seen in aggregate consumption and welfare. Over a certain range of (not too high) capital requirements, the benefits due to lower deadweight default costs result in higher consumption and welfare. See solid black line in panel (A) of Figure 2.

Welfare in the Foreign country instead deteriorates with higher capital requirements on domestic exposures of Home banks. This reflects the presence of the negative trade and cross-border lending spillovers. See red dotted lines in panel (A) of Figure 2.

The difference between the optimal "union-wide" capital requirements and the associated welfare levels provides a summary statistic of the spillovers between the two countries. We see that the capital requirement that maximises Union-wide welfare is a lower than the Home one, but closer to the Home rather than the Foreign optimum, suggesting that the negative spillover imposed on the Foreign countries are less sizeable than the overall benefits accruing to the Home country.

4. Reciprocation of Capital Requirement Tightening

[Figure 3 - 4 HERE]

The previous experiment we assumes tighter capital requirements only applies on domestic exposures by domestically owned banks in the Home country. Now, we consider the case in which the Foreign country decides to reciprocate the capital requirement tightening. Hence, all exposures in the Home countries are subject to the same increase in capital requirements. This regardless of whether those are by Home banks or Foreign banks.

In the Basel III framework, the reciprocation of macroprudential measures is compul-

sory for Countercyclical Capital Buffers (CCyB). When a country increases the CCyB on its domestically regulated banks, other countries authomatically apply the higher capital requirements to its branches operating in the activating country. However, it is still but voluntary for other measures. Indeed, reciprocity does not automatically apply to certain types of capital increases, such as capital conservation buffers or systemic buffers.

Cross-country Spillovers. Under reciprocity, in addition to the trade and cross-border lending spillovers, the Foreign country experiences an additional spillover which operates via the bank solvency channel. The latter is the results of the imposition of tighter capital requirements on the international exposure of the Foreign economy, which increases the soundness of the banking sector in the Foreign country (*positive bank solvency spillovers*). See red dashed line in Figure 3.

Welfare. The positive bank solvency spillovers is the main reason why higher bank capital requirements in Home can improve Foreign welfare. See red dashed line in panel (B) of Figure 2. While the probability of failure of Foreign banks' operations in Foreign do not change, Foreign banks operating in Home become safer, reducing the DI costs for Foreign households.

The welfare figure shows a non-monotonic effect: welfare increases for small increases and declines thereafter indicating that the spillovers are partially offsetting. GDP in the Foreign country experience a smaller decline as Home capital requirements are increased but the welfare loss from this is partially offset by the reduction in the reduction in the cost of bank default.

The difference in welfare between the Home and Union-wide capital requirement and the country specific choices is further reduced, indicating that the presence of offsetting spillovers generate a rather smaller overall welfare distortion. Overall, the benefits of reciprocating capital requirements are summarized in Figure 4 which compares the Union-wide welfare with and without reciprocity.

5. Common Deposit Insurance

[Figure 5 - ?? HERE]

Finally we add an additional financial linkage between the two countries: a common deposit insurance (DI) fund. This is considered to be an important part of the Banking Union in Europe (CITATIONS) because it would improve risk-sharing and coordination among European countries. The benefits of jointly financed DI are not modelled in our framework and a full cost-benefit analysis is beyond the scope of our paper. Instead, we examine its implications for the cross-border spillovers due to capital requirement changes. For this exercise, we the capital requirement implementation on domestic exposure by Home banks under the assumption of reciprocity by the Foreign economy.

A common DI fund implies that depositor losses due to bank failures are shared by the fiscal authorities of both countries:

$$T_G = T_G^{MU} \tag{41}$$

$$T_G^* = RER_t^* T_G \tag{42}$$

where $T_{G,t}^{MU} = T_{G,t} + RER_t T_{G,t}^*$.

The common DI amplifies the *positive solvency spillover*: fewer bank defaults in one country now benefit both countries rather than predominantly the domestic country.

Spillovers. Figure 5 shows how the Home economy (black dashed lines) and Foreign economy (red dotted lines) are affected by higher capital requirements on Home loans. Comparing the solid line in Figure 5 to the one with nationally funded DI (Figure 3), we can see that there is little difference in the impact on GDP, investment and bank default in Home as the Home capital requirement is increased. The fundamental effect of capital requirements on the domestic banking sector is unchanged. Higher capital requirements reduce costly bank

failures while also increasing the weighted average cost of capital for banks with negative effect on the production of domestic goods.

Welfare. Where common deposit insurance makes a bigger difference relative to nationally funded DI is in the division of the gains from higher Home capital requirements. See panel (D) of Figure 2. We can now see that Home welfare rises much less relative to the Baseline and it peaks at a lower bank capital ratio. In contrast, Foreign welfare now increases in a much more remarkable way with higher Home capital requirements, peaking at a higher level.

The behaviour of welfare in the two countries is intuitive. Home suffers very similar costs from a reduction in domestic production as in the baseline. However, it captures only half of the benefits from lower bank failure costs since it now shares those costs with the Foreign economy to begin with. In contrast, Foreign gains since it captures some of the benefits from lower deposit insurance costs without paying any of the costs from restricting domestic leverage and hence domestic goods supply.

The different wealth effect of higher capital requirements spills over on to the terms of trade too. We see from the dashed line in Figure 5 that despite the reduction in the supply of Home goods, the Home terms of trade now deteriorate between 8 and 9 per cent capital requirements and only improves afterwards. Foreign households anticipate lower future tax liabilities from deposit insurance costs and this wealth effect leads to higher consumption. Since preferences exhibit home bias, this boosts demand for Foreign goods and pushes up Foreign's terms of trade. This effect is strongest over the range of capital requirements that lead to the largest decline in the probability of failure of Home banks. Once Home's banks become sufficiently safe, higher capital requirements start to reduce Foreign's terms of trade as in the Baseline.

This exercise demonstrates that common DI, while beneficial for a number of (here unmodelled) reasons, considerably dilutes the incentives of individual countries to set the socially optimal capital requirements from a union-wide perspective. Hence, in a banking union

setting, a centralized framework for setting bank capital requirements would become even more important than it is currently with the nationally funded DI framework.

6. Additional Results

In this section we show that the results results presented above are robust to alternative institutional frameworks. First, we show that the a common DI amplifies the net positive spillovers of capital requirements even without reciprocation of capital requirements. Second, we consider the case of country-specific capital requirement measures which also apply to all exposures of domestic banks, including their foreign exposures. In this case, the cross-border lending spillovers are amplified. However, the results are qualitatively unchanged.

6.1 Common Deposit Insurance without Reciprocity

[Figure 6 HERE]

6.2 Capital Requirements on All Domestic Exposures

[Figures 7-9 HERE]

7. Conclusions

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Table 1: Baseline Calibration

Parameter	**Notation**	**Value**	**Calibration**
PREFERENCES			
Discount Factor	β	0.9942	Calibrated
Frish Elasticity	η	1	Preset
Dis-Utility Labour	φ	1	Preset
Portfolio Adjustment Costs	$\varkappa_X$	1	Preset
TECHNOLOGY			
Capital Share	α	0.3	Preset
Depreciation	δ	0.03	Preset
Capital Adjustment Cost	ψ	2	Preset
Capital Service Cost	ζ	0.00022	Calibrated
FINANCIAL			
Bank Survival	θ_B	0.9098	Calibrated
Start-Up Funding	ξ	0.8075	Calibrated
SS Capital Requirement	ϕ_{ss}	0.08	Calibrated
Default Costs	μ	0.3	Preset
SS IID Risk	$\sigma_{B,ss}$	0.0286	Calibrated
INTERNATIONAL			
Trade Elasticity	γ	2	Preset
Home Bias	χ	0.7	Preset
Home Bias for Capital	χ_K	0.92	Calibrated
STEADY STATES			
Net Foreign Assets	B_{ss}	0	Preset
Inflation	Π^*_{ss}	1.0044	Calibrated

Note: Baseline parameterization of the model.

Table 2: Model fit

Targets	**Definition**	**Data**	**Model**
Real risk-free rate	$(\beta - 1) \times 400$	2.32	2.32
Inflation	$(\bar{\pi} - 1) \times 400$	1.77	1.77
Capital requirement	ϕ	0.08	0.08
Banks' default	$F(\overline{\omega}) \times 400$	0.665	0.665
Real equity return of banks	$(\rho - 1) \times 400$	7.066	7.066
Banks' price to book ratio	ν	1.148	1.148
Capital share of households	K_H/K	0.22	0.22
Export Capital share of banks	$K_{B,EX}/(K_{B,EX} + K_{B,L})$	0.10	0.10

Note: Data targets used to calibrate the model as well as the corresponding model values.

A Model Appendix

B Data Appendix

- Gross Domestic Product: Gross domestic product at market price, Chain linked volumes, reference year 2005, Euro. Source: ESA - ESA95 National Accounts, Macroeconomic Statistics (S/MAC), European Central Bank.

- GDP Deflator: Gross domestic product at market price, Deflator, National currency, Working day and seasonally adjusted, Index. Source: ESA - ESA95 National Accounts, Macroeconomic Statistics (S/MAC), European Central Bank.

- Fraction of capital held by households: We set our calibration target for this variable by identifying it with the proportion of assets of the NFC sector whose financing is not supported by banks. To compute this proportion we use data from the EA sectoral financial accounts, which include balance sheet information for the NFC sector (Table 3.2) and a breakdown of bank loans by counterparty sector (Tables 4.1.2 and 4.1.3). From the raw NFC balance sheet data, we first produce a "net" balance sheet in which,

in order to remove the effects of the cross-holdings of corporate liabilities, different types of corporate liabilities that appear as assets of the NFC sector get subtracted from the corresponding "gross" liabilities of the corporate sector. Next we construct a measure of leverage of the NFC sector

$$LR = \frac{\text{NFC Net Debt Securities } + \text{ NFC Net Loans } + \text{ NFC Net Insurance Guarantees}}{\text{NFC Net Assets}}$$

and a measure of the bank funding received by the NFC sector

$$BF = \frac{\text{MFI Loans to NFCs}}{\text{NFC Net Assets}}.$$

From these definitions, the fraction of debt funding to the NFC sector not coming from banks can be found as $(LR - BF)/LR$. Finally, to estimate the fraction of NFC assets whose financing is not supported by banks, we simply assume that the financing of NFC assets not supported by banks follows the same split of equity and debt funding as the financing of NFC assets supported by banks, in which case the proportion of physical capital in the model not funded by banks, K_H/K, should just be equal to $(LR - BF)/LR$. This explains the target value of K_H/K in Table 2 .

- Bank Equity Return: Median Return on Average Equity (ROAE), 100 Largest Banks, Euro Area. Source: Bankscope.

- Price to book ratio for banks. Source: Datastream

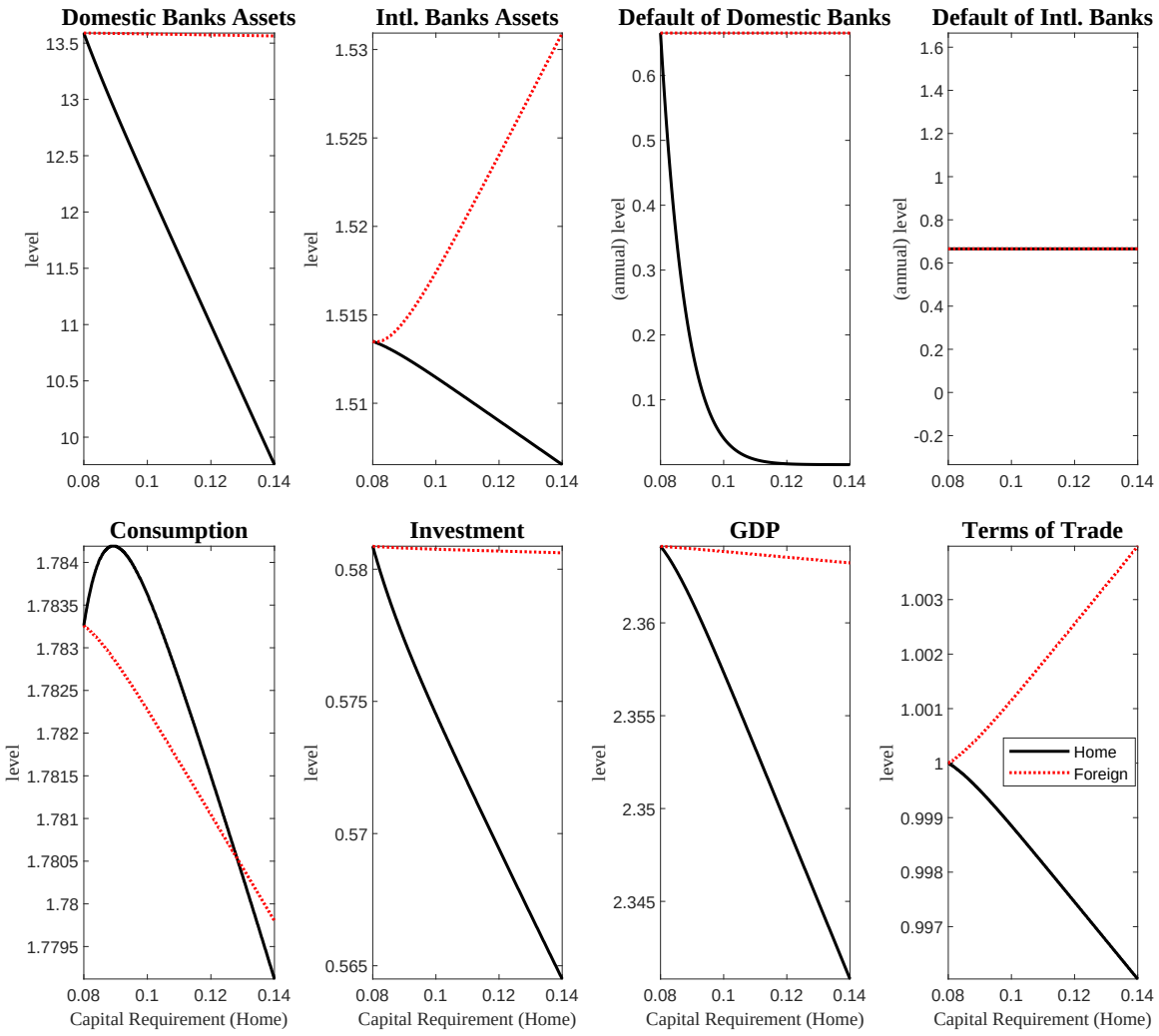
- Cross Border Capital Share: we collect proprietary data for 300 largest banks in the Euro Area for the period 2003–2023. The IBSI dataset contains detailed information on loans extended not only to domestic firms but also to foreign firms operating in other EA countries. We treat subsidiaries of foreign banks as domestic banks because they are domestically active and domestically regulated even if they are foreign owned.

Using this data, we compute

$$\text{share of cross-border loans}_t = \frac{\sum_b \text{Foreign Corporate Loans}_{b,t}}{\sum_b (\text{Domestic + Foreign Corporate Loans})_{b,t}}.$$

Source: Individual Balance Sheet Item (IBSI).

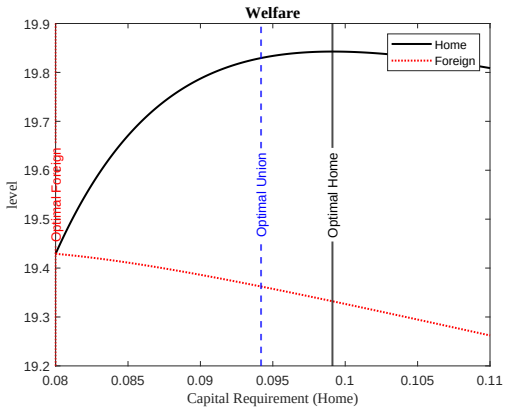
Figure 1: Capital Requirements on Domestic Exposure: Spillovers (w/o Reciprocity)



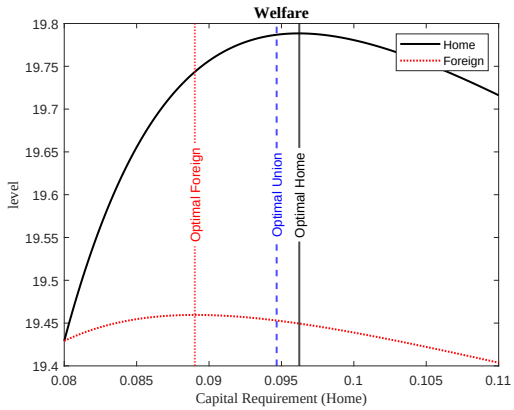
Notes:

Figure 2: Tighter Capital Requirements on Domestic Exposure: Welfare Implications

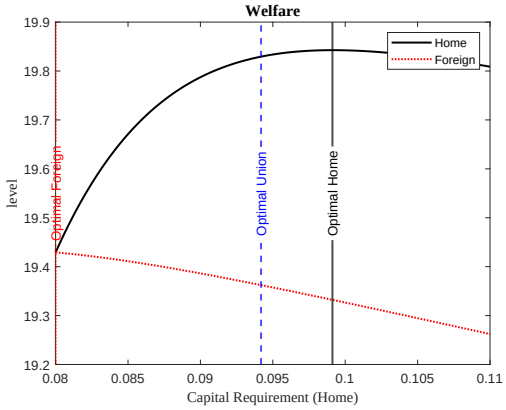
(A) Baseline (w/o Reciprocity)



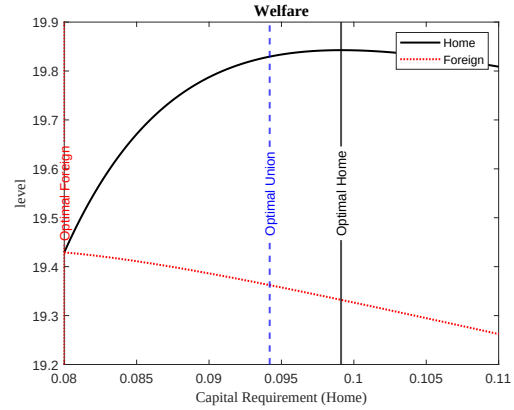
(B) Baseline (with Reciprocity)



(C) Common DI (w/o Reciprocity)

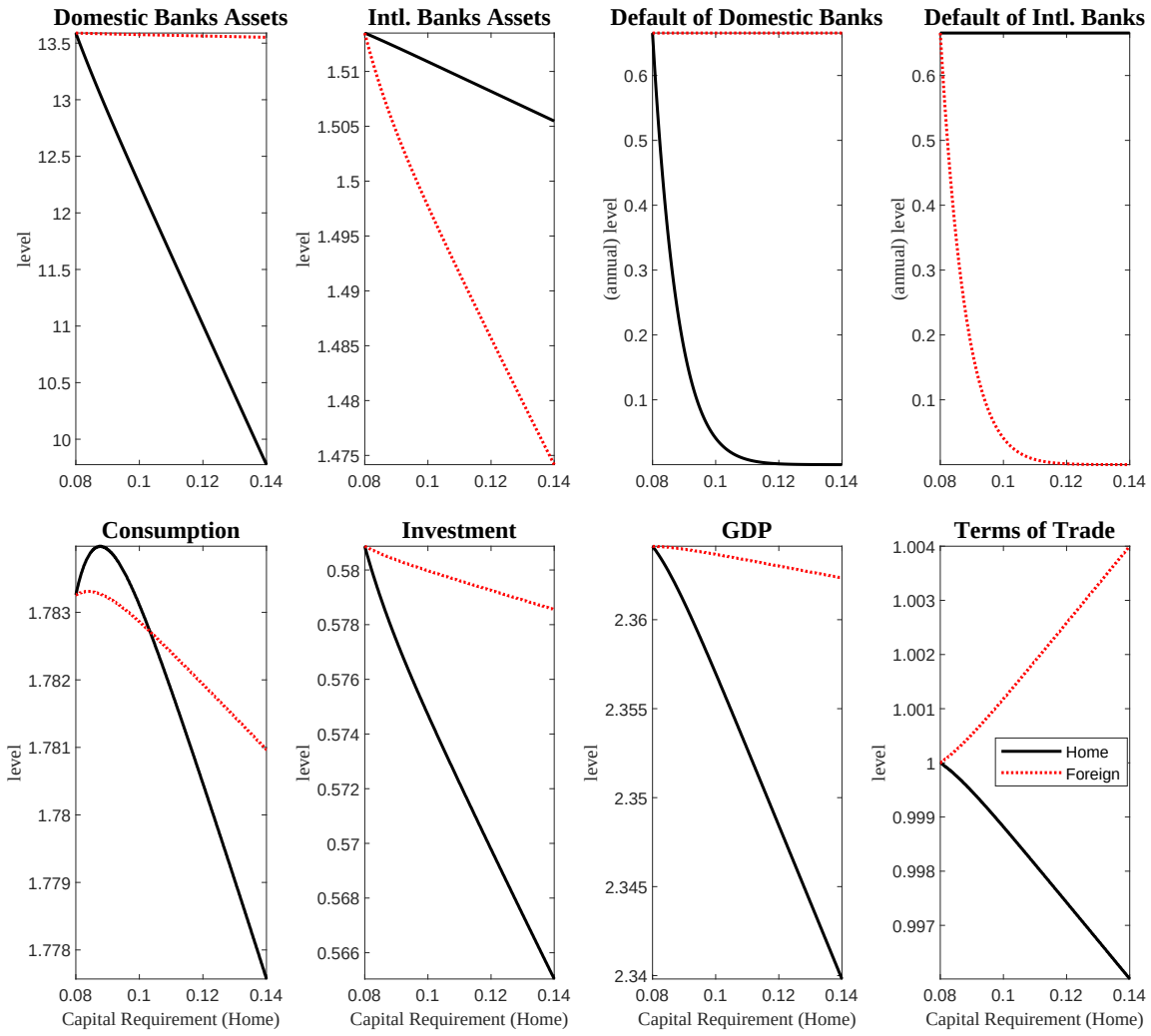


(D) Common DI (with Reciprocity)



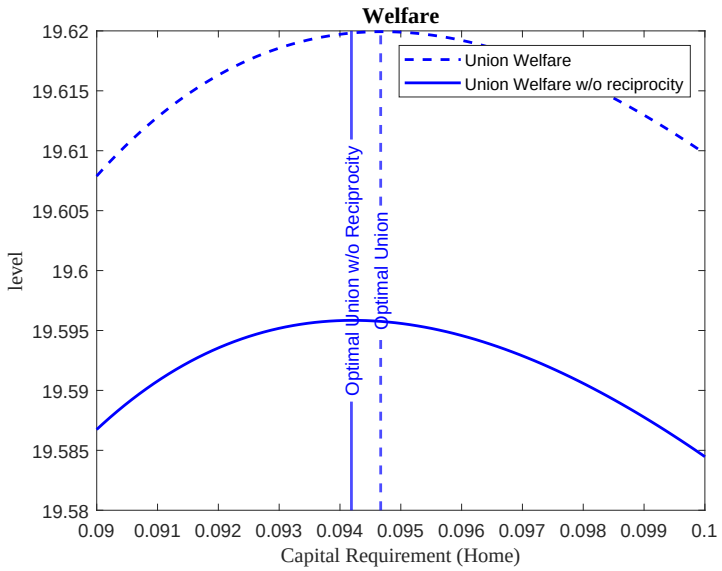
Notes: Welfare implications of higher capital requirements on domestic exposure in Home country. The top panels of this figure present the case of nationally funded DI. The bottom panels of this figure present results for common DI.

Figure 3: Capital Requirements on Domestic Exposure: Spillovers (with Reciprocity)



Notes:

Figure 4: Capital Requirements on Domestic Exposure: Union-Wide Welfare



Notes:

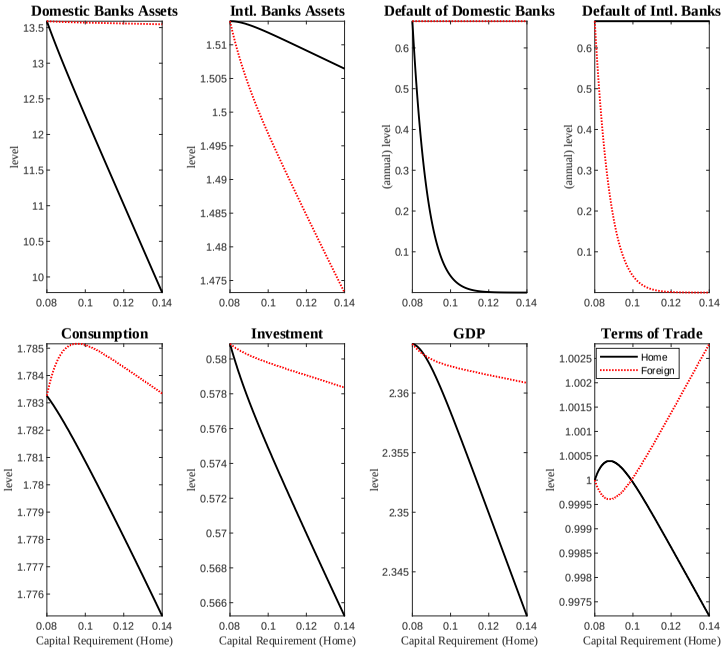


Figure 5: Common DI (with Reciprocity)

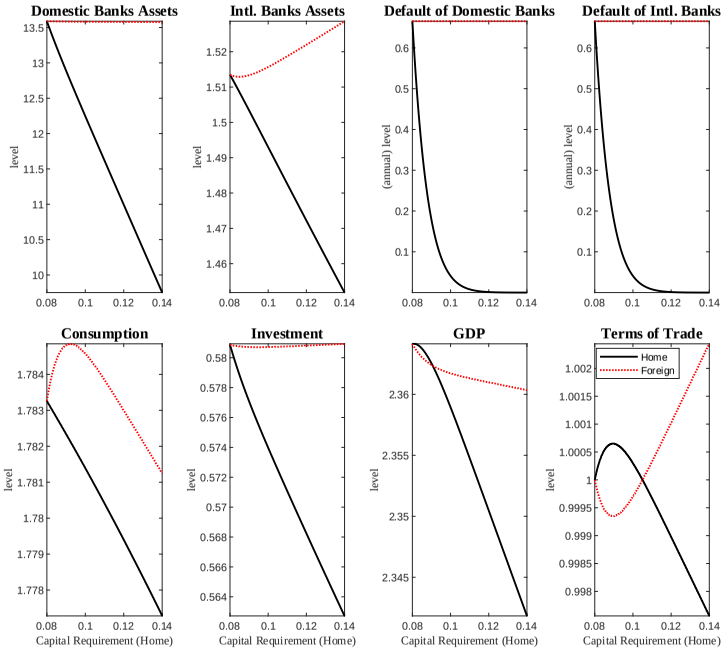


Figure 6: Common DI (w/o Reciprocity)

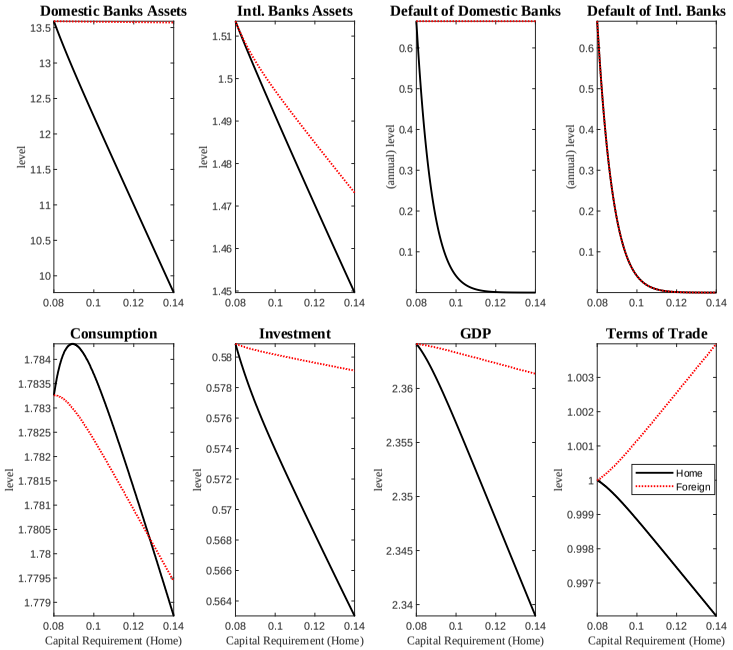


Figure 7: CR on All Exp. (with Reciprocity)

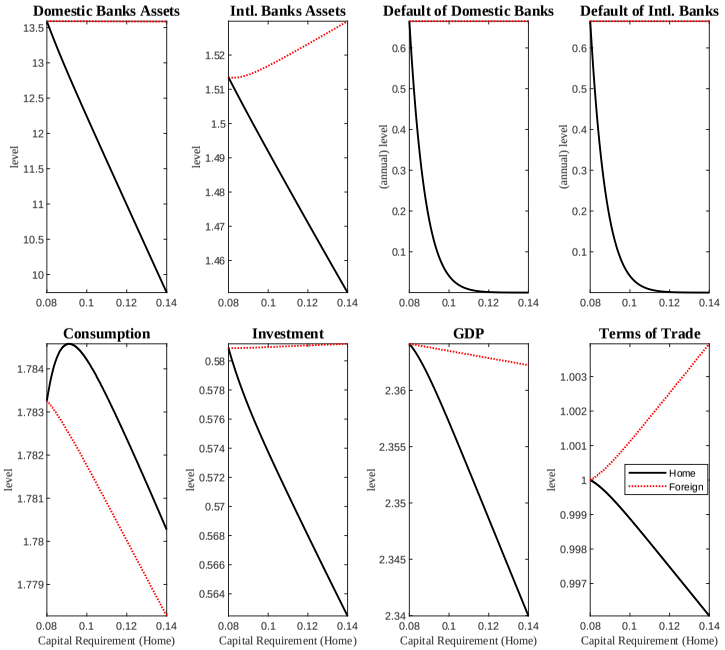
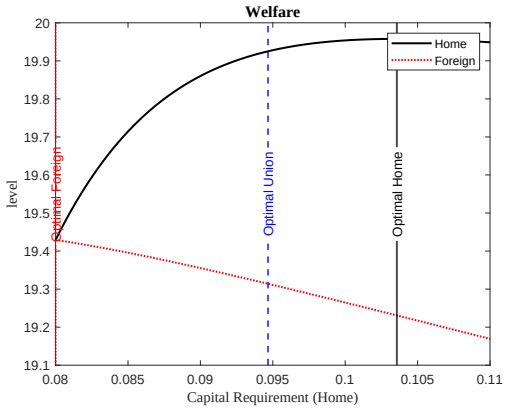


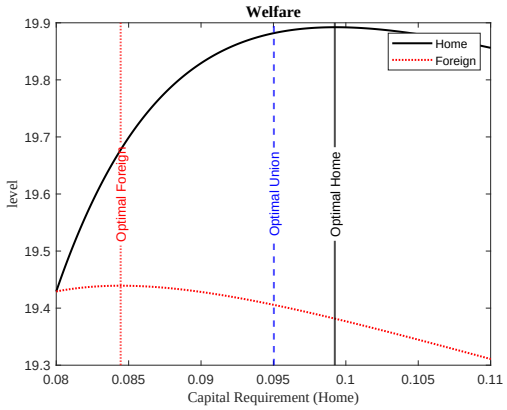
Figure 8: CR on All Exp.(w/o Reciprocity)

Figure 9: Tighter Capital Requirements: Home and Foreign Welfare Implications

(A) All Exposures (w/o Reciprocity)



(B) All Exposures (with Reciprocity)



Notes: Welfare implications of higher capital requirements on all exposure of domestic banks in Home country. The left panel panels presents the case of no reciprocation of capital requirement tightening. The right panel presents results under reciprocation of measures.