Cross-Border Regulatory Spillovers and Macroprudential Policy Coordination

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Abstract

We develop a core-periphery model with financial frictions and cross-border banking to assess the magnitude of regulatory spillovers and the gains from macroprudential policy coordination. A core global bank lends to its affiliates in the periphery and banks in both regions are subject to risk-sensitive capital regulation. Following an expansionary monetary policy in the core, a countercyclical response in capital requirements in the core induces the global bank to increase cross-border lending. We calculate welfare gains associated with countercyclical capital buffers under a range of policy regimes, including independent policymaking, full coordination, and reciprocity—a regime in which capital ratios set in the core are imposed on the global bank's affiliates abroad. One of our key results is that, even when regulatory spillovers are strong, reciprocity can make all parties better off if regulators attach a sufficient weight to financial stability considerations. With a standard, utility-based welfare criterion, reciprocity may also perform better than independent policymaking when regulatory spillovers are weak.

Keywords: Regulatory Spillovers, Macroprudential Policy, Cooperation

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1. Introduction

In recent years there has been greater recognition that, in a world where financial institutions and markets are highly interconnected, differences in national macroprudential policies can be an important source of international spillovers. In response to, for instance, a tightening of capital requirements at home, banks with a global presence may respond by increasing lending abroad, to either their affiliates or foreign-country borrowers. Avdjiev et al. (2017), Beirne and Friedrich (2017), Forbes et al. (2017), Hills et al. (2017), Tripathy (2020) and Franch et al. (2021) have all provided evidence to that effect. To the extent that it reflects an equilibrium response by lenders and borrowers, this loan portfolio reallocation (often referred to as *regulatory arbitrage*), is not inherently good or bad. Nevertheless, observers have argued that it may lead to large swings in capital flows, which in turn may magnify the transmission of financial shocks and exacerbate financial risks in recipient countries.[1] In turn, aggregate fluctuations and policy responses in recipient countries may generate significant spillback effects, through both trade and financial channels, which may hamper the achievement of the initial objectives set out by regulators in source countries. The implication is that the combination of national macroprudential policies may be sub-optimal from the perspective of the world economy—even when each country's national macroprudential policy, taken in isolation, is optimal. If policy decisions, when taken independently, can magnify risks for all parties, coordination (in some form) may improve welfare and promote global financial stability. This reasoning is what underlies Basel III's *Principle of reciprocity*, which applies to countercyclical capital buffers.[2]

From a theoretical perspective, it is important to note that even though cross-border spillovers and spillbacks associated with changes in national regulation may be significant, it does not necessarily follow that they reduce global welfare and that cooperation is *prima facie*

[1] See Buch and Goldberg (2017) for a review of the evidence.

[2] See Basel Committee on Banking Supervision (2011) and Agénor and Pereira da Silva (2022) for a discussion.

welfare improving. Indeed, as argued by Korinek (2016), if capital flows reflect an equilibrium response of optimizing agents (as noted earlier), they are not necessarily a source of Pareto inefficiencies. Korinek's *first welfare theorem for open economies* spells out the conditions that need to be violated to generate inefficiency and create a scope for cooperation. One of these conditions relates to limitations in the ability to use policy instruments, due, for instance, to manipulation costs, which affect the policymaker's objective function and create incentives for burden sharing.

Contributions aimed at modeling regulation-induced cross-border bank capital flows and at quantifying the gains from macroprudential coordination remain scant. Agénor et al. (2019, 2021), for instance, present relevant two-region, core-periphery DSGE models with financial frictions, but macroprudential policy is modeled as a generic tax and the issue of reciprocity in capital requirements is not discussed. Chen and Phelan (2021) also abstracted from reciprocity arrangements.

This paper contributes to the literature in two related ways. We characterize the cross-border spillovers that occur when regulators in the core region tighten their macroprudential stance in response to an expansionary monetary shock in that region. We then evaluate the potential benefits of reciprocity agreements involving countercyclical capital buffers, which respond endogenously to credit fluctuations. Specifically, the paper extends the model in Agénor et al. (2019) by assuming, first, that banks in the periphery are all affiliates set up by the global bank and loans between them occur through an internal capital market. Second, the model accounts for economies of scope in lending domestically and abroad by the global bank. Third, banks in both regions are subject to a risk-sensitive capital regulatory regime and countercyclical capital buffers react endogenously to credit fluctuations. Fourth, as in Korinek (2016), we account for instrument manipulation costs and study their implications for coordination. Fifth, we conduct our analysis in terms of a general specification of policy preferences, which dwells on Bodenstein et al. (2019) and Agénor and Jackson (2022), and allows us to assess the extent to which institutional mandates matter for assessing policy performance. Using a parameterized version of the model, an expansionary monetary policy in the core—a key driver of the global financial cycle—is used to illustrate how changes in capital regulation and borrowing costs affect cross-border bank capital flows. Welfare gains are calculated for four policy regimes: core activism only (in which the core regulator sets its policy so as to maximize its own objective function, whereas the periphery regulator does not react), independent policies (Nash), coordination, and reciprocity—a regime where countercyclical capital buffers set in the core region are also imposed on affiliates of the global bank operating in the periphery. An important novelty of our analysis therefore is to treat reciprocity (or *partial* cooperation) as an independent policy regime, whose performance can be compared with other regimes.

Our main results can be summarized as follows. Following an expansionary monetary policy in the core, a countercyclical increase in capital requirements in that region induces the global bank to reallocate more of its loan portfolio towards lending to its affiliates abroad. The magnitude of this regulatory-induced cross-border spillover (or regulatory spillover, for short) depends on the degree of substitutability between domestic and foreign loans, which is captured through a cost parameter related to the degree of economies of scope in lending. If regulatory spillovers are weak, reciprocity performs uniformly better than the core acting alone, regardless of the importance regulators attach to financial stability. However, the stronger spillovers are, the larger must be the weight on financial stability for reciprocity to be Pareto-improving, that is, for the policy response to benefit all parties—and therefore the world at large.[3]

With a standard, utility-based welfare criterion, reciprocity may also perform better than Nash if regulatory spillovers are weak or if concerns for financial stability are suffi-

[3] The focus on Pareto improvements, as in Agénor and Jackson (2022), for instance, provides a stricter policy evaluation criterion than requiring only that cooperation benefits the world as a whole—an outcome that may occur, both in our setting and in general, even if one party is worse off. Thus, the issue of how cooperation agreements should be enforced (a recurrent concern in practice) becomes irrelevant.

ciently strong. At the same time, even when reciprocity is Pareto-improving, gains relative to the core acting alone are not generally large. This may help to explain why, in practice, reciprocity agreements are rarely activated.[4] Finally, our analysis shows that, in an asymmetric world in which domestic distortions can exacerbate financial risks associated with capital flows, and regulators are concerned with financial stability, the presence of instrument manipulation costs is a necessary, but not sufficient, condition for coordination to be Pareto-improving. Extensive sensitivity analysis, including a stock treatment of bank capital, show that these results are robust to a wide range of specification and parameter alterations.

How do these results compare to the relevant literature? Partial equilibrium models of international macroprudential policy coordination include, from a banking perspective, Acharya (2003), Dell'Ariccia and Marquez (2006), Kara (2016), and Park and Kim (2018), from a banking perspective, and Bengui (2014) and Jeanne (2014), from a broader macroeconomic perspective. This literature has shed useful light on a number of factors, including heterogeneity in the structure of banking markets, liquidity provision, and cross-border spillovers. However, the partial equilibrium nature of these models, even properly calibrated, also means that they are not well suited to provide a through quantitative assessment of the gains associated with macroprudential coordination. In addition, none of them assesses the performance of reciprocity arrangements. As noted earlier, to our knowledge, the only DSGE-based contribution that relates directly to ours is Rubio (2020). In her model macroprudential regulation takes the form of setting a loan-to-value ratio (a borrower-based instrument), whereas in ours it consists of capital requirements (a lender-based instrument), along the lines of Basel III. More importantly, the case that she considers is one where only the core responds to a shock in its own jurisdiction; reciprocity is defined in terms of both countries responding optimally, using separate instruments. By contrast, in our paper reci-

[4]See https://www.bis.org/bcbs/ccyb/ for a summary of the evidence on reciprocity activations.

procity (or *partial* coordination) corresponds to the case where the periphery applies the *same* countercyclical response parameter as the core. Thus, what Rubio defines as reciprocity corresponds, in our framework, to *full* cooperation. Thus, her results are not strictly comparable to ours. Nevertheless, we also found, as she did, that full cooperation, compared to the core acting alone, can be Pareto-improving—with the caveat that, in our case, this occurs only if regulators care sufficiently about financial stability.

The remainder of the paper proceeds as follows. Section 2 presents the model. Its equilibrium and its steady-state solution are briefly characterized in Section 3, and its parameterization is discussed in Section 4. Section 5 considers an expansionary financial shock in the core, with and without the activation of countercyclical capital buffers in that region. Welfare gains from reciprocity are assessed in Section 6. The last section concludes.

2. The Model

The world economy consists of two regions, core and periphery, of size $n \in (0,1)$ and $1-n$, respectively. Each region is populated by a representative household, a continuum of monopolistic firms producing intermediate goods (IG), a representative final good producer (FG), a representative capital good producer (KG), a government, a central bank, and a regulator. IG firms produce intermediates using labor and physical capital, and set prices in monopolistic fashion. The KG producer borrows from local banks to invest and transform final goods into physical capital, which is rented to IG firms. Trade between the two regions involves only intermediate goods. A single global bank operates in the core economy. It owns a continuum of affiliates in the periphery. Regions trade in government bonds, but markets for cash and credit are segmented. In particular, firms in either region cannot directly lend or borrow internationally. The exchange rate between the two regions is fully flexible.

Banks in both regions issue debt-like instruments to satisfy a risk-sensitive capital regulatory regime. This assumption is consistent with the growing use of hybrid securities, or so-called contingent convertible capital instruments, or CoCos, to absorb losses (by converting them into common equity) and satisfy regulatory capital requirements. Under Basel III (and its implementation legislation, such as CRD V in the European Union), CoCos can qualify as either Additional Tier 1 (AT1) or Tier 2 capital.[5] Banks pay interest on household deposits and the liquidity that they borrow from the central bank, as well as interest on the liabilities that they issue. At the end of each period, banks close their books and start afresh at the beginning of the next period. Thus, all profits are distributed.

2.1. Core Economy

In what follows we describe the behavior of households, the global bank and the regulatory capital regime, the central bank, and the regulator in the core economy. The structure of production is the same in both regions, and details for these sectors, as well as the government, are relegated to Appendix A. Superscripts C and P are used (as first acronym) to identify core and periphery, respectively.

2.1.1. Households

The objective of the representative household in the core economy is to maximize

$$U_t^C = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left\{ \frac{(C_{t+s}^C)^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} - \eta_N \frac{(\int_0^1 N_{t+s}^{C,j} dj)^{1+\psi_N}}{1+\psi_N} + \ln[(x_{t+s}^C)^{\eta_x} (H_{t+s}^C)^{\eta_H}] \right\}, \tag{1}$$

where C_t^C is consumption of the final good, $N_t^{C,j}$ hours provided to IG producer j, x_t^C a composite index of real monetary assets, H_t^C the housing stock, $\Lambda \in (0,1)$ a discount factor, $\varsigma > 0$ the intertemporal elasticity of substitution, ψ_N the inverse of the Frisch elasticity of labor supply, $\mathbb{E}_t$ the expectation operator, and $\eta_N, \eta_x, \eta_H > 0$ are preference parameters.

[5] Issuance of CoCos by banks has increased substantially since they were first used in 2009, especially in the form of AT1 instruments. See Avdjiev et al. (2020).

The monetary asset consists of cash balances, m_t^C, and bank deposits, d_t^C, both measured in terms of the price of final output, P_t^C:

$$x_t^C = (m_t^C)^\nu (d_t^C)^{1-\nu}. \qquad \nu \in (0,1) \tag{2}$$

The household's flow budget constraint is

$$\begin{aligned} &m_t^C + d_t^C + b_t^{CC} + z_t^{-1} b_t^{CP} + p_t^{CH} \Delta H_t^C + V_t^C \\ &\qquad = w_t^C N_t^C - T_t^C - C_t^C + \frac{m_{t-1}^C}{1+\pi_t^C} + (\frac{1+i_{t-1}^{CD}}{1+\pi_t^C}) d_{t-1}^C + (\frac{1+i_{t-1}^{CB}}{1+\pi_t^C}) b_{t-1}^{CC} \\ &\qquad + (1+i_{t-1}^P) z_t^{-1} b_{t-1}^{CP} + J_t^{CI} + J_t^{CK} + J_t^{CB} + (\frac{1+i_{t-1}^{CV}}{1+\pi_t^C}) V_{t-1}^C - \Theta_V^C \frac{(V_t^C)^2}{2}, \end{aligned} \tag{3}$$

where $N_t^C = \int_0^1 N_t^{C,j} dj$, $p_t^{CH} = P_t^{CH}/P_t^C$ is the real price of housing (with P_t^{CH} denoting the nominal price), $1+\pi_t^C = P_t^C/P_{t-1}^C$, b_t^{CC} ($z_t^{-1} b_t^{CP}$) real holdings of one-period, noncontingent core (periphery) government bonds, $z_t = E_t P_t^C / P_t^P$, the real exchange rate measured from the perspective of the periphery, with P_t^P the price of the periphery's final good and E_t the nominal exchange rate (defined so that an increase is a depreciation), i_t^{CD} the interest rate on bank deposits, i_t^{CB} the interest rate on core government bonds, i_t^P the premium-adjusted (or *effective*) interest rate on periphery government bonds, w_t^C the economy-wide real wage, T_t^C real lump-sum taxes, and J_t^{CI}, J_t^{CK}, and J_t^{CB}, end-of-period profits (if any) of the IG producer, the KG producer, and the global bank, respectively. V_t^C represents real holdings of bank capital (modeled as one-period debt, as noted earlier), and i_t^{CV} the nominal interest rate on bank capital. The last term, $0.5\Theta_V^C (V_t^C)^2$, represents transactions costs that households incur when holding bank capital, with $\Theta_V^C > 0$.[6] Housing does not depreciate.

Households face intermediation costs when acquiring periphery bonds on international markets. The effective rate of return on these bonds is given by

$$1 + i_t^P = (1 + i_t^{PB})(1 - \theta_t^{CP}) \mathbb{E}_t (E_t / E_{t+1}), \tag{4}$$

[6] As in Markovic (2006), for instance, the presence of these costs can be viewed as reflecting asymmetric information. They capture the fact that households may incur costs (for instance, fees paid to brokers or credit rating agencies in practice) to continually assess the health of the banks for which they have invested in. For simplicity, this cost is taken to be a deadweight loss for society.

where i_t^{PB} is the (unadjusted) periphery bond rate and θ_t^{CP} an intermediation premium, which increases with the core household's own stock of periphery bonds:

$$\theta_t^{CP} = 0.5\theta_0^B b_t^{CP}, \tag{5}$$

with $\theta_0^B > 0$ denoting a symmetric cost parameter. This specification captures in a simple way the assumption of imperfect capital mobility across regions.[7]

The household maximizes (1) subject to (2)-(5), and taking the path of interest rates, the periphery bond rate, as well as prices and inflation, and all lump-sum transfers and taxes, as given. The full set of first-order conditions are provided in Appendix A; they give, in particular,

$$V_t^C = \frac{i_t^{CV} - i_t^{CB}}{\Theta_V^C(1+i_t^{CB})}, \quad b_t^{CP} \simeq \frac{(1+i_t^{PB})\mathbb{E}_t(E_t/E_{t+1}) - (1+i_t^{CB})}{\theta_0^B(1+i_t^{PB})\mathbb{E}_t(E_t/E_{t+1})}. \tag{6}$$

The first equation defines the demand for bank capital, which is positively (negatively) related to the rate of return on these assets (government bonds). With no adjustment cost ($\Theta_V^C = 0$), it boils down to $i_t^{CV} = i_t^{CB}$. The second equation defines core household demand for periphery bonds.

2.1.2. Global Bank

The balance sheet of the global bank is given by

$$l_t^{CK} + l_t^{PC} = V_t^C + d_t^C + l_t^{CB}, \tag{7}$$

where l_t^{CK} is lending to core KG producers, l_t^{PC} lending to its affiliates in the periphery, l_t^{CB} borrowing from the core central bank, and

$$V_t^C = V_t^{CR} + V_t^{CE}, \tag{8}$$

with V_t^C denoting total capital, V_t^{CR} required capital, and V_t^{CE} excess capital. Deposits and central bank loans are perfect substitutes.

[7] See Agénor (2020, Chapter 1) for a discussion. For simplicity, these intermediation costs are also taken to be a pure deadweight loss.

The global bank is subject to risk-based capital requirements; it must hold an amount of capital that covers an endogenous percentage of its risky loans to domestic producers. Loans to its affiliates in the periphery are made through an internal capital market and are not subject to regulation. With σ_t^{CK} denoting the risk weight on domestic loans, capital requirements are given by

$$V_t^{CR} = \rho_t^C \sigma_t^{CK} l_t^{CK}, \tag{9}$$

where $\rho_t^C \in (0,1)$ is the capital adequacy ratio, defined later. The risk weight is inversely related to the repayment probability of core firms on their loans, $q_t^C \in (0,1)$:

$$\sigma_t^{CK} = (q_t^C/\tilde{q}^C)^{-\phi_q^C}, \tag{10}$$

where $\phi_q^C \geq 0$ and $\tilde{q}^C$ is the steady-state value of q_t^C.

The global bank's expected real profits at the end of period t (or beginning of $t+1$), $\mathbb{E}_t J_{t+1}^{CB}$, are defined as

$$\mathbb{E}_t J_{t+1}^{CB} = q_t^C(1+i_t^{CL})l_t^{CK} + (1-q_t^C)\kappa \mathbb{E}_t p_{t+1}^{CH} H_t^C \tag{11}$$

$$+(1+i_t^{CP})l_t^{PC} - (1+i_t^{CD})d_t^C - (1+i_t^{CR})l_t^{CB} - (1+i_t^{CV})V_t^C$$

$$-\gamma_V^C V_t^C + (1-\phi_E^C)^{-1}\gamma_{VV}^C (V_t^{CE})^{1-\phi_E^C} - \Gamma(l_t^{CK}, l_t^{PC}),$$

where i_t^{CR} is the marginal cost of borrowing from the central bank (the refinance rate) and i_t^{CP} the interest rate on lending to affiliates in the periphery. The first term in (11) is expected repayment when there is no default by domestic firms, whereas the second is the value of collateral seized in case of default, corresponding to a fraction $\kappa \in (0,1)$ of the expected value of the housing stock, $\mathbb{E}_t p_{t+1}^{CH} H_t^C$. The third term is income from lending to affiliates. The fourth term is repayment to depositors and the fifth repayment to the central bank.

The sixth term, $(1+i_t^{CV})V_t^C$, represents the gross value of bank capital redeemed. The linear term, $\gamma_V^C V_t^C$, captures the cost associated with issuing capital, such as underwriting costs. The term $\gamma_{VV}^{C}(1-\phi_{E}^{C})^{-1}(V_t^{CE})^{1-\phi_E^C}$, where $\gamma_{VV}^{C} \geq 0$ and $\phi_E^C \in (0,1)$, captures the view that maintaining a positive level of excess capital generates a pecuniary benefit—it represents a signal that the bank's financial position is strong, and reduces the intensity of regulatory scrutiny, which in turn reduces the cost associated with providing the information required by the supervision authority.[8] The restriction $\phi_E^C < 1$ ensures that holding excess capital entails decreasing marginal benefits.

The term $\Gamma(l_t^{CK}, l_t^{PC})$ measures the nonseparable cost of managing the two types of bank loans and is defined as

$$\Gamma(l_t^{CK}, l_t^{PC}) = \gamma_K l_t^{CK} + \gamma_L l_t^{PC} + 2\gamma\sqrt{l_t^{CK} l_t^{PC}}, \tag{12}$$

where $\gamma_K, \gamma_L > 0$ and $\gamma < 0$. Thus, economies of scope (or cost complementarity) prevails; lending more domestically reduces the cost of lending abroad, and vice versa.[9]

The global bank sets the domestic deposit and loan rates, the cost of borrowing by affiliates, and the amount of excess capital, so as to maximize expected profits (11), subject to the balance sheet and capital requirement constraints (7)-(9), the cost function (12), taking all other variables as given:

$$1+i_t^{CD}, 1+i_t^{CL}, 1+i_t^{CP}, V_t^{CE} = \arg\max \mathbb{E}_t J_{t+1}^{CB}.$$

As shown in Appendix B, the solution to this problem gives

$$1+i_t^{CD} = \frac{\eta_D}{1+\eta_D}(1+i_t^{CR}), \tag{13}$$

$$1+i_t^{CL} = \frac{\eta}{q_t^C}\left\{(1-\rho_t^C\sigma_t^{CK})(1+i_t^{CR}) + \rho_t^C\sigma_t^{CK}(1+i_t^{CV}+\gamma_V^C) + \gamma_K + \gamma\left(\frac{l_t^{PC}}{l_t^{CK}}\right)^{0.5}\right\}, \tag{14}$$

[8] Excess capital holdings is a common characteristic of banking systems around the world, as documented, for instance, by the World Bank (2020, Figure O.4). The signal essentially means that the bank has a bigger cushion in case of distress; see Repullo and Suarez (2013).

[9] There is broad evidence of economies of scope in banking (see Beccalli and Rossi (2020)), as they relate to bank loans and deposits. However, as far as we know, no study has focused specifically on efficiency in the joint production of domestic and foreign loans. We therefore consider extensive sensitivity analysis with respect to γ.

$$1 + i_t^{CP} = \frac{\eta_P}{1+\eta_P}\left\{1 + i_t^{CR} + \gamma_L + \gamma(\frac{l_t^{CK}}{l_t^{PC}})^{0.5}\right\}, \tag{15}$$

$$V_t^{CE} = (\frac{\gamma_{VV}^C}{i_t^{CV} + \gamma_V^C - i_t^{CR}})^{1/\phi_E^C}, \tag{16}$$

where η_D, η_L and η_P are gross interest elasticities of the supply of deposits, the demand for domestic loans, and the demand for foreign loans, respectively, and $\eta = \eta_L/(1+\eta_L)$.

Equation (13) defines the deposit rate as a mark-down over the refinance rate. Equation (14) shows that the loan rate depends negatively on the repayment probability and positively on a weighted average of the gross refinance rate, $1 + i_t^{CR}$, and the marginal cost of raising bank capital, $1 + i_t^{CV} + \gamma_V^C$. Weights on each component of funding costs are measured in terms of the ratio of required capital to loans, $1 - \rho_t^C\sigma_t^{CK}$ and $\rho_t^C\sigma_t^{CK}$, respectively. Thus, assuming that raising funds through bank capital is more costly than borrowing from the central bank ($i_t^{CV} + \gamma_V^C > i_t^{CR}$), all else equal an increase in the capital adequacy ratio, ρ_t^C, or the risk weight, σ_t^{CK}, also increases the loan rate. In addition, because of cost complementarity ($\gamma < 0$), an increase in the foreign-domestic loan ratio lowers the marginal cost of producing loans and reduces the cost of lending.

Equation (15) shows that the interest rate on loans to periphery banks is a markup over the marginal cost of lending, which consists of the cost of borrowing from the central bank (the refinance rate) augmented by the marginal cost of issuing and managing loans to periphery banks, given by the derivative of the cost function (12) with respect to l_t^{PC}. Because $\gamma < 0$, an increase in the relative proportion of lending at home reduces the marginal cost of producing foreign loans and lowers the cost of borrowing for periphery banks.

Equation (16) shows that an increase in the cost of issuing capital reduces excess capital, whereas an increase in the marginal benefit, γ_{VV}^C, raises it. Finally, from (8), (9), and (16), it can be inferred that an increase in the capital ratio raises the cost of issuing bank capital. In turn, this has a negative effect on the desired level of excess capital. In that sense, required and excess capital holdings are substitutes.

The repayment probability on loans to local firms depends positively on the expected value of collateral relative to the volume of loans, and the cyclical position of the economy:

$$q_t^C = (\frac{\kappa \mathbb{E}_t p_{t+1}^{CH}/\tilde{p}^{CH}}{l_t^{CK}/\tilde{l}^{CK}})^{\psi_1^C}(\frac{Y_t^C}{\tilde{Y}^C})^{\psi_2^C}, \quad \psi_1^C, \psi_2^C > 0 \tag{17}$$

where $\tilde{Y}^C$ is the steady-state level of core final output.[10] The collateral-loan ratio reflects a moral hazard effect, whereas the cyclical position of the economy reflects the fact that (unit) monitoring costs tend to fall in good times.

2.1.3. Central Bank and Regulator

The central bank operates a standing facility, through which its supply of (uncollateralized) loans to the global bank, l_t^{CB}, is perfectly elastic at the prevailing policy rate, i_t^{CR}. It supplies cash, in quantity m_t^{Cs}, to households and firms. Its balance sheet is thus

$$l_t^{CB} = m_t^{Cs}. \tag{18}$$

In turn, the policy rate is set on the basis of an inertial Taylor rule:

$$\frac{1+i_t^{CR}}{1+\tilde{\imath}^{CR}} = (\frac{1+i_{t-1}^{CR}}{1+\tilde{\imath}^{CR}})^{\chi^C} \left\{ (\frac{1+\pi_t^C}{1+\pi_T^C})^{\varepsilon_1^C} (\frac{Y_t^C}{\tilde{Y}^C})^{\varepsilon_2^C} \right\}^{1-\chi^C} \epsilon_t, \tag{19}$$

where $\chi^C \in (0,1)$, $\varepsilon_1^C > 1$, $\varepsilon_2^C > 0$, $\tilde{\imath}^{CR}$ is the steady-state value of the refinance rate, $\pi_T^C \geq 0$ the inflation target, and ϵ_t a stochastic shock which follows a first-order autoregressive process, $\epsilon_t = (\epsilon_{t-1})^{\rho_\epsilon} \exp(\xi_t)$, where $\rho_\epsilon \in (0,1)$ and $\xi_t \sim \mathbf{N}(0, \sigma_\xi)$ is a serially uncorrelated random shock with zero mean.

The capital ratio consists of deterministic and cyclical components, ρ^{CD}, and ρ_t^{CC}:

$$\rho_t^C = \rho^{CD} + \rho_t^{CC}. \tag{20}$$

[10] Agénor and Pereira da Silva (2017), dwelling on Allen et al. (2011), formally derive an equation similar to (17) as part of the bank's optimization problem, by assuming that monitoring costs are endogenous and that *ex ante* monitoring effort is directly related to the probability of repayment.

Component ρ^{CD} can be viewed as the minimum capital adequacy ratio imposed under the Basel arrangements, whereas ρ_t^{CC} is the countercyclical capital buffer, which is adjusted in response to credit growth:

$$\frac{1+\rho_t^{CC}}{1+\tilde{\rho}^{CC}} = \left(\frac{1+\rho_{t-1}^{CC}}{1+\tilde{\rho}^{CC}}\right)^{\chi_1^C} \left\{ \left(\frac{l_t^{CK}}{l_{t-1}^{CK}}\right)^{\chi_2^C} \right\}^{1-\chi_1^C}, \tag{21}$$

where $\chi_1^C \in (0,1)$ and $\chi_2^C > 0$. The focus on credit growth is consistent with Basel III's recommendations, and the evidence suggesting that excessive credit expansion has often been associated with financial crises (see Taylor (2015)). In effect, credit is an *operational target* for financial stability.

2.2. *Periphery*

As for the core, we consider in turn the behavior of households, commercial banks, the central bank, and the regulator.

2.2.1. *Households*

Periphery households have the same utility function, and a similar budget constraint, as core households. Their resource allocation problem is thus similar, with the effective rate of return on core government bonds i_t^C defined as, symmetrically to (4),

$$1 + i_t^C = (1 + i_t^{CB})(1 - \theta_t^{PC})\mathbb{E}_t(E_{t+1}/E_t), \tag{22}$$

where θ_t^{PC} is the intermediation premium faced by periphery households, defined as in (5):

$$\theta_t^{PC} = 0.5\theta_0^B b_t^{PC}. \tag{23}$$

The solution is analogous to the one derived for the core in Appendix A. In particular,

$$V_t^P = \frac{i_t^{PV} - i_t^{PB}}{\Theta_V^P(1+i_t^{PB})}, \qquad b_t^{PC} \simeq \frac{(1+i_t^{CB})\mathbb{E}_t(E_{t+1}/E_t) - (1+i_t^{PB})}{\theta_0^B(1+i_t^{CB})\mathbb{E}_t(E_{t+1}/E_t)}, \tag{24}$$

where $\Theta_V^P > 0$. The first equation defines demand for bank capital and the second demand for core government bonds. The first equations in (6) and (24) give $1 + i_t^{PB} \simeq (1 + i_t^{CB})\mathbb{E}_t(E_{t+1}/E_t)$ when $\theta_0^B \to 0$, which corresponds to uncovered interest parity.

2.2.2. *Commercial Banks*

The balance sheet of periphery bank $i \in (0,1)$ is given by

$$l_t^{PK,i} = (1-\mu)d_t^{P,i} + V_t^{P,i} + z_t l_t^{PC,i} + l_t^{PB,i}, \tag{25}$$

where $l_t^{PK,i}$ is loans to firms, $d_t^{P,i}$ deposits, $\mu \in (0,1)$ the required reserve ratio on these deposits, $z_t l_t^{PC,i}$ borrowing from the global bank (with $l_t^{PC,i}$ measured in foreign-currency terms), at the rate $i_t^{CP,i}$, $V_t^{P,i}$ total capital, and $l_t^{PB,i}$ borrowing from the central bank.

Under nonreciprocity, commercial banks (which are all foreign affiliates of the global bank) are subject to regulation by the host jurisdiction. Total bank capital and the risk-based regulatory regime are thus characterized by equations similar to (8)-(10):

$$V_t^{P,i} = V_t^{PR,i} + V_t^{PE,i},$$

$$V_t^{PR,i} = \rho_t^P \sigma_t^P l_t^{PK,i} = \rho_t^P (q_t^{P,i}/\tilde{q}^{P,i})^{-\phi_q^P} l_t^{PK,i}, \tag{26}$$

where ρ_t^P is the capital adequacy ratio and $\phi_q^P \geq 0$.

The market for deposits is competitive, and deposits and central bank liquidity are perfect substitutes. Thus,

$$i_t^{PD,i} = (1-\mu)i_t^{PR}. \tag{27}$$

By contrast, monopolistic competition prevails in the loan market. The demand for loans to bank i, $l_t^{PF,i}$, is given by the downward-sloping curve

$$l_t^{PK,i} = (\frac{1+i_t^{PL,i}}{1+i_t^{PL}})^{-\zeta_L} l_t^{PK}, \tag{28}$$

where $i_t^{PL,i}$ is bank i's loan rate, $l_t^{PK} = [\int_0^1 (l_t^{PK,i})^{(\zeta_L-1)/\zeta_L} di]^{\zeta_L/(\zeta_L-1)}$ the amount borrowed by the KG producer (equal to the level of investment, as shown in Appendix A), with $\zeta_L > 1$ denoting the elasticity of substitution between differentiated loans, and $1 + i_t^{PL} = [\int_0^1 (1+i_t^{PL,i})^{1-\zeta_L} di]^{1/(1-\zeta_L)}$ the aggregate loan rate.

Expected profits of bank i at the end of period t are given by

$$\mathbb{E}_t J_{t+1}^{PB,i} = q_t^{P,i}(1+i_t^{PL,i})l_t^{PK,i} + (1-q_t^{P,i})\left(\kappa^i \mathbb{E}_t p_{t+1}^{PH} H_t^P\right) - (1+i_t^{PD,i})d_t^{P,i} + \mu d_t^{P,i} \tag{29}$$
$$-(1+i_t^{PR})l_t^{PB,i} - (1+i_t^{CP})\mathbb{E}_t(\frac{E_{t+1}}{E_t})z_t l_t^{PC,i} - \gamma_P z_t \frac{(l_t^{PC,i})^2}{2}$$
$$-(1+i_t^{V,i})V_t^{P,i} - \gamma_V^P V_t^{P,i} + (1-\phi_E^P)^{-1}\gamma_{VV}^P (V_t^{PE,i})^{1-\phi_E^P},$$

where $\gamma_{VV}^P, \gamma_V^P > 0$, $\phi_E^P \in (0,1)$, i_t^{PR} is the refinance rate, and $q_t^P \in (0,1)$ the repayment probability. As before, the first two terms represent expected income (with $\mathbb{E}_t p_{t+1}^{PH} H_t^P$ the expected value of housing collateral) from lending, the third interest paid on deposits, the fourth reserve requirements held at the central bank, the fifth repayment on loans from the central bank, and the sixth repayment to the global bank. In addition, periphery banks incur a convex cost that increases with global bank loans, $0.5\gamma_P z_t (l_t^{PC,i})^2$, where $\gamma_P > 0$. This assumption helps to capture in a simple way imperfect substitutability between domestic and foreign borrowing. The last three terms relate to the cost of servicing bank capital and the benefit that excess capital provides, analogously to (11).

Each bank maximizes profits with respect to their loan rate, excess capital, and their demand for foreign loans, subject to (25) and (28), taking all other variables as given:

$$1+i_t^{PL,i}, V_t^{PE}, z_t l_t^{PC,i} = \arg\max \mathbb{E}_t J_{t+1}^{PB,i}. \tag{30}$$

As shown in Appendix B, in a symmetric equilibrium the solution is

$$1+i_t^{PL} = \frac{\zeta^L}{(\zeta^L - 1)q_t^P}[(1-\rho_t^P \sigma_t^P)(1+i_t^{PR}) + \rho_t^P \sigma_t^P (1+i_t^{PV} + \gamma_V^P)], \tag{31}$$

$$l_t^{PC} = \frac{1}{\gamma_P}\left\{(1+i_t^{PR}) - (1+i_t^{CP})\mathbb{E}_t(\frac{E_{t+1}}{E_t})\right\}, \tag{32}$$

$$V_t^{PE} = (\frac{\gamma_{VV}^P}{i_t^{PV} + \gamma_V^P - i_t^{PR}})^{1/\phi_E^P}. \tag{33}$$

Equation (31) shows once again that a tighter macroprudential response raises the cost of loans, whereas equation (32) indicates that a higher cost of borrowing from the global bank (adjusted for expected depreciation) reduces the demand for foreign loans. Equation (33) takes the same form as (16).

The repayment probability, as in (17), depends positively on the expected value of collateral relative to the volume of loans, and the cyclical position of the economy:

$$q_t^P = (\frac{\kappa \mathbb{E}_t p_{t+1}^{PH}/\tilde{p}^{PH}}{l_t^{PK}/\tilde{l}^{PK}})^{\psi_1^P}(\frac{Y_t^P}{\tilde{Y}^P})^{\psi_2^P}, \quad \psi_1^P, \psi_2^P > 0 \tag{34}$$

where Y_t^P is the periphery's final output and $\tilde{Y}^P$ its steady-state value.

2.2.3. Central Bank and Regulator

Under full exchange rate flexibility, analogously to (18) the balance sheet of the periphery central bank is given by

$$l_t^{PB} = m_t^{Ps}. \tag{35}$$

The periphery central bank also operates a standing facility. Its refinance rate is set through a Taylor rule similar to (19):

$$\frac{1+i_t^{PR}}{1+\tilde{\imath}^{PR}} = (\frac{1+i_{t-1}^{PR}}{1+\tilde{\imath}^{PR}})^{\chi^P}\left\{(\frac{1+\pi_t^P}{1+\pi_T^P})^{\varepsilon_1^P}(\frac{Y_t^P}{\tilde{Y}^P})^{\varepsilon_2^P}\right\}^{1-\chi^P}, \tag{36}$$

where $\pi_T^P \geq 0$ is the inflation target, $\chi^P \in (0,1)$ and $\varepsilon_1^P, \varepsilon_2^P > 0$.

As in (20) and (21), the regulator sets both a deterministic component, ρ^{CD}, and a cyclical component, ρ_t^{PC}, of the capital ratio,

$$\rho_t^P = \rho^{PD} + \rho_t^{PC}, \tag{37}$$

with the latter responding again to credit growth:

$$\frac{1+\rho_t^{PC}}{1+\tilde{\rho}^{PC}} = (\frac{1+\rho_{t-1}^{PC}}{1+\tilde{\rho}^{PC}})^{\chi_1^P}\left\{(\frac{l_t^{PK}}{l_{t-1}^{PK}})^{\chi_2^P}\right\}^{1-\chi_1^P}, \quad \chi_1^P \in (0,1), \ \chi_2^P > 0 \tag{38}$$

2.3. Regulatory Reciprocity

Suppose now that regulators engage in a reciprocity agreement, which requires imposing to periphery banks (which, again, are all affiliates of the global bank) the same capital adequacy ratio as applied in the core, is in place.[11] Thus, instead of (26), we have

$$V_t^{PR} = \rho_t^C \sigma_t^P l_t^{PK}, \tag{39}$$

where σ_t^P remains as defined earlier. Equations (31) now includes ρ_t^C instead of ρ_t^P, whereas (37) and (38) no longer apply.

The main financial flows between agents and regions are summarized in Figure 1.

3. Equilibrium and Steady State

The equilibrium conditions of the model are provided in Appendix A. Many of these conditions are standard, whereas others reflect the specific focus of this paper. For instance, given that the global bank sets the interest rate on loans to the periphery banks (see 16)), market equilibrium requires the actual supply of loans to be determined by (32). In addition, from (8), (9), the equilibrium condition of the market for bank capital is

$$V_t^C = \rho_t^C \sigma_t^{CK} l_t^{CK} + V_t^{CE}, \tag{40}$$

which, using (6) and (16), can be used to solve for the rate of return on bank capital, i_t^{CV}. The bond rate is solved from the equilibrium condition of the money market.

The steady-state solution of the model is briefly described in Appendix D. Several of its key features are fairly standard and fundamentally similar to those described in Agénor et al. (2019), so we also refer to that paper for a more detailed discussion.

[11] Thus, in this regime, capital requirements faced by periphery banks are the same, whether banks are subject to core or periphery regulation. The implication is that, although under existing banking legislation affiliates should be interpreted as branches under reciprocity (rather than subsidiaries), to ensure a consistent comparison the optimization problem of periphery banks is the same regardless of how they are incorporated.

4. Parameterization

The model's parameterization dwells to a significant extent on standard values used in the literature on small open-economy and two-country models. Accordingly, this section focuses on the parameters that are important from the perspective of this study. A more detailed discussion is relegated to Appendix D.

The core and periphery regions correspond to two groups of countries: *major advanced economies* (MAEs) and *systemically-important middle-income countries* (SMICs), respectively. As defined in Agénor and Pereira da Silva (2022), MAEs are the United States, the euro area, and Japan, whereas SMICs are Brazil, China, India, Indonesia, Mexico, Russia, South Africa, and Turkey. This classification is based on empirical studies in which these groups of countries were identified as those that have exerted the largest financial spillovers and spillbacks on each other. Based on GDP measures for the two regions, the relative size of the core is set at $n = 0.818$.

The cost parameter related to core (periphery) bond holdings by core (periphery) households, θ_0^B, is set at 0.2, consistent with imperfect capital mobility. The cost parameter associated with holdings of bank capital, Θ_V, is calibrated at 2.64 for the core and 1.83 for the periphery, to ensure that the cost of issuing capital is higher than the refinance rate.

Regarding the global bank and periphery banks, The elasticity of the repayment probability with respect to the effective collateral-loan ratio is set at $\psi_1^C = 0.05$ for MAEs and $\psi_1^P = 0.1$ for SMICs, whereas the elasticity with respect to output deviations is set at $\psi_2^C = \psi_2^P = 0.9$. The cost parameter γ_P is set at 0.1 for the core and 0.15 for the periphery, in order to generate sensible values for initial interest rates. The elasticities η_D, η_L and ζ_L are set such that they generate a mark-down of the deposit rate relative to the policy rate of about 100 basis points in the core, and a mark-up of the loan rate over the policy rate (given repayment probabilities of 0.96 in the core and 0.936 in the periphery) of about 264 basis points in the core and 423 basis points in the periphery. These results are in line with the evidence for MAEs and SMICs, which suggests higher default rates and higher lending spreads for the latter group of countries. The parameters of the cost function (12), γ_L and γ_K, are set at the same low value of 0.1, as in Agénor and Jackson (2022), whereas γ, which measures the strength of economies of scope in lending, -0.1 initially.

Regarding the regulatory regime, the cost parameter γ_V is set at 0.01. The capital adequacy ratio, ρ, is set at 0.08, which corresponds to the floor value set under the current Basel regime. The initial risk weight is equal to unity; by implication, the required capital-loan ratio is also 8 percent. The benefit parameter γ_{VV} is set at 0.001, to ensure that the excess capital-loan ratio is about 4 percent, in line with the evidence. Finally, parameters ϕ_E^C and ϕ_E^P, which measure the marginal benefit of excess capital in the core and the periphery, respectively, are set at 0.5 and 0.45, in line with Agénor and Jackson (2022).

Initial steady-state values show that loans from the global bank to its affiliates in the periphery amount to 8.4 percent of the region's output. The required and excess capital ratios account for 8 and 4 percent, respectively, of investment loans. Thus, the total capital-risk weighted assets ratio is 12 percent, consistent with the evidence (see World Bank (2020)).

5. Core Expansionary Shock

Monetary policy spillovers from major advanced (core) economies have been identified in a number of studies as one of the key drivers of the global financial cycle and international capital flows. These studies include Bruno and Shin (2015), Temesvary et al. (2018), Buch et al. (2019), Albrizio et al. (2020), Brauning and Ivashina (2020), Miranda-Agrippino and Rey (2020), and Cesa-Bianchi and Sokol (2022). Others, including Morais et al. (2019), and Tillmann et al. (2019), have documented statistically significant effects of these flows on recipient countries. To illustrate the model's properties, we therefore consider an expansionary monetary policy shock in the core, with and without a regulatory response in that region.

5.1. Constant Capital Adequacy Ratios

Figure 2 illustrates the results of a transitory reduction of 1 percentage point in the refinance rate in the core, as defined in (19), with two values of the parameter measuring the degree of economies of scope, $\gamma = -0.1$ and $\gamma = -0.2$, both under no activism. In both cases, the drop in the refinance rate lowers the loan rate in the core and leads to an expansion in investment, thereby raising aggregate demand and prices in that region. Because the global bank borrows more from the core central bank—credit to domestic producers goes up, and the lower refinance rate reduces the deposit rate, and thus the amount of deposits available to fund domestic lending operations—liquidity increases. To maintain money market equilibrium, the nominal bond rate must fall. This, combined with an increase in inflation, leads to an unambiguous reduction in the expected real bond rate, which in turn induces households to spend more today. The increase in consumption is associated with a higher demand for housing, which raises their real price. Higher house prices raise collateral values, but because the increase in investment (and thus domestic loans by the global bank) is relatively larger, the collateral-loan ratio actually falls, thereby *reducing* the repayment probability—despite the increase in cyclical output, which operates in the opposite direction. This mitigates somewhat the initial drop in the loan rate and the increase in investment.

Required bank capital increases in the core, both because loans expand and because the risk weight rises, due to the reduction in the repayment probability. Given that capital adequacy ratios in both regions (ρ_t^C and ρ_t^P) remain constant in this experiment, the increase in the risk weight—and thus the cost of issuing bank capital to meet regulatory requirements—mitigates the drop in the loan rate. At the same time, because the differential between the marginal cost of issuing capital, $i_t^{CV} + \gamma_V^C$, and the refinance rate, i_t^{CR}, falls, excess capital increases. The leverage ratio—the ratio of loans to unweighted regulatory bank capital, $l_t^{CK}/(\rho_t^C l_t^{CK} + V_t^{CE})$, which differs from the inverse of the commonly-defined bank capital ratio, $V_t^C/(\sigma_t^{CK} l_t^{CK})$—rises as well.[12] The spread $i_t^{CV} - i_t^{CB}$, or equivalently the excess return on bank capital, must also increase for households to alter the composition of their portfolios and hold a greater amount of bank-issued liabilities.

Cross-border spillovers occur through several channels. First, the fall in asset returns in the core induces periphery households to reduce their holdings of core government bonds. Second, through the bank portfolio channel, lending to periphery banks by the global bank rises (see Figure 2). The increase in lending at home lowers the global bank's marginal operating costs, which mitigates the initial drop in the loan rate there and reduces the cost at which it lends to its affiliates. As a result, the demand for loans by periphery banks increases. The capital inflow to the periphery translates into a nominal and real appreciation.

Third, the appreciation puts downward pressure on inflation in the periphery. The central bank's response is to reduce its policy rate, which in turn leads to a reduction in the loan rate and an expansion in aggregate demand. The bond rate falls also (through the same mechanism as described earlier) and this induces households to shift consumption to the present, raising real house prices in the process. Once again, the collateral-loan ratio falls and (despite higher cyclical output) so does the repayment probability. This mitigates the initial drop in the loan rate and the expansion in credit. Consequently, as in the core, the risk weight rises, which leads (combined with the increase in loans) to higher bank capital. However, there is no substitution between required and excess capital, as the differential between the marginal cost of issuing bank capital and the refinance rate now falls. Thus, the net effect of the shock on total bank capital is again positive. All other effects are, qualitatively, similar to those discussed earlier for the core. Finally, the appreciation also lowers the price of intermediate goods for the periphery, thereby stimulating the region's imports. The opposite occurs for the core. However, because of home bias in production, this substitution effect is muted in both regions.

[12] Note that both the leverage ratio and the bank capital ratio will vary, despite ρ_t^C and ρ_t^P constant, because in the model banks also hold excess capital.

The dotted lines in Figure 2 show what happens when the parameter that captures the cost complementarity effect is stronger, that is, $\gamma = -0.2$ instead of -0.1. Qualitatively, the results are the same. Quantitatively, however, they differ for the periphery. In particular, lending by the global bank increases substantially more, and so do investment and the leverage ratio in that region. There is a positive correlation between the strength of the complementary effect (as measured by $|\gamma|$) and the spillover effects of global lending.

5.2. Core Activism

Consider now the case where the countercyclical capital rule (21) is operated by the core regulator. To illustrate the results, we set $\chi_1^C = 0.1$ (which implies a relatively low degree of persistence) and $\chi_2^C = 50$.[13] The results are reported in Figure 3.

While the magnitudes of some effects differ, qualitatively they are generally close to those obtained under no activism. Notable differences relate, not surprisingly, to changes in bank capital, and thus the leverage ratio, and the core loan rate. Intuitively, as credit initially expands in the core, the regulator in that region raises the countercyclical capital ratio, therefore mitigating the drop in the loan rate and the lending boom. In fact, the policy response is strong enough to generate an increase in the domestic cost of borrowing. Total bank capital is also higher compared to no activism, despite a strong substitution effect between its components, and as a result the leverage ratio falls.

Under activism, lending by the global bank to periphery banks rises again, but initially by more than under activism. The policy mitigates the drop in the loan rate and the expansion in investment, in both regions. But although the increase in domestic lending is weaker, the refinance rate in the core drops by more as a result of the smaller increase in cyclical output. The result therefore is a larger drop in the interest rate on loans to periphery banks, and therefore higher lending to these banks and a larger capital inflow in that region. As shown

[13] This relatively high value of χ_2^C is related to the fact that, in this experiment, the instrument manipulation cost is implicitly 0. This issue is discussed in the next section.

in Figure 3, the policy also helps to stabilize output and consumption in both regions.

To characterize further the magnitude of regulatory spillovers, we computed asymptotic mean values of lending by the global bank, for a range of values of γ, under both no activism and core prudential activism. The results are displayed in Figure 4. As expected, the stronger economies of scope are (the larger $|\gamma|$ is), the larger the increase in lending to the periphery—regardless of whether the core regulator reacts or not. Thus, financial spillovers (in the form of increased global lending) are indeed an equilibrium response to the shock under consideration. In addition, for any given value of $|\gamma|$, spillovers through global lending are stronger when the core regulator reacts. In what follows, given our focus on activist policy regimes, we will refer to $|\gamma|$ as a measure of the strength of regulatory spillovers.

6. Gains from Coordination

Regulator j's objective function takes the form

$$W_t^j = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left\{ \varkappa_U^j u_{t+s}^j - \varkappa_L^j \left(\frac{l_{t+s}^{jK}}{Y_{t+s}^j} - \frac{\tilde{l}^{jK}}{\tilde{Y}^j}\right)^2 - \varkappa_I^j \left(\rho_{t+s}^{jC} - \rho_{t+s-1}^{jC}\right)^2 \right\}, \tag{41}$$

where u_t^j is the period utility function defined in (1), $\varkappa_U^j = 0$ or 1, $\varkappa_L^j \in (0,1)$ measures the degree of bias towards financial stability in policy preferences, as in Bodenstein et al. (2019) and Agénor and Jackson (2022), and $\varkappa_I^j > 0$ is a parameter that captures the cost associated with changes in capital ratios. Thus, the objective function that the regulator seeks to maximize depends not only on household utility but also financial stability concerns. The standard welfare maximization approach corresponds to $\varkappa_U^j = 1$ and $\varkappa_L^j = 0$. The opposite case, $\varkappa_U^j = 0$ and $\varkappa_L^j = 1$, corresponds to the two-stage welfare maximization approach defined in Agénor and Flamini (2022), in which the objective function is a loss function defined in terms of financial stability only (as a result of an institutional mandate) and policy performance is evaluated in terms of household welfare. In addition to these polar cases, policy performance can be assessed by setting $\varkappa_U^j = 1$ and varying $\varkappa_L^j$ between 0 and 1, thereby allowing us to determine how strong the financial stability objective must be—short of being the only objective—for reciprocity to be preferable to other policy regimes.

6.1. *Alternative Policy Regimes*

We consider four alternative policy regimes. Under *core activism only*, the regulator in the core sets its capital buffer so as to maximize its own objective function, whereas the regulator in the periphery does not react. This is the base scenario analyzed also by Rubio (2020). Under the *independent policymaking* (or Nash), each regulator determines the optimal value of the response parameter χ_2^j in their policy rules, so that $\chi_2^{C,N} = \arg\max W_t^C\big|_{\chi_2^P=\chi_2^{P,N}}$ and $\chi_2^{P,N} = \arg\max W_t^P\big|_{\chi_2^C=\chi_2^{C,N}}$. Under *reciprocity*, the regulator in the core sets the response parameter in its policy rule so as to maximize its own objective function only, whereas the regulator in the periphery imposes the same optimal value of the countercyclical capital buffer in its jurisdiction; thus, $\chi_2^{C,R} = \arg\max W_t^C$ and $\rho_t^{PC} = \rho_t^{CC}$, $\forall t$. Under (full) *coordination*, regulators jointly determine the optimal response parameters, denoted $\chi_2^{C,O}$ and $\chi_2^{P,O}$, so as to maximize a weighted sum of each region's objective function; thus, $\chi_2^{C,O}, \chi_2^{P,O} = \arg\max[nW_t^C + (1-n)W_t^P]$, where $n \in (0,1)$.[14]

Policies are computed under commitment and welfare gains are assessed in terms of consumption-equivalent variations. Second-order approximations to both the household utility function and the model, conditional on the deterministic steady state, are used (see Appendix E). To ensure consistency, the term that captures bias towards financial stability is used to solve for optimal responses, not to compute welfare gains.

6.2. *Results*

Table 1 shows the results for the standard welfare approach ($\varkappa_L^j = 0$) and three values of the bias parameter ($\varkappa_L^j = 0.2, 0.5, 1.0$), and for three values of γ, which measures the strength

[14]Given the focus of this paper on reciprocity arrangements, we do not elaborate on the comparison between these regimes and no activism, and between (full) coordination and Nash.

of regulatory spillovers, -0.01, -0.1 and -0.2. The instrument manipulation cost $\varkappa_I^j$ is set uniformly to a low value of 0.1.[15] To facilitate comparisons, the degree of persistence in the regulatory policy rules, χ_1^j, is kept at 0.1 throughout.[16] A grid step of 0.001 points is used to search for the optimal values of χ_2^j.

The first result is that under all regimes, and regardless of the weight attached to financial stability, the core's policy response becomes more aggressive as the strength of regulatory spillovers increases. However, under the standard welfare approach ($\varkappa_L^j = 0$, Panel A), the periphery is better off under reciprocity, compared to the core acting alone, only if $|\gamma|$ is low. As the strength of spillovers (as measured by $|\gamma|$) increases, reciprocity is Pareto-improving—all parties are better off—only if regulators put greater emphasis on financial stability, that is, if $\varkappa_L^j$ is relatively high (Panel D). This is shown more clearly in Figure 5, which displays combinations of $\varkappa_L^j$ and $|\gamma|$ for which reciprocity is Pareto-improving relative to the core acting alone. When $\varkappa_L^j = 0$ (Panel A) this is the case when $\gamma = -0.04$. But as $|\gamma|$ increases, so must the weight attached to financial stability, $\varkappa_L^j$, for welfare gains to be positive for all parties. This is the case, in particular, with equal weights ($\varkappa_U^j = \varkappa_L^j = 1$, Panel D). This result also holds when $\varkappa_U^j = 0$ and $\varkappa_L^j = 1$, when only financial stability matters.

The second result is that under the standard welfare approach, the periphery is always worse off under reciprocity compared to Nash. However, as illustrated in Figure 6, if $|\gamma|$ is not too large (below 0.08) and if financial stability matters sufficiently for the regulator ($\varkappa_L^j \geq 0.7$), reciprocity can be Pareto-improving relative to Nash. Intuitively, even though the core and the world economy may benefit, the loss for the periphery resulting from partial coordination increases with stronger regulatory spillovers. Thus, if $|\gamma|$ is sufficiently high (above 0.08 in the figure), there are no Pareto-improving outcomes, regardless of the value

[15] Sensitivity analysis is reported in Appendix F. In general, the optimal response parameters vary inversely with the magnitude of the instrument cost. However, what matters here is how they vary *across* policy regimes, for a given cost. The *existence* of a cost is also important, as discussed later on.

[16] Using uniformly higher persistence parameters would affect the values of χ_2^j across the board but would not have any impact on the rankings of policy regimes.

of $\varkappa_L^j$—including the case where regulators are only concerned with financial stability.

The third result is that the periphery is also worse off under coordination, relative to reciprocity. The reason is that coordination requires the periphery to react more aggressively as $|\gamma|$ increases; thus, coordination involves some degree of *burden sharing*, a situation where the regulator in the core reacts either less or the same, but the regulator in the periphery reacts more. As a result, spillback effects to the core are substantially mitigated. But although the core and the world are generally better off, the periphery is worse off because it incurs a higher cost to instrument manipulation.

A broader implication of our results is the extent to which instrument costs matter. With no manipulation cost, it is optimal for the core regulator to fully stabilize credit fluctuations at home ($\chi_2^C \to \infty$); thus, there is no rationale for coordination. This is consistent with Korinek's (2016) analysis, as alluded to earlier. At the same time, while necessary, a positive instrument cost is not sufficient for coordination to be Pareto-improving. The magnitude of financial frictions (namely, the degree of cost complementarity for the global bank) and the degree to which regulators care about financial stability, also play a crucial role.[17]

6.3. Sensitivity Analysis

To assess the robustness of these results, sensitivity analysis was conducted with respect to the specification of the capital regime and a number of key parameters. Experiments involved exogenous excess capital, the cost of instrument manipulation, the relative size of each region (n), the degree of trade and financial integration, and a stock specification of bank capital. For lack of space, these results are discussed in detail in Appendix F. While the optimal values of the countercyclical response parameters, and the magnitude of welfare gains across regimes, varied somewhat, the key results highlighted earlier (and the role of parameters $|\gamma|$ and $\varkappa_L^j$) remained fundamentally the same. This is the case, in

[17] Note also that, in our setting, the use of simple policy rules to maximize the objective function (41) may constrain the attainable allocations below the Pareto frontier.

particular, when n is set equal to 0.5, to capture the principle of "one country, one vote" under coordination, or when the degree of financial integration is increased, by reducing the cost parameter θ_0^B from 0.2 to 0.1 and 0.01. A notable new result is that under greater trade integration, and under the standard welfare approach ($\varkappa_U^j = 1$, $\varkappa_L^j = 0$), reciprocity may also be Pareto-improving relative to Nash if regulatory spillovers are not too strong. Intuitively, tighter trade links between regions enhance the potential for spillovers and spillbacks, which benefit all parties even under partial coordination.

7. Concluding Remarks

The main results of the paper were summarized in the introduction. To conclude, it is worth pointing out a potentially fruitful extension of our analysis. A key assumption of the model is that *all* banks in the periphery are foreign affiliates. This helped to simplify the model and made it easier to understand the channels through which regulatory spillovers are transmitted across countries. However, as a result we were unable to capture the substitution effects that may occur between domestic and foreign lenders *within* the periphery, and their indirect impact on capital flows induced by regulatory changes occurring in the core—the key experiment that we focused on in the paper.

A model with both domestic and foreign banks operating in the periphery would also be necessary to assess another type of cross-border spillovers—the possibility that tighter regulation in the periphery on domestic banks may induce foreign branches (which are not subject to local prudential rules) to extend more credit to local borrowers, thereby hampering the achievement of the policy's intended goal. There is evidence that this type of (inward) spillovers have been quite significant as well (Buch and Goldberg (2017)). These are actually the type of regulatory spillovers that Basel III's Principle of reciprocity is designed to address. In such conditions, it is possible that our results provide only a lower bound on the potential benefits that reciprocity agreements may generate for the world economy.

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Table 1
Optimal Policy Responses and Welfare Gains
under Alternative Policy Regimes[1]

	$\gamma = -0.01$	$\gamma = -0.1$	$\gamma = -0.2$
		Panel A	
Standard Welfare Objective, $\varkappa_L^j = 0.0$			
Core activism: Optimal χ_2^C	0.020	0.022	0.025
Reciprocity: Optimal χ_2^C $(\rho_t^{PC} = \rho_t^{CC})$	0.020	0.023	0.027
Nash: Optimal $\chi_2^{C,N}, \chi_2^{P,N}$	$0.020, 0.014$	$0.022, 0.008$	$0.025, 0.006$
Coordination: Optimal $\chi_2^{C,O}, \chi_2^{P,O}$	$0.020, 0.000$	$0.022, 0.049$	$0.025, 0.051$
Gain from reciprocity, rel. to core activism			
Core	−0.0008	0.0015	0.0043
Periphery	0.0025	−0.0196	−0.2142
World	−0.0007	0.0014	0.0036
Gain from reciprocity, rel. to Nash			
Core	−0.0002	0.0010	0.0033
Periphery	−0.0004	−0.0282	−0.2303
World	−0.0002	0.0008	0.0025
Gain from coordination, rel. to reciprocity			
Core	0.0008	0.0019	0.0042
Periphery	−0.0025	−0.1729	−0.5424
World	0.0007	0.0006	0.0012
		Panel B	
Biased policy preferences, $\varkappa_L^j = 0.2$			
Core activism: Optimal χ_2^C	0.018	0.020	0.022
Reciprocity: Optimal χ_2^C $(\rho_t^{PC} = \rho_t^{CC})$	0.018	0.020	0.023
Nash: Optimal $\chi_2^{C,N}, \chi_2^{P,N}$	$0.018, 0.013$	$0.020, 0.008$	$0.022, 0.006$
Coordination: Optimal $\chi_2^{C,O}, \chi_2^{P,O}$	$0.018, 0.000$	$0.020, 0.040$	$0.022, 0.043$
Gain from reciprocity, rel. to core activism			
Core	−0.0007	0.0014	0.0041
Periphery	0.0028	−0.0122	−0.1588
World	−0.0006	0.0013	0.0036
Gain from reciprocity, rel. to Nash			
Core	−0.0002	0.0008	0.0031
Periphery	−0.0001	−0.0210	−0.1772
World	−0.0002	0.0007	0.0025
Gain from coordination, rel. to reciprocity			
Core	0.0007	0.0014	0.0031
Periphery	−0.0028	−0.1122	−0.4479
World	0.0006	0.0006	0.0011

Table 1 (concluded)
Optimal Policy Responses and Welfare Gains
under Alternative Policy Regimes[1]

	$\gamma = -0.01$	$\gamma = -0.1$	$\gamma = -0.2$
		Panel C	
Biased policy preferences, $\varkappa_L^j = 0.5$			
Core activism: Optimal χ_2^C	0.016	0.016	0.017
Reciprocity: Optimal χ_2^C $(\rho_t^{PC} = \rho_t^{CC})$	0.016	0.016	0.018
Nash: Optimal $\chi_2^{C,N}, \chi_2^{P,N}$	$0.016, 0.011$	$0.016, 0.007$	$0.017, 0.006$
Coordination: Optimal $\chi_2^{C,O}, \chi_2^{P,O}$	$0.016, 0.000$	$0.016, 0.028$	$0.017, 0.030$
Gain from reciprocity, rel. to core activism			
Core	-0.0006	0.0011	0.0037
Periphery	0.0029	-0.0006	-0.0729
World	-0.0006	0.0011	0.0035
Gain from reciprocity, rel. to Nash			
Core	-0.0002	0.0006	0.0026
Periphery	0.0001	-0.0094	-0.0953
World	-0.0002	0.0006	0.0024
Gain from coordination, rel. to reciprocity			
Core	0.0006	0.0008	0.0014
Periphery	-0.0029	-0.0465	-0.2492
World	0.0006	0.0005	0.0005
		Panel D	
Biased policy preferences, $\varkappa_L^j = 1.0$			
Core activism: Optimal χ_2^C	0.011	0.010	0.010
Reciprocity: Optimal χ_2^C $(\rho_t^{PC} = \rho_t^{CC})$	0.011	0.010	0.010
Nash: Optimal $\chi_2^{C,N}, \chi_2^{P,N}$	$0.011, 0.008$	$0.010, 0.006$	$0.010, 0.006$
Coordination: Optimal $\chi_2^{C,O}, \chi_2^{P,O}$	$0.011, 0.001$	$0.010, 0.007$	$0.010, 0.010$
Gain from reciprocity, rel. to core activism			
Core	-0.0004	0.0007	0.0017
Periphery	0.0028	0.0085	0.0141
World	-0.0004	0.0007	0.0017
Gain from reciprocity, rel. to Nash			
Core	-0.0001	0.0003	0.0007
Periphery	0.0004	-0.0001	-0.0126
World	-0.0001	0.0003	0.0006
Gain from coordination, rel. to reciprocity			
Core	0.0004	-0.0002	0.0000
Periphery	-0.0024	0.0005	0.0000
World	0.0003	-0.0002	0.0000

[1]Welfare gains are assessed in terms of consumption-equivalent variations. Specifically, the gain from Regime B relative to Regime A is measured in terms of the fraction of the consumption stream under regime A that would leave households in both regions indifferent between living in a world where Regime B is in place, and a world where Regime A prevails. A positive value implies a welfare improvement. In all panels, the weight $\varkappa_U^j$ is 1 and the instrument cost is $\varkappa_I^j = 0.1$.

Figure 1
Core-Periphery Model with Capital Regulation:
Main Interactions and Financial Flows

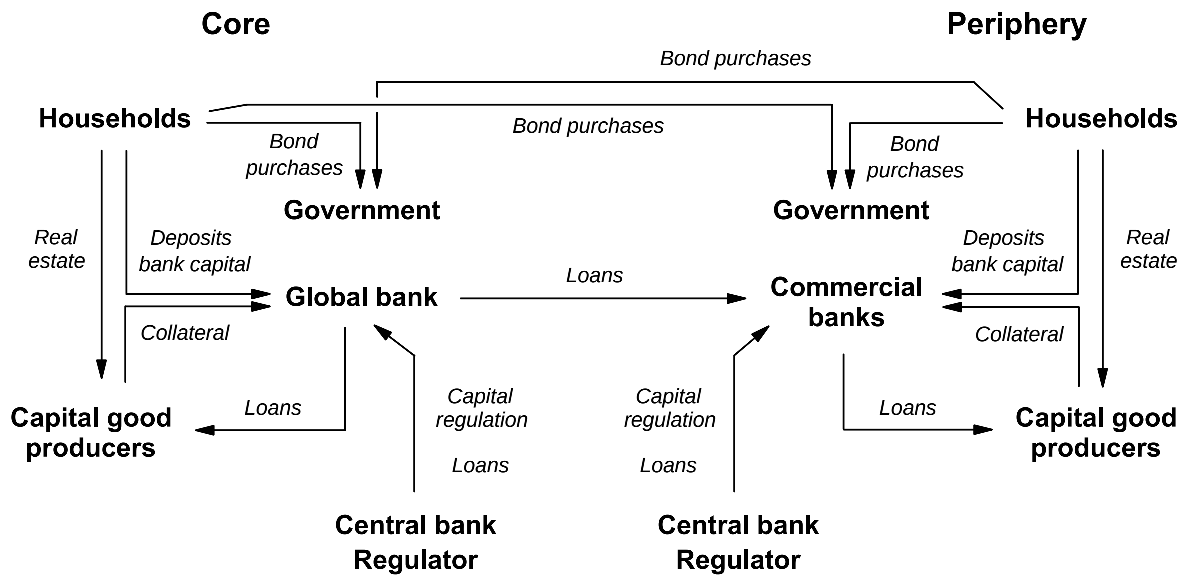
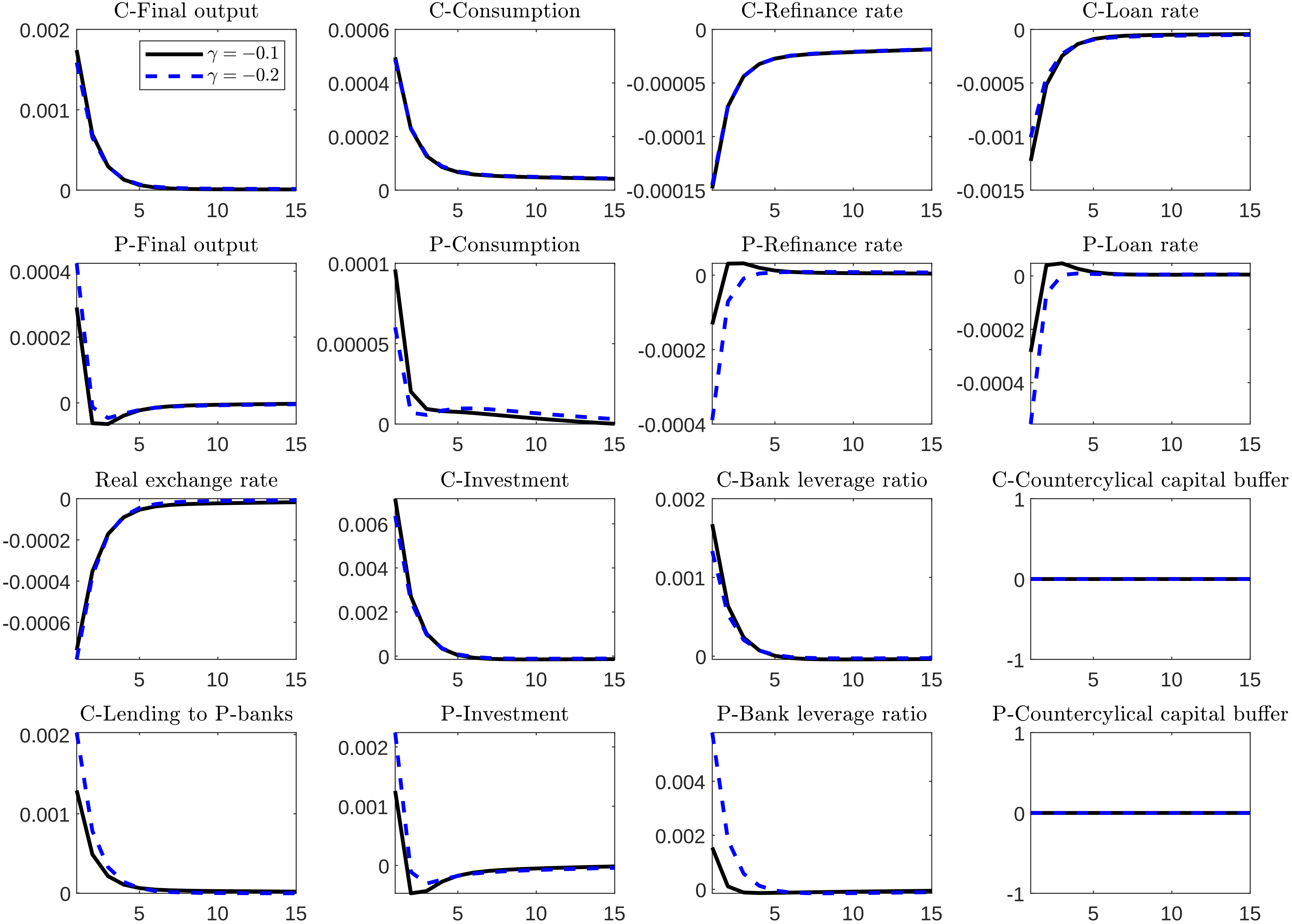


Figure 2

Transitory Negative Shock to Core Refinance Rate

(Deviations from steady state)

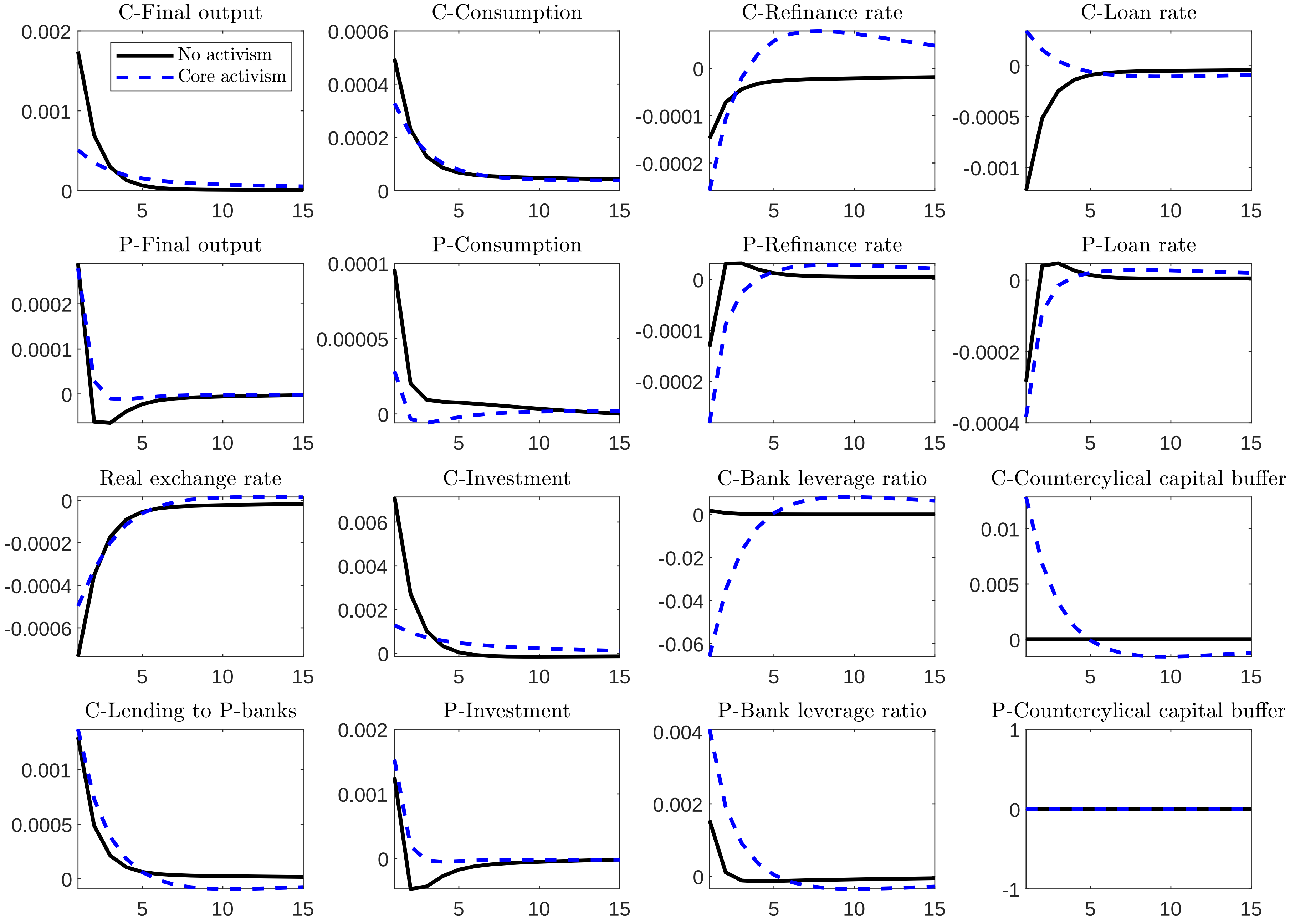


Notes: The responses of consumption, investment, final output, core lending to periphery banks, and the real exchange rate are expressed as percent deviations from their steady-state values. The responses of the loan rate, the refinance rate, the leverage ratio, and the countercyclical capital buffer are expressed as absolute deviations (or percentage points) from their steady-state values.

Figure 3

Transitory Negative Shock to Core Refinance Rate, with Core Prudential Response

(Deviations from steady state)



Notes: See notes to Fig. 2. "No activism" corresponds to the continuous line in Fig. 2, whereas "Core activism" refers to the endogenous response by the core regulator only, through its countercyclical capital rule. The response parameter in the rule is set at 50 and persistence at 0.1.

Figure 4
Degree of Economies of Scope and Magnitude of Regulatory Spillovers
(Asymptotic conditional means)

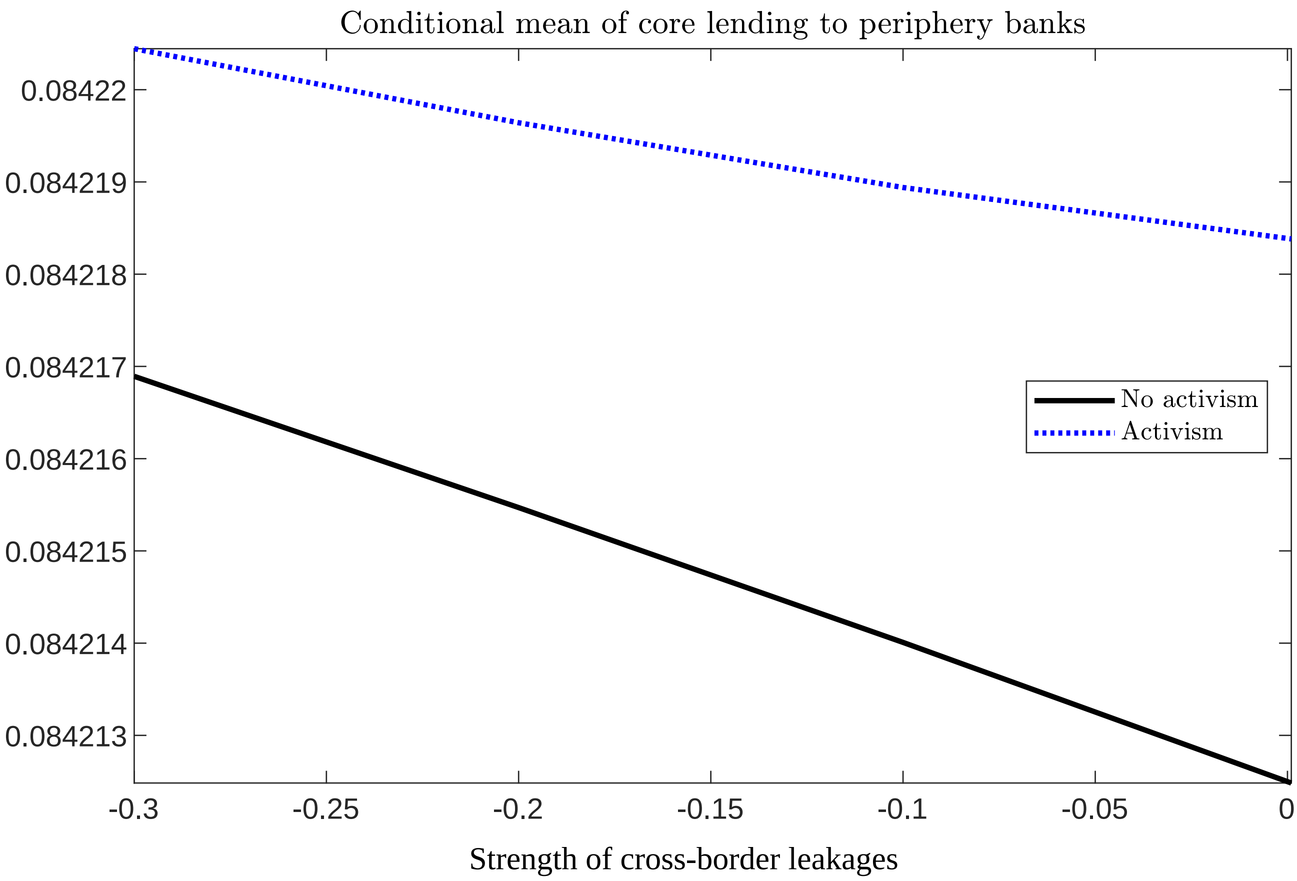
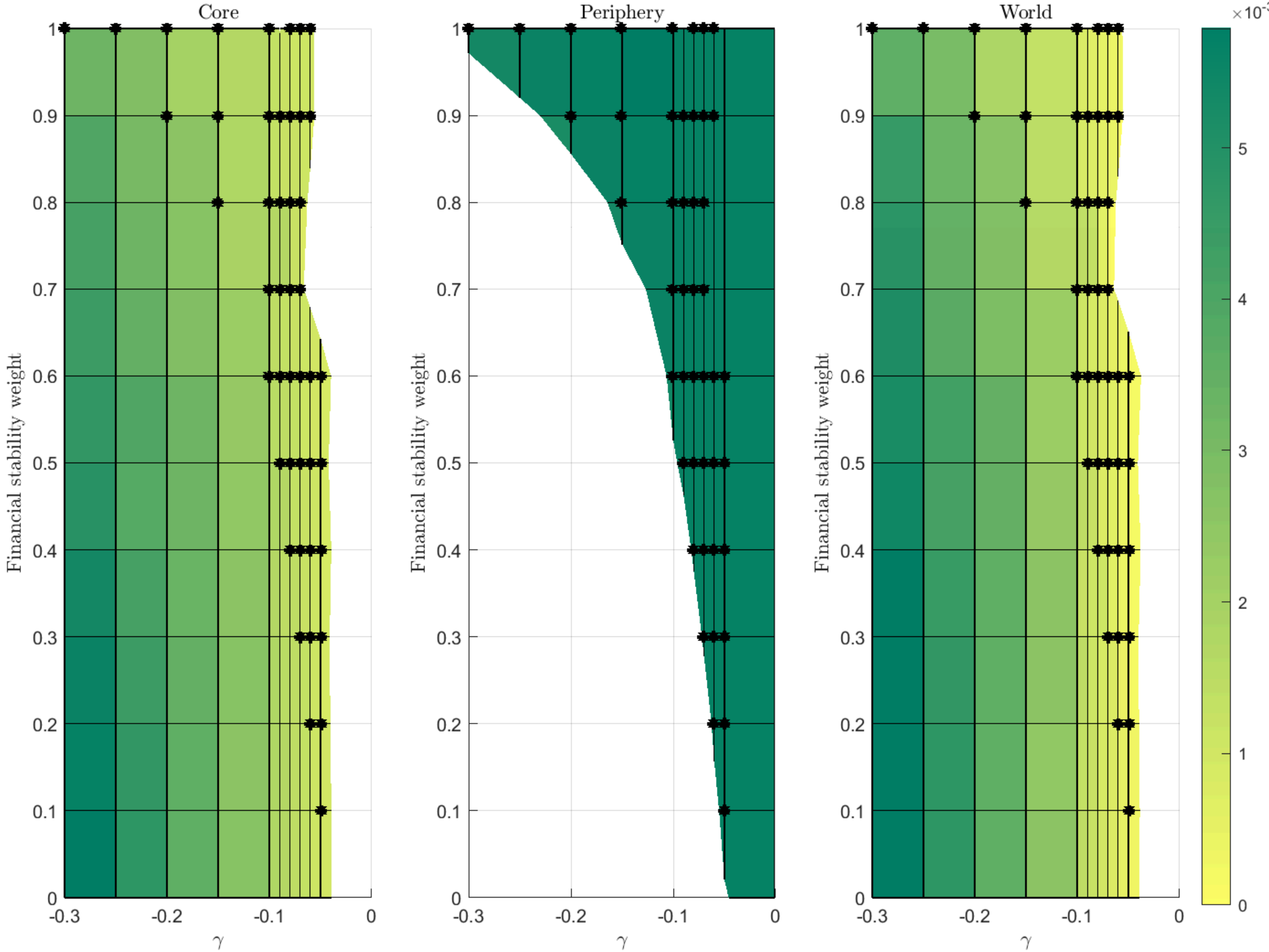
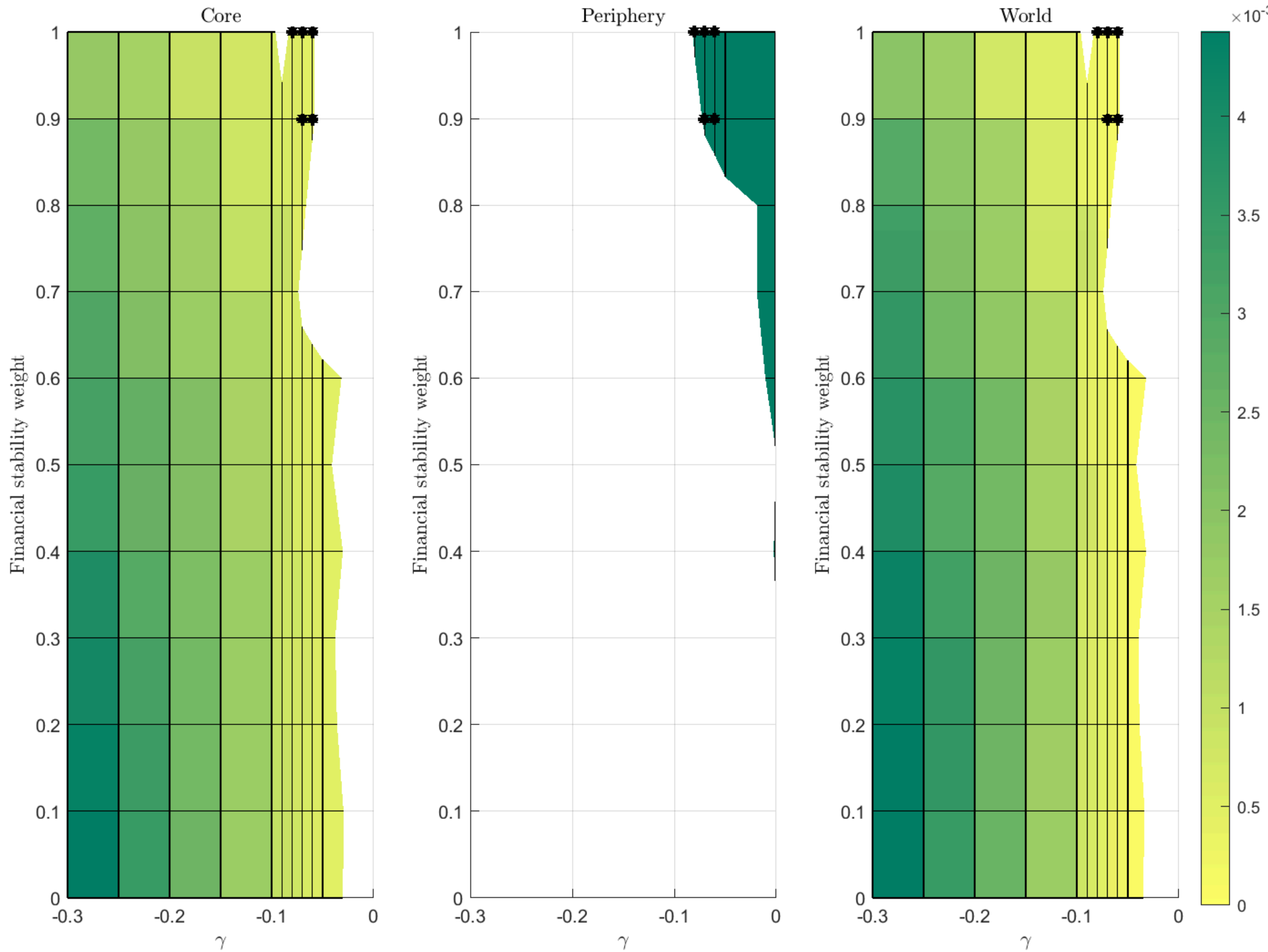


Figure 5
Welfare Gains of Reciprocity vs. Core Activism Only
as a Function of the Strength of Regulatory Spillovers and Weight of Financial Stability



Note: Parameter combinations identified by markers are those for which reciprocity makes all parties better off, relative to core activism only. White zones in each panel correspond to combinations which generate welfare losses for the relevant party.

Figure 6
Welfare Gains of Reciprocity vs. Nash
as a Function of the Strength of Regulatory Spillovers and Weight of Financial Stability



Note: Parameter combinations identified by markers are those for which reciprocity makes all parties better off, relative to the Nash equilibrium. White zones in each panel correspond to combinations which generate welfare losses for the relevant party.