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# Global banking, financial spillovers and macroprudential policy coordination

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**Abstract**

The transmission of financial shocks and the gains from international macroprudential policy coordination are studied in a two-region, core–periphery model with a global bank, a two-level financial structure and imperfect financial integration. The model replicates the stylized facts associated with global banking shocks, with respect to output, credit, house prices and real exchange rate fluctuations in recipient countries, as documented empirically. Numerical experiments, based on a parametrized version of the model, show that the gains from coordination increase with the degree of financial integration, which raises the scope for spillback effects from the periphery to the core, through trade and private capital flows. However, even when coordination is Pareto-improving, the resulting gains may be highly asymmetric across regions.

## 1 | INTRODUCTION

There is growing evidence that international financial spillovers have become a two-way street—they occur not only from the major advanced economies to the rest of the world, as in decades past, but also, and increasingly, from a group of large middle-income countries to advanced economies.[1] Indeed, these countries are now interconnected financially more than ever before. As documented by Cerutti and Zhou (2017), McCauley *et al.* (2017) and World Bank (2018), this process has been partly the result of banking globalization, which has taken the form of growing networks of foreign branches and subsidiaries centred on global parent banks located in advanced economies—despite the retrenchment (especially of non-major European banks) observed in the immediate aftermath of the global financial crisis. Studies such as Bruno and Shin (2015), Temesvary *et al.* (2018), Avdjiev *et al.* (2018), Cesa-Bianchi *et al.* (2018) and Buch *et al.* (2019) provide robust evidence that changes in monetary policy in the USA—in large part due to the role of the US dollar as a global funding currency—have a strong impact on cross-border lending by US banks, consistent with the existence of an international bank lending channel. Similar results have been established by Gräb and Żochowski (2017) in the case of euro area banks, in response to monetary policy accommodation by the European Central Bank.

The fact that cross-border spillovers operate in both directions and have become more significant does not *prima facie* create a case for greater policy coordination across countries. Indeed, spillovers (financial or otherwise) do not necessarily reduce global welfare, and coordination is not always needed to improve welfare. In a global recession, for instance, uncoordinated expansionary fiscal policies in a core group of countries with small budget deficits and low public debt ratios can benefit all countries. But because financial markets are prone to amplification effects, and because business and financial cycles remain imperfectly synchronized across countries—even when they share a common currency—this new environment creates the potential for shocks in one jurisdiction to be magnified and transmitted to others through bank and non-bank related short-term capital flows, with the possibility that these flows may exacerbate financial instability in both source and recipient countries.

These risks have led policymakers in some large middle-income countries to issue pleas for policymakers in major advanced economies to go beyond their institutional mandate—which typically requires them to take account of the external impact of their policies only insofar as they feed back onto their own economies—and internalize the cross-border spillover effects associated with their decisions and their possible adverse consequences (see Mishra and Rajan 2016).[2] Some observers have gone further and have argued in favour of greater coordination of macroprudential policies (in both their structural and countercyclical components) across countries, to mitigate the adverse effects of cross-border capital flows and promote global financial stability.

The foregoing discussion suggests that the analytical case for macroprudential policy coordination across countries rests fundamentally on whether financial risks represent negative externalities that tend to increase with the magnitude of spillovers and reverse spillovers (also referred to as *spillbacks*), and the extent to which business and financial cycles are synchronized across countries. Conversely, independent national macroprudential policies that help to contain systemic risks in one's own country may help to promote financial stability elsewhere by reducing the scope for negative trade and financial spillovers, therefore creating positive externalities and making the need to cooperate less compelling. Thus, as noted by Engel (2016), coordination is desirable mainly when it enables countries to improve their policy trade-offs.[3] At the same time, to make an *empirical* case for international coordination of macroprudential policies, it must be shown that there are potentially significant gains for participating countries, and consequently the world economy as a whole, from doing so. Indeed, these gains must be sufficiently large quantitatively to mitigate incentives to renege and ensure that countries remain voluntarily in a cooperative agreement.

Yet even though much can be learned from the early literature on international *monetary* policy coordination—reviewed by Frankel (2016), for instance—research on this issue remains very limited. Among the few contributions available, based explicitly on a game-theoretic approach, are Agénor *et al.* (2021) and Chen and Phelan (2021). Agénor *et al.* (2021) study the effects of coordinated and independent macroprudential policies in a model with financial frictions, as in Gertler and Karadi (2011), and where global banks in a core region lend domestically and to banks in the periphery.[4] Their results show that the global welfare gain from coordination can be relatively large (of the order of 1–2% of steady-state consumption), essentially because it mitigates significantly the cross-border spillovers of country-specific shocks. Chen and Phelan (2021), dwelling on the continuous-time framework developed by Brunnermeier and Sannikov (2015), formulate a symmetric two-country model in which countries have limited ability to issue state-contingent contracts in international markets. As a result, the relative share of global wealth held by each country affects its own level of output. Because of market incompleteness, national macroprudential regulation of each country's borrowing position (in the form of restrictions on capital flows) can improve national welfare. However, tight regulation in one country creates incentives for the other to reciprocate, to avoid being relatively poorer on average. Coordination, by eliminating these incentives, generates gains for both countries.

Also adopting a game-theoretic approach, this paper contributes to the literature by focusing on a two-region, core–periphery dynamic stochastic general equilibrium model with imperfect financial integration and a global bank in the core region lending to banks in the periphery. As in some of the contributions alluded to earlier, our analysis considers two levels of financial frictions: between firms and banks in each region, and between periphery banks and the global bank. In contrast with the open-economy literature in the Kiyotaki–Moore tradition, financial intermediaries in the periphery are not constrained on how much they can borrow from the global bank; instead, they must pay a premium that increases with the amount borrowed. A higher premium, in turn, mitigates the incentive to borrow. The model is parametrized for two groups of countries, the major advanced economies and a group of large (deemed *systemically important*) middle-income countries, which have been identified in some recent studies, reviewed in Agénor and Pereira da Silva (2022), as generating significant spillbacks on advanced economies.

To assess the gains from coordination—a regime under which a benevolent regulator internalizes the consequences of policy interdependence—we focus on policy responses to a global lending shock. In an important contribution, Aldasoro *et al.* (2020) provide robust evidence on the causal effects of cross-border bank lending shocks on a sample of 22 emerging markets. Using a new identification procedure (based on exploiting the heterogeneity in the size distribution of confidential data on bilateral bank lending flows), they find that an increase in cross-border bank credit leads to a loosening of domestic financial conditions (in the form of a drop in domestic interest rates), an increase in domestic lending, an expansion in investment and domestic output, a real and nominal exchange rate appreciation, and higher house prices.[5] These 'stylized facts' are replicated for the first time in our core–periphery model, with the cross-border bank lending shock taking the form of a transitory reduction in the cost of borrowing by periphery banks from the global bank. We view the ability of the model to reproduce these facts as an essential first step to address the issue at stake. In addition, by its very nature—it solves simultaneously, rather than recursively, for the global equilibrium—the model captures not only spillovers (from the core to the periphery) but also the spillback effects (from the periphery to the core) associated with that shock. Both features make the model highly suitable for evaluating the benefits (or lack thereof) of international macroprudential policy coordination.

Regulators in both regions are endowed with a narrow institutional mandate, which consists of promoting financial stability. This is consistent with the evidence on these mandates, especially since the global financial crisis (see Calvo *et al.* 2018). To do so, they have at their disposal a simple implementable macroprudential rule. To assess the gains from coordination, we use a two-stage approach, as in Agénor and Flamini (2022). In a first stage, the optimal parameters of the policy rule are solved for using a loss function approach, consistent with a delegated mandate defined in terms of an *operational target* for financial stability—mitigating credit fluctuations. In a second stage, the performance of the rule is evaluated in terms of household welfare. Thus, compared to the standard welfare maximization approach, our two-stage procedure brings together both the positive and normative aspects of policy evaluation.

Our experiments show that the welfare gains from macroprudential policy coordination are positive and increasing with the degree of financial integration, measured in terms of reductions in transactions costs in global capital markets. The key reason is that greater integration increases the magnitude of not only spillovers but also spillbacks, which enhance the potential benefits of coordination for the particular shock that we consider. In addition, coordination does not involve *burden sharing*—a less aggressive policy response from the regulator in the region where the shock occurs, compared to independent policy-making, coupled with a stronger response in the other region. Whether coordination is Pareto-improving or not depends in part on whether the size of regions matters in setting global policy objectives. At the same time, even when it is Pareto-improving, the resulting welfare gains can differ substantially across regions. Although our analysis considered only a single (albeit important) financial shock, the fact that gains may be highly asymmetric raises the issue of what type of incentives must be put in place for countries to enter, and remain, voluntarily in a cooperative macroprudential policy agreement.

The remainder of the paper proceeds as follows. Section 2 describes the model. In line with a number of recent contributions, and to enhance analytical tractability, macroprudential regulation is introduced as a time-varying tax on bank loans. Such a tax can be viewed as a *generic* specification consistent with the price-based channel through which two major lender-based instruments of macroprudential policy, capital requirements and dynamic provisions, operate in terms of their impact on the market cost of borrowing.[6] A simple implementable macroprudential rule, linking the tax on loans to deviations in the credit-to-output ratio, is defined. The equilibrium and some key features of the steady state are discussed briefly in Section 3, and a benchmark parametrization is presented in Section 4. To characterize the properties of the model, the impulse response functions associated with a positive global lending shock (in the form of a temporary reduction in the cost of borrowing from the global bank) are described in Section 5, under no policy activism. The gains from coordinating macroprudential policies across regions are evaluated in Section 6, whereas sensitivity analysis is reported in Section 7. Finally, Section 8 discusses some potentially fruitful extensions.

# 2 | THE WORLD ECONOMY

The world economy consists of two regions, called core and periphery, of normalized economic size $n \in (0, 1)$ and $1 - n$, respectively. Population size in both parts of the world is normalized to unity. The nominal exchange rate between the two regions is fully flexible. Each region is populated by a representative household, a continuum of monopolistic firms producing intermediate goods (IGs), a representative final good (FG) producer, a representative capital good (CG) producer, a government, and a central bank, which also operates as the macroprudential regulator. Preferences and technologies have the same structure in both regions.

Each household owns a single CG-producing firm and makes its housing stock available free of charge to that firm, which uses it as collateral against which to borrow from banks.[7] A single global bank operates in the core economy, whereas a continuum of commercial banks operates in the periphery. The global bank behaves as a monopoly, whereas commercial banks in the periphery are monopolistic competitors in the credit market.[8] In line with the *original sin* argument (Eichengreen *et al.* 2005), banks in the periphery cannot borrow in their own currency. They are also unable to fully hedge against foreign exchange risk. In addition, the cost at which periphery banks borrow from the global bank is increasing in the amount borrowed. Regions trade in IGs and government bonds, whereas cash and credit markets are segmented. In particular, firms in either region cannot directly lend or borrow internationally.

## 2.1 | Core economy

In what follows, we describe the behaviour of households, the global bank, the central bank and the government in the core economy. Because households and the government behave essentially in the same way in both regions, we describe next only the behaviour of banks and the central bank in the periphery. The structure of production is also the same in both regions, and details are provided in the Appendix.

### 2.1.1 | Households

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

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

where $u_t^C$ is the period utility function, $C_t^C$ is consumption of the FG, $N_t^{C,j}$ is the number of hours provided to IG producer $j \in (0,1)$, $x_t^C$ is a composite index of real monetary assets, $H_t^C$ is housing property, $\Lambda \in (0,1)$ is a discount factor, $\varsigma > 0$ is the intertemporal elasticity of substitution in consumption, $\psi_N$ is the inverse of the Frisch elasticity of labour supply, $\mathbb{E}_t$ is the expectation operator conditional on information available at the beginning of date $t$, and $\eta_N, \eta_x, \eta_H > 0$ are preference parameters. (Superscripts $C$ and $P$ are used throughout to identify core and periphery, respectively.) Households derive utility from housing services, which are proportional to their stock of dwellings.[9]

In standard fashion, money generates utility because it facilitates transactions. The composite monetary asset consists of real cash balances $m_t^C$ and real bank deposits $d_t^C$, both measured in terms of the price of final output $P_t^C$:[10]

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

The core household's flow budget constraint is

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

where $N_t^C = \int_0^1 N_t^{C,j}\,\mathrm{d}j$ is labour supply, $p_t^{CH} = P_t^{CH}/P_t^C$ is the real price of housing (with $P_t^{CH}$ denoting the nominal price), $1+\pi_t^C = P_t^C/P_{t-1}^C$, $b_t^{CC}$ ($z_t^{-1} b_t^{CP}$) is real holdings of one-period, non-contingent core (periphery) government bonds, $z_t = E_t P_t^C / P_t^P$ is the real exchange rate measured from the perspective of the periphery, with $P_t^P$ the price of the periphery's FG and $E_t$ the nominal exchange rate (expressed in terms of units of periphery currency per unit of core currency, so that an increase in $E_t$ is a depreciation), $i_t^{CD}$ is the interest rate on bank deposits, $i_t^{CB}$ is the interest rate on core government bonds, $i_t^P$ is the premium-adjusted (or *effective*) interest rate on periphery government bonds, $w_t^C$ is the economy-wide real wage, $T_t^C$ is real lump-sum taxes, and $J_t^{CI}, J_t^{CK}, J_t^{CB}$ are profits (if any) of the IG producer, the CG producer and the global bank, respectively. For simplicity, housing does not depreciate.

Core households face intermediation costs when acquiring periphery bonds.[11] The rate of return on these bonds, in foreign currency terms, is given by

$$1 + i_t^P = (1 + i_t^{PB})(1 - \theta_t^{CP}), \tag{4}$$

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

$$\theta_t^{CP} = \frac{\theta_0^B}{2}\, b_t^{CP}, \tag{5}$$

with $\theta_0^B > 0$ denoting a symmetric cost parameter. Because households internalize the impact of their portfolio decisions on the intermediation costs that they face on world capital markets, this specification captures in a simple way the assumption (consistent with the evidence) of imperfect capital mobility across regions.[12]

The representative household maximizes equation (1) with respect to sequences $\left\{C_{t+s}^C, N_{t+s}^C, m_{t+s+1}^C, d_{t+s+1}^C, b_{t+s+1}^{CC}, b_{t+s+1}^{CP}, H_{t+s+1}^C\right\}_{s=0}^{\infty}$, subject to equations (2)–(5), and taking core interest rates and the periphery bond rate, as well as prices and inflation, and all lump-sum transfers and taxes, as given. The first-order conditions are

$$(C_t^C)^{-1/\varsigma} = \Lambda\, \mathbb{E}_t \left\{ (C_{t+1}^C)^{-1/\varsigma}\, \frac{1+i_t^{CB}}{1+\pi_{t+1}^C} \right\}, \tag{6}$$

$$N_t^C = \left[ \frac{w_t^C (C_t^C)^{-1/\varsigma}}{\eta_N} \right]^{1/\psi_N}, \tag{7}$$

$$m_t^C = \frac{\eta_x \nu (C_t^C)^{1/\varsigma}(1+i_t^{CB})}{i_t^{CB}}, \tag{8}$$

$$d_t^C = \frac{\eta_x (1-\nu)(C_t^C)^{1/\varsigma}(1+i_t^{CB})}{i_t^{CB} - i_t^{CD}}, \tag{9}$$

$$\frac{p_t^{CH}}{(C_t^C)^{1/\varsigma}} - \frac{\eta_H}{H_t^C} - \Lambda\, \mathbb{E}_t \left[ \frac{p_{t+1}^{CH}}{(C_{t+1}^C)^{1/\varsigma}} \right] = 0, \tag{10}$$

$$\frac{z_t^{-1}}{(C_t^C)^{1/\varsigma}} - (1+i_t^{PB})\Lambda\, \mathbb{E}_t \left[ \frac{z_{t+1}^{-1}}{(C_{t+1}^C)^{1/\varsigma}} \,(1-\theta_0^B b_t^{CP}) \right] = 0, \tag{11}$$

together with appropriate transversality conditions. These results are standard, with the exception of the last two, which define core household demand for housing services and periphery bonds. After some manipulations, equation (11) can be written as

$$1 + i_t^{CB} = (1-\theta_0^B b_t^{CP})(1+i_t^{PB})\, \mathbb{E}_t \left( \frac{E_t}{E_{t+1}} \right), \tag{12}$$

which defines implicitly the demand for periphery bonds under imperfect capital mobility. The standard uncovered interest parity condition obtains when $\theta_0^B \to 0$.

### 2.1.2 | Global bank

The balance sheet of the global bank is given by

$$l_t^{CK} + l_t^{CP} = d_t^C + l_t^{CB}, \tag{13}$$

where $l_t^{CK}$ is lending to core CG producers, $l_t^{CP}$ is lending to periphery banks, and $l_t^{CB}$ is borrowing from the core central bank.[13]

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

$$\mathbb{E}_t J_{t+1}^{CB} = q_t^C (1+i_t^{CL})(1-\tau_t^C) l_t^{CK} + (1-q_t^C)\kappa\, \mathbb{E}_t p_{t+1}^{CH} H_t^C + (1+i_t^{CP}) l_t^{CP}$$
$$- (1+i_t^{CD}) d_t^C - (1+i_t^{CR}) l_t^{CB} - \gamma^C\, \frac{(l_t^{CP})^2}{2} + \Omega_t^C, \tag{14}$$

where $i_t^{CR}$ is the marginal cost of borrowing from the central bank, $i_t^{CP}$ is the interest rate on loans to periphery banks, $\tau_t^C \in (0,1)$ is the tax rate on domestic loans imposed for macroprudential reasons, and $q_t^C \in (0,1)$ is the repayment probability of core firms on their loans. The first term in equation (14) 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, $\mathbb{E}_t p^{CH}_{t+1} H^C_t$. The third term, $(1 + i^{CP}_t) l^{CP}_t$, measures repayment on periphery loans. The fourth term is repayment to depositors, and the fifth term is repayment to the central bank, neither of which is state-contingent. The global bank also incurs a non-contingent convex cost that increases with the amount of international lending to periphery banks, as measured by $0.5\gamma^C (l^{CP}_t)^2$, where $\gamma^C > 0$. This cost can be viewed as reflecting operational expenses incurred when gathering information and screening borrowers in the context of cross-border transactions. It may also reflect the fact that as the scale of lending increases, more resources must be devoted to monitoring these operations and reporting to national regulators, given that they involve foreign parties. The last term, $\Omega^C_t$, represents the proceeds of the loan tax; in order to abstract from the fiscal effects of macroprudential policy, these proceeds are assumed to be rebated in lump-sum fashion.

The bank has monopoly power in the deposit and domestic credit markets. It sets the deposit and lending rates, together with the amount of lending to periphery banks, so as to maximize expected profits:

$$1 + i^{CD}_t, 1 + i^{CL}_t, l^{CP}_t = \arg\max \mathbb{E}_t J^{CB}_{t+1}. \tag{15}$$

Solving equation (15), using equation (14) and subject to equation (13), taking the repayment probabilities as given, yields

$$1 + i^{CD}_t = \frac{1 + i^{CR}_t}{1 + \eta_D^{-1}}, \tag{16}$$

$$1 + i^{CL}_t = \frac{1 + i^{CR}_t}{(1 + \eta_L^{-1})(1 - \tau^C_t) q^C_t}, \tag{17}$$

$$l^{CP}_t = \frac{i^{CP}_t - i^{CR}_t}{\gamma^C}, \tag{18}$$

where $\eta_D > 0$ and $\eta_L < 0$ are gross interest elasticities of the supply of deposits and the demand for loans, respectively. Equation (17) shows that the wedge between the policy rate and the loan rate depends on both the risk of default and the macroprudential tax rate. In addition, equation (18) indicates that the supply of loans to periphery banks is increasing in the differential between the return on these loans and the marginal cost of borrowing, as measured by $i^{CP}_t - i^{CR}_t$.

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

$$q^C_t = \left( \frac{\kappa\, \mathbb{E}_t p^{CH}_{t+1} H^C_t / \tilde{p}^{CH} \tilde{H}^C}{l^{CK}_t / \tilde{l}^{CK}} \right)^{\varphi^C_1} \left( \frac{Y^C_t}{\tilde{Y}^C} \right)^{\varphi^C_2}, \quad \varphi^C_1, \varphi^C_2 > 0, \tag{19}$$

where $Y^C_t$ is final output, and variables with a tilde represent steady-state values. Agénor and Pereira da Silva (2017) formally derive an equation similar to (19) as part of the bank's optimization problem, by assuming that *ex ante* monitoring effort is related directly to the probability of repayment—a common assumption in the microtheoretical literature on banking (for instance, see Allen *et al.* 2011; Dell'Ariccia *et al.* 2014)—and that (unit) monitoring costs are countercyclical.[14] The collateral–loan ratio reflects, from a borrower's perspective, a *skin in the game* effect: more collateral induces debtors to act more diligently and thereby raises the repayment probability.

In the Appendix, loans contracted by CG producers are related explicitly to investment. Thus, given equation (17), the supply of these loans is perfectly elastic. In addition, because the supply of deposits is determined by households (given in equation (16)), and the supply of loans to periphery banks is set in equation (18) on the basis of the net return to lending, borrowing by the global bank from the core central bank is determined residually from equation (13).

### 2.1.3 | Central bank

The core central bank operates a standing facility, which involves a perfectly elastic supply of (uncollateralized) loans to the global bank, $l_t^{CB}$, at the prevailing cost of borrowing. It supplies cash, in quantity $m_t^{Cs}$. Its balance sheet is thus

$$l_t^{CB} = m_t^{Cs}. \tag{20}$$

The supply of liquidity to the global bank is perfectly elastic at the prevailing rate $i_t^{CR}$, which is set on the basis of an inertial Taylor rule:

$$\frac{1+i_t^{CR}}{1+\tilde{\imath}^{CR}} = \left(\frac{1+i_{t-1}^{CR}}{1+\tilde{\imath}^{CR}}\right)^{\chi^C} \left\{\left(\frac{1+\pi_t^C}{1+\pi_T^C}\right)^{\varepsilon_1^C} \left(\frac{Y_t^C}{\tilde{Y}^C}\right)^{\varepsilon_2^C}\right\}^{1-\chi^C}, \tag{21}$$

where $\tilde{\imath}^{CR}$ is the steady-state value of the refinance rate, $\pi_T^C \geq 0$ is the inflation target, $\chi^C \in (0,1)$, and $\varepsilon_1^C, \varepsilon_2^C > 0$.

As noted earlier, macroprudential regulation takes the form of a time-varying tax on bank loans to domestic firms.[15] We consider a simple implementable rule whereby changes in the macroprudential tax rate are related to an *operational target* for systemic risk, the credit growth rate. The focus on that variable is consistent with the evidence that suggests that fast credit expansions often lead to excessive leverage, making the economy more vulnerable to negative shocks, and fuelling financial instability.[16] It also reflects the assumption that inefficient credit fluctuations are not observable directly, which implies that in practice, regulators can adopt only policies that are based on noisy indicators of financial risks. Specifically, the rule is defined as

$$\frac{1+\tau_t^C}{1+\tilde{\tau}^C} = \left(\frac{1+\tau_{t-1}^C}{1+\tilde{\tau}^C}\right)^{\chi_1} \left\{\left(\frac{l_t^{CK}}{l_{t-1}^{CK}}\right)^{\chi_2^C}\right\}^{1-\chi_1}, \tag{22}$$

where $\chi_1 \in (0,1)$ is a persistence parameter, and $\chi_2^C > 0$ is the response parameter to the credit growth rate.[17] Thus, from equations (17) and (22), borrowing is more costly during episodes of credit booms, and this in turn helps to mitigate risks to financial stability.

## 2.2 | Periphery

As for the core region, we consider in turn household decisions, the behaviour of banks, and the policy rules of the central bank in the periphery.

### 2.2.1 | Households

Periphery households have the same utility function as core households. They also face a resource allocation problem similar to the one core households are confronted with, in which the effective rate of return on core government bonds, $i_t^C$, is defined, symmetrically to equation (4), as

$$1 + i_t^C = (1 + i_t^{CB})(1 - \theta_t^{PC})\, \mathbb{E}_t\left(\frac{E_{t+1}}{E_t}\right),$$

where $\theta_t^{PC}$ is the intermediation premium faced by periphery households, defined analogously to equation (5):

$$\theta_t^{PC} = \frac{\theta_0^B}{2}\, b_t^{PC}.$$

The solution is therefore analogous to equations (6)–(11). In particular, periphery demand for core government bonds can be written as

$$1 + i_t^{PB} = (1 - \theta_0^B b_t^{PC})(1 + i_t^{CB})\, \mathbb{E}_t\left(\frac{E_{t+1}}{E_t}\right), \tag{23}$$

which implies again that uncovered interest parity holds when $\theta_0^B \to 0$. Thus, as discussed later, the impact of increased financial integration on the gains from coordination can be assessed by considering a reduction $\theta_0^B$.

### 2.2.2 | Commercial banks

Financial intermediation in the periphery involves a two-level structure: firms borrow from domestic banks, and domestic banks borrow from the global bank. Domestic firms cannot borrow abroad directly, due to the inability of foreign lenders to enforce the terms of domestic loan contracts in case of bankruptcy.

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

$$l_t^{PK,i} = (1 - \mu)d_t^{P,i} + z_t l_t^{PC,i} + l_t^{PB,i}, \tag{24}$$

where $l_t^{PK,i}$ is loans to periphery firms, $d_t^{P,i}$ is household deposits (determined analogously to equation (9)), $\mu \in (0,1)$ is the required reserve ratio on these deposits, $z_t l_t^{PC,i}$ is borrowing from the global bank (with $l_t^{PC,i}$ measured in foreign currency terms) at the rate $i_t^{CP,i}$, and $l_t^{PB,i}$ is borrowing from the periphery central bank. Thus, due to the absence of hedging instruments, periphery banks are exposed to exchange rate risk; fluctuations in the real exchange rate generate balance sheet effects.[18]

The market for deposits is competitive, and deposits and central bank liquidity are perfect substitutes. This ensures therefore that for all $i$, the following no-arbitrage condition holds:

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

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

$$l_t^{PK,i} = \left(\frac{1 + i_t^{PL,i}}{1 + i_t^{PL}}\right)^{-\zeta_L} l_t^{PK}, \tag{25}$$

where $i_t^{PL,i}$ is the interest rate on the loan extended by bank $i$,

$$l_t^{PK} = \left[\int_0^1 (l_t^{PK,i})^{(\zeta_L-1)/\zeta_L}\, \mathrm{d}i\right]^{\zeta_L/(\zeta_L-1)}$$

is the amount borrowed by the representative CG producer (set equal to the level of investment, as shown in the Appendix), with $\zeta_L > 1$ denoting the elasticity of substitution between differentiated loans, and

$$1 + i_t^{PL} = \left[\int_0^1 (1 + i_t^{PL,i})^{1-\zeta_L}\, \mathrm{d}i\right]^{1/(1-\zeta_L)}$$

is the aggregate loan rate.

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

$$\begin{aligned}\mathbb{E}_t J_{t+1}^{PB,i} &= q_t^{P,i}(1 + i_t^{PL,i})(1 - \tau_t^P) l_t^{PK,i} + (1 - q_t^{P,i})(\kappa^i p_{t+1}^{PH} H_t^{P,i}) - (1 + i_t^{PD,i}) d_t^{P,i} + \mu d_t^{P,i} \\ &\quad - (1 + i_t^{PR}) l_t^{PB,i} - (1 + i_t^{CP})\, \mathbb{E}_t\left(\frac{E_{t+1}}{E_t}\right) z_t l_t^{PC,i} - \gamma^P z_t \frac{(l_t^{PC,i})^2}{2} + \Omega_t^{P,i}, \end{aligned} \tag{26}$$

where $\kappa^i \in (0,1)$, $i_t^{PR}$ is the marginal cost of borrowing from the central bank, $\tau_t^P \in (0,1)$ is the macroprudential tax rate, and $q_t^P \in (0,1)$ is the repayment probability on loans to periphery CG producers. As before, the first two terms represent expected income (net of taxes) from lending, with $p_{t+1}^{PH} H_t^{P,i}$ representing the expected value of housing collateral, the third term represents interest paid on deposits, the fourth term represents reserve requirements held at the central bank and returned to bank $i$ at the end of the period, the fifth term represents repayment on loans from the central bank, and the sixth term represents expected repayment to the global bank. In addition, periphery banks incur a (non-contingent) convex cost that increases with the amount borrowed abroad, as measured by $0.5\gamma^P z_t (l_t^{PC,i})^2$, where $\gamma^P > 0$. A rationale for this cost is that as borrowing increases, banks must devote more resources to monitoring these operations and reporting to national regulators. This assumption helps to capture in a simple way imperfect substitutability between domestic and foreign borrowing. The last term, $\Omega_t^{P,i}$, represents the revenue of the macroprudential tax levied on bank $i$, which again is transferred back in lump-sum fashion to that bank.

Each bank maximizes profits with respect to their loan rate and their demand for foreign loans:

$$1 + i_t^{PL,i}, l_t^{PC,i} = \arg\max \mathbb{E}_t J_{t+1}^{PB,i}. \tag{27}$$

Solving equation (27) using equation (26), subject to equations (24) and (25), and taking the repayment probability as given, yields, in a symmetric equilibrium,

$$1 + i_t^{PL} = \frac{\zeta_L}{\zeta_L - 1} \frac{1 + i_t^{PR}}{(1 - \tau_t^P) q_t^P}, \tag{28}$$

$$l_t^{PC} = \frac{1}{\gamma^P}\left\{(1 + i_t^{PR}) - (1 + i_t^{CP})\, \mathbb{E}_t\left(\frac{E_{t+1}}{E_t}\right)\right\}. \tag{29}$$

Equation (28) shows once again that a tighter macroprudential response raises the cost of loans, whereas equation (29) indicates that a higher cost of borrowing from the global bank (adjusted for expected depreciation) reduces the demand for foreign loans. As before, borrowing from the central bank is determined residually from the balance sheet equation (24).

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

$$q_t^{P,i} = \left( \frac{\kappa^i \, \mathbb{E}_t p_{t+1}^{PH} H_t^{P,i} / \tilde{p}^{PH} \tilde{H}^P}{l_t^{PK,i} / \tilde{l}^{PK}} \right)^{\varphi_1^P} \left( \frac{Y_t^P}{\tilde{Y}^P} \right)^{\varphi_2^P}, \quad \varphi_1^P, \varphi_2^P > 0,$$

where $Y_t^P$ is final output, and $\tilde{Y}^P$ its steady-state value. As noted earlier, this specification can be derived as part of banks' optimization problem by assuming a one-to-one relationship between the probability of repayment and monitoring effort, as well as endogenous (unit) monitoring costs.

### 2.2.3 | Central bank

Analogously to equation (20), the balance sheet of the periphery central bank is given by

$$l_t^{PB} = m_t^{Ps}.$$

The central bank also operates a standing facility. Its supply of liquidity to banks is perfectly elastic at the rate $i_t^{PR}$, which is set through a Taylor rule similar to equation (21):

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

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

The tax on loans is also set according to a rule similar to equation (22):[19]

$$\frac{1 + \tau_t^P}{1 + \tilde{\tau}^P} = \left( \frac{1 + \tau_{t-1}^P}{1 + \tilde{\tau}^P} \right)^{\chi_1^P} \left\{ \left( \frac{l_t^{PK}}{l_{t-1}^{PK}} \right)^{\chi_2^P} \right\}^{1-\chi_1^P}, \tag{30}$$

where $\chi_1^P \in (0, 1)$, and $\chi_2^P > 0$.

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

## 3 | EQUILIBRIUM AND STEADY STATE

As shown in the Appendix, in a symmetric equilibrium, all IG firms in both regions produce the same output, prices are the same across firms, and total output of core and periphery IGs must be equal to world demand for these goods. In addition, equilibrium in the market for FGs requires that output be equal to domestic absorption, inclusive of price adjustment costs.

The equilibrium condition of the market for cash is solved for the bond rate. The equilibrium in the market for periphery loans requires equating equations (18) and (29), that is, $l_t^{CP} = l_t^{PC}$, which is solved for the equilibrium interest rate on these loans. The equilibrium condition of the housing market is solved, using equation (10), to determine the dynamics of real house prices. In equilibrium, net trade in government bonds (or equivalently, the world net supply of bonds) must be zero. Analogously, in a two-region world, current account surpluses and deficits must be

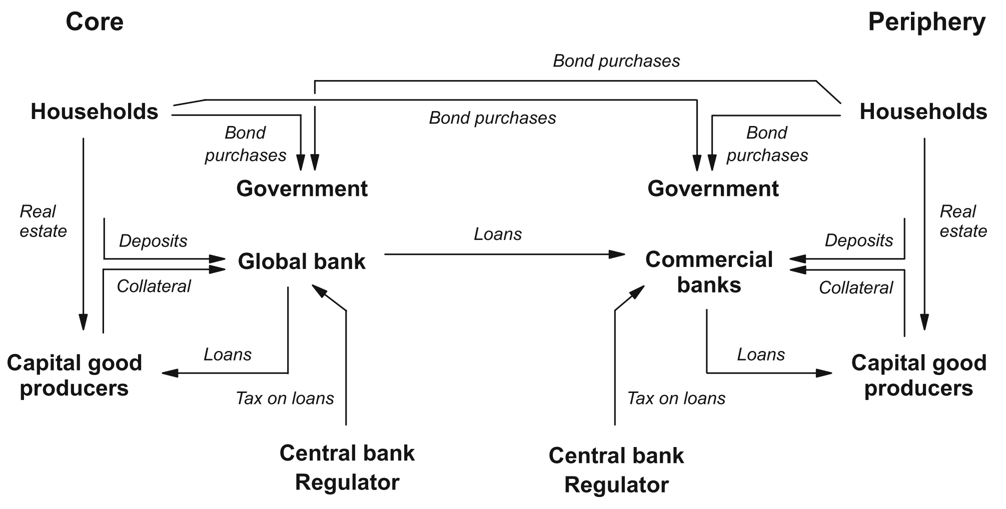


**FIGURE 1** Model structure: financial side.

zero, so $n\ CA_t^C + (1-n)E_t^{-1}\ CA_t^P = 0$, where $CA_t^j$ is the current account of region $j$, also defined in the Appendix.

The steady-state solution of the model, assuming a zero target inflation rate, is briefly described in Appendix B.[20] Several of its key features are fundamentally similar to those described in Agénor *et al.* (2014, 2018) for a small open economy, so we refer to those papers for a more detailed discussion.[21]

## 4 | PARAMETRIZATION

To assess the properties of the model and evaluate the gains from coordination, we parametrize it for two groups of countries, corresponding to the core and periphery, respectively: *major advanced economies* (MAEs) and *systemically important middle-income countries* (SMICs). In standard fashion, MAEs consist of the USA, the euro area and Japan, whereas SMICs, as defined in Agénor and Pereira da Silva (2022), consist of Brazil, China, India, Indonesia, Mexico, Russia, South Africa and Turkey. These groups of countries, as discussed by the International Monetary Fund (2016) and subsequent studies by Arezki and Liu (2020) and Fang *et al.* (2021), represent those that have exerted the largest financial spillovers and spillbacks to each other in recent years.

Our benchmark parametrization is based to a large extent on standard values used in the literature on small open-economy and two-country models. In addition, a number of asymmetries across regions are captured. In particular, we account for the fact that, as documented elsewhere (see Agénor 2020, ch. 1), financial frictions are more pervasive in middle-income countries. In addition, for some of the parameters that are deemed critical from the perspective of this paper, sensitivity analysis is reported later.

The discount factor $\Lambda$ is set at 0.98 for MAEs and 0.95 for SMICs, which gives a steady-state annualized interest rate (real and nominal, given zero inflation in the steady state) of about 2.0% in the first case, and 5.3% in the second. Thus, consistent with the evidence, real interest rates are significantly higher in SMICs. The intertemporal elasticity of substitution is set uniformly at 0.5, in line with the empirical evidence discussed by Braun and Nakajima (2012) and Thimme (2017). In both regions, the relative weight of the disutility of working, $\eta_N$, is set at 25, which gives time allocated to work as less than half of total time available (itself normalized to unity). The Frisch elasticity of labour supply is set at 0.33 (implying that $\psi_N = 3$), which is within the range of estimates discussed by Chetty *et al.* (2011) and used commonly in the literature.

The parameter for composite monetary assets, $\eta_x$, is set at a low value, 0.01, to capture the common assumption in the literature that the direct utility value of money is fairly small (see, for instance, Coenen *et al.* 2009; Christoffel and Schabert 2015). For the housing preference parameter, $\eta_H$, we use the same value 0.1 as in Notarpietro and Siviero (2015). The share parameter in the index of money holdings, $\nu$, which corresponds to the relative share of cash in narrow money, is set at 0.2 to capture the predominant use of deposits in transactions in both regions.

There is no direct evidence to calibrate the cost parameter related to core (periphery) bond holdings by core (periphery) households, $\theta_0^B$, a positive value of which, as noted earlier, corresponds to imperfect capital mobility. However, as can be inferred from equations (12) and (23), $\theta_0^B$ plays a significant role in determining the impact of a change in domestic or foreign interest rates on private capital flows. Thus that parameter can be calibrated indirectly, by choosing a value that matches the evidence on such impact. Accordingly, $\theta_0^B$ is set initially at 0.2, which implies on impact a capital inflow of the order of 0.38% of GDP in response to a 100-basis-point increase in the refinance rate in the periphery.[22] This value is consistent with the reduced-form estimates reported by Villamizar-Villegas *et al.* (2022) for some of the studies included in their meta-analysis, corresponding to a positive 100-basis-point increase in the domestic policy rate in a group of (mostly middle-income) recipient countries.

The distribution parameter between home and imported IGs in the production of the FG (which also measures the degree of home bias), $\Lambda_I$, is set at 0.8 for MAEs and 0.6 for SMICs, to reflect the fact that the latter group is relatively more open than the former. The elasticity of substitution between baskets of domestic and imported composite IGs used in the production of the FG, $\eta_I$, is set at 2.5, which implies that these goods are substitutes in the production of the FG. The elasticities of substitution between core IGs among themselves, $\theta^{CC}$, and imported periphery goods among themselves, $\theta^{PP}$, are both set equal to 10. Quint and Rabanal (2014), in particular, use the same value. This implies a steady-state mark-up of 11%. The share of capital in output of IGs, $\alpha$, is set at 0.35, for both regions, a fairly standard value for both developed and developing economies (see, for instance, Coenen *et al.* 2009; Boz *et al.* 2015; Cuadra and Nuguer 2018). The adjustment cost parameter for prices of domestic IGs, $\phi_I$, is also set uniformly at 74.5 to capture a relatively high degree of nominal price stickiness. This value is close to the average value initially estimated by Ireland (2001, Table 3) and implies a Calvo-type probability of not adjusting prices of approximately 0.71% per period, or equivalently, an average period of price fixity of about 3.5 quarters. These figures are consistent with the point estimates of Quint and Rabanal (2014, Table 2) and Christoffel and Schabert (2015, Table 2) for advanced economies, and the values used by Agénor *et al.* (2018) for middle-income countries.

The capital depreciation rate, $\delta_K$, is set at a quarterly rate of 0.01% for the core and 0.025% for the periphery, which is within the span of values used typically in the literature. The difference between the two regions captures the well-documented fact that firms' physical capital degrades faster in developing economies, due to weaker quality of basic infrastructure. The adjustment cost incurred by the CG producer for transforming investment into capital, $\Theta_K$, is set at 14, in order to match the fact that the standard deviation of the cyclical component of investment is 3–4 times more volatile as output in most countries (see, for instance, Hnatkovska and Koehler-Geib 2018).

Regarding the global bank and periphery banks, the (effective) collateral–loan ratio, $\kappa$, is set at 0.4 for MAEs, and at 0.2 for SMICs, to capture weaknesses in debt enforcement procedures in the latter group of countries, as documented by Djankov *et al.* (2008). The elasticity of the repayment probability with respect to the effective collateral–loan ratio is set at $\varphi_1^C = 0.05$ for MAEs, and $\varphi_1^P = 0.1$ for SMICs, whereas the elasticity with respect to deviations in output from its steady state is set initially at $\varphi_2^C = 0.1$ for the core and, consistent with Agénor *et al.* (2018), $\varphi_2^P = 0.2$ for the periphery. The cost parameters $\gamma^C$ and $\gamma^P$ are set at 0.2 and 0.1, respectively, in order to generate sensible values for initial interest rates. The elasticities $\eta_D$, $\eta_L$ and $\zeta_L$ are set equal to 2.5, 4.5 and 4.5, respectively. This gives a mark-down of the deposit rate relative to the policy rate of about 100 basis points in the core region, and a mark-up of the loan rate over the policy rate (given repayment probabilities 0.96 in the core and 0.936 in the periphery) of about 260 basis points in the core, and 420 basis points in the periphery. The latter results are in line with the evidence for MAEs and SMICs, which suggests significantly higher default rates and higher lending spreads for the latter group of countries.

The degree of persistence in the core central bank's policy response, $\chi$, is set at 0.7, whereas the response parameters of its policy rate to inflation and output deviations, $\varepsilon_1$ and $\varepsilon_2$, are set at 1.7 and 0.1, respectively, as in Coenen *et al.* (2009). For the periphery central bank, the corresponding values are $\chi = 0.0$, $\varepsilon_1 = 2.0$ and $\varepsilon_2 = 0.4$, based on the evidence reported in Agénor *et al.* (2014, 2018). In particular, the weight on output fluctuations in SMICs is significantly higher than in MAEs, which is a well-documented fact in the literature. The required reserve ratio $\mu$ is set at 0.3, consistent with the evidence for some major countries in Latin America (see Agénor and Pereira da Silva 2017).

The share of non-interest government spending in final output, $\varphi^G$, is set at 0.2 for the core (as in Coenen *et al.* (2009), again, and Alpanda and Aysan (2014)) and 0.25 for the periphery, as in Agénor *et al.* (2018). These values are consistent with actual data for MAEs and SMICs, and close to those used in a number of other contributions.

Parameter values are summarized in Table 1, whereas initial steady-state values for some key variables are shown in Table 2. They indicate, in particular, that the shares of (IG) exports are of the order of 10% for both regions, and that the amount of loans from the global bank to the periphery banks is relatively large in proportion of the region's output. The macroprudential tax rates, $\tau^C$ and $\tau^P$, are set at 0 initially in both regions.

## 5 | GLOBAL LENDING SHOCK

To characterize the properties of the model, we consider a global lending shock taking the form of a temporary reduction in the cost of borrowing from the global bank, $i_t^{CP}$, when there is no countercyclical macroprudential policy, that is, $\chi_2^C = \chi_2^P = 0$ in equations (22) and (30). Specifically, given that $l_t^{CP} = l_t^{PC}$, we use equation (29) to solve for lending by the global bank, and rewrite equation (18) to solve for the cost of these loans, so that $i_t^{CP} = (\gamma^C l_t^{CP} + i_t^{CR})\epsilon_t^C$. The multiplicative shock, $\epsilon_t^C$, can be interpreted broadly as reflecting exogenous changes in risk perception by lenders, which induce them to adjust the cost at which periphery banks can borrow abroad.[23] Moreover, $\epsilon_t^C$ is assumed to follow a first-order autoregressive process of the form $\epsilon_t^C = (\epsilon_{t-1}^C)^{\rho^C} \exp(\xi_t^C)$, where $\rho^C \in (0, 1)$ and $\xi_t^C \sim N(0, \sigma_{\xi^C})$. There is no available evidence on the degree of persistence of global lending shocks; after experimenting with a range of values (from a low of 0.2 to a high of 0.95), we opted to set $\rho^C$ at an intermediate value 0.6.[24]

The results of a 1 percentage point reduction in the cost of borrowing from the global bank are shown by the continuous lines in Figure 2. The lower cost of foreign loans induces periphery banks to borrow more, which translates into a capital inflow. In turn, the inflow of capital leads to an exchange rate appreciation, which lowers inflation and thus the refinance rate in the periphery. As a result, the loan rate also falls, thereby stimulating investment and raising aggregate demand. The increase in cyclical output leads to a higher repayment probability, which further reduces the loan rate. At the same time, the drop in the refinance rate—which is mitigated by the output expansion—leads to a reduction in both the deposit rate and the demand for deposits, which is accommodated in part by an increase in money demand. To maintain equilibrium in the money market, the nominal bond rate (the opportunity cost of holding cash) must fall. Given our calibration, this drop exceeds the fall in (one-period ahead) inflation, implying that the (expected) real bond rate also falls—thereby reducing incentives to save and inducing households to increase current consumption.

**TABLE 1** Benchmark Parametrization: Key Parameter Values

| Parameter | Description | MAEs | SMICs |
|---|---|---|---|
| *Households* | | | |
| $\Lambda$ | Discount factor | 0.98 | 0.95 |
| $\varsigma$ | Elasticity of intertemporal substitution | 0.5 | 0.5 |
| $\eta_N$ | Relative weight of the disutility of working | 25.0 | 25.0 |
| $\psi_N$ | Inverse of Frisch elasticity of labour supply | 3.0 | 3.0 |
| $\eta_x$ | Preference parameter for money holdings | 0.01 | 0.01 |
| $\eta_H$ | Preference parameter for housing | 0.1 | 0.1 |
| $\nu$ | Share parameter in index of money holdings | 0.2 | 0.2 |
| $\theta_0^B$ | Cost parameter, intermediation on world capital markets | 0.2 | 0.2 |
| *Producers* | | | |
| $\Lambda_I$ | Share of own-region IGs in final output | 0.6 | 0.8 |
| $\eta_I$ | Elasticity of substitution, baskets of IGs | 2.5 | 2.5 |
| $\theta^{CC}, \theta^{PP}$ | Elasticity of own-region demand, IGs | 10.0 | 10.0 |
| $\alpha$ | Share of capital, IGs production | 0.35 | 0.35 |
| $\phi_I$ | Adjustment cost parameter, IGs prices | 74.5 | 74.5 |
| $\delta_K$ | Depreciation rate of capital | 0.01 | 0.025 |
| $\Theta_K$ | Adjustment cost parameter, investment | 14 | 14 |
| *Banks* | | | |
| $\kappa$ | Effective collateral–loan ratio | 0.4 | 0.2 |
| $\varphi_1$ | Elasticity of repayment probability, collateral | 0.05 | 0.1 |
| $\varphi_2$ | Elasticity of repayment probability, cyclical output | 0.1 | 0.2 |
| $\eta_D$ | Elasticity of deposit supply by households | 2.5 | — |
| $\eta_L, \zeta_L$ | Elasticity of loan demand by capital producers | 4.5 | 4.5 |
| $\gamma^C$ | Cost parameter, loan supply by global bank | 0.2 | — |
| $\gamma^P$ | Cost parameter, demand for global bank loans | — | 0.05 |
| *Central bank* | | | |
| $\mu$ | Required reserve ratio | — | 0.3 |
| $\chi$ | Degree of interest rate smoothing | 0.7 | 0.0 |
| $\varepsilon_1$ | Response of policy rate to inflation deviations | 1.7 | 2.0 |
| $\varepsilon_2$ | Response of policy rate to output deviations | 0.1 | 0.4 |
| $\chi_1$ | Persistence parameter, tax on loans rule | 0.1 | 0.1 |
| *Government* | | | |
| $\psi^G$ | Share of government spending in final output | 0.2 | 0.25 |
| *Shocks* | | | |
| $\rho^C$ | Persistence parameter, global lending shock | 0.6 | — |

**TABLE 2** Initial Steady-State Values: Key Variables

| Variable | Description | MAEs | SMICs |
|---|---|---|---|
| $Y^{CP}/Y^{CI}$ | Share of exports in production of IGs, core | 0.098 | — |
| $Y^{PC}/Y^{PI}$ | Share of exports in production of IGs, periphery | — | 0.094 |
| $C^j$ | Private consumption | 0.650 | 0.650 |
| $I^j$, $l^{jF}$ | Investment, loans to IG firms | 0.150 | 0.100 |
| $r^{jK}$ | Rental rate of capital | 0.031 | 0.083 |
| $l^{PC}$ | Loans from global bank to periphery banks | 0.253 | — |
| $q^{jF}$ | Repayment probability, loans to IG firms | 0.960 | 0.936 |
| $i^{jB}$, $i^{jR}$ | Government bond rate, central bank refinance rate | 0.020 | 0.053 |
| $i^{jD}$ | Bank deposit rate | 0.010 | 0.037 |
| $i^{jL}$ | Loan rate, loans to CG producers | 0.046 | 0.095 |
| $i^{CP}$ | Loan rate, global bank loans to periphery banks | 0.040 | — |
| $\tau^j$ | Countercyclical tax rate on loans to domestic producers | 0.0 | 0.0 |

*Notes*: In proportion of each region's output or in %; $j = C, P$.

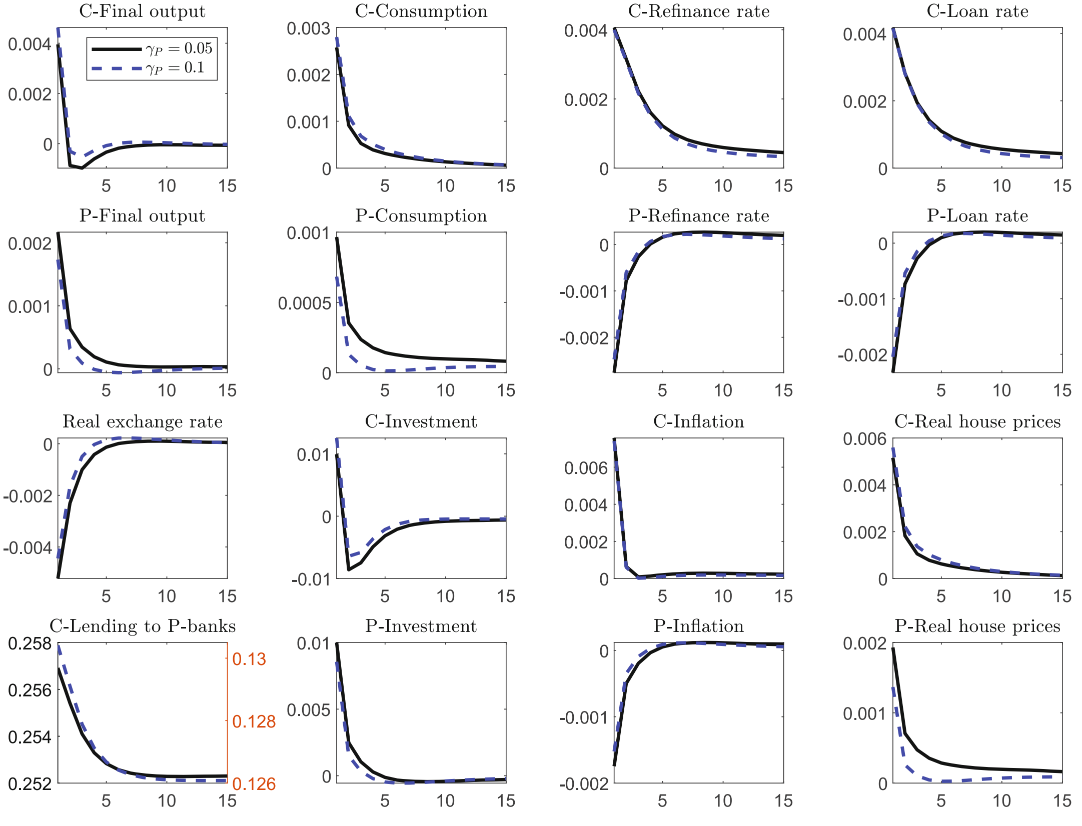


**FIGURE 2** Positive global banking shock. *Notes*: Consumption, investment, output, real house prices, the real exchange rate, and core lending to periphery banks are percentage deviations from their steady-state values. The loan rate, the refinance rate, and the inflation rate are absolute deviations from their steady-state values. Low cost corresponds to 0.05, and high cost to 0.1.

The increase in household spending is also associated with higher demand for housing services, which tends to raise their price. In turn, higher house prices raise the value of collateral and induce a further increase in the repayment probability and downward pressure on the loan rate, which amplifies the expansion of investment. These effects persist over several quarters, before the economy returns to its initial equilibrium position.

Fluctuations in the periphery are transmitted back to the core through trade and financial channels. While the real exchange rate appreciation reduces the domestic cost of imported intermediates in the periphery, thereby increasing their demand and reducing the demand for domestic intermediates, it also has an adverse effect on periphery exports of these goods.[25] The opposite occurs in the core; the demand for home intermediates increases, which raises the demand for physical capital, its expected rate of return, and investment. In turn, this raises core output and inflation, and leads to higher policy and market interest rates. However, the increase in the nominal bond rate is smaller than the increase in (one-period ahead) inflation, and as a result, the (expected) real bond rate falls. Current consumption therefore increases in the core as well, and so do the demand for housing services and house prices. The ensuing increase in collateral values, together with the expansion in output, combine to generate an increase in the repayment probability, which mitigates the initial upward jump in the loan rate. At the same time, the increase in the bond rate in the core region, coupled with the reduction in that rate in the periphery, implies that the demand for periphery bonds by core households falls, whereas the demand for core bonds by periphery households increases. This mitigates the initial capital inflow in the periphery associated with increased bank foreign borrowing. In addition, the increase in the marginal cost of borrowing from the core central bank mitigates the drop in the cost at which periphery banks borrow from the global bank. Nevertheless, the net effect is, from the perspective of the periphery, a capital inflow and an initial appreciation.

The results corresponding to a higher cost parameter in the profit function of periphery banks, parameter $\gamma^P$ in equation (26), are shown as dashed lines in Figure 2. They are largely similar to those described earlier. In particular, the increase in lending by the global bank generates an investment boom in the periphery. The key difference is quantitative; lending by the global bank to periphery banks is now lower, as expected. A higher cost parameter in the profit function of the global bank, parameter $\gamma^C$ in equation (14), generates a similar result and is not reported for clarity.

In sum, the impulse response functions associated with a global lending shock replicate all the causal effects associated with an increase in cross-border lending on macroeconomic and financial variables in recipient countries, as identified by Aldasoro *et al.* (2020) and summarized in the Introduction.[26] The effect on house prices is also consistent with the evidence, provided by Banti and Phylaktis (2019), of a positive link between global lending shocks and global house prices. The positive correlation between the policy rate in the periphery and borrowing by periphery banks is consistent as well with the empirical evidence provided by Avdjiev *et al.* (2018) on lending in global funding currencies. Moreover, our experiments show that movements in major macroeconomic variables (except inflation, and thus interest rates) are positively correlated across regions.[27]

The fact that the model is able to reproduce, and be consistent with, well-documented facts regarding cross-border effects of global lending shocks, while at the same time accounting for spillback effects to the core, makes it a natural starting point for assessing the gains from international macroprudential policy coordination. Indeed, the question now, given that these shocks can create significant fluctuations in both regions, is whether cooperation between regulators can promote global stability and generate significant gains, compared to a setting where they act solely on the basis of their own interests.

## 6 | GAINS FROM COORDINATION

As noted earlier, regulators in both regions are assigned an institutional mandate by society—to promote financial stability. Specifically, each regulator $j = C, P$ seeks to minimize a policy loss function in terms of its own credit-to-output ratio, adjusted for the cost of changing its policy instrument, in a fashion similar to Rudebusch and Svensson (1999), Taylor and Williams (2010), and Debortoli *et al.* (2019), in the context of monetary policy, and Angelini *et al.* (2014) with respect to macroprudential policy:

$$\mathcal{L}_t^j = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left( \frac{l_t^{jK} / \tilde{l}^{jK}}{Y_t^j / \tilde{Y}^j} \right)^2 + \varkappa_W \, \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s (\tau_{t+s}^j - \tau_{t+s-1}^j)^2, \tag{31}$$

where $\varkappa_W \geq 0$ is a parameter that measures the cost (assumed quadratic) associated with changes in the macroprudential instrument.

Under independent (Nash) policies, the regulator in each region sets its instrument, taking as given the behaviour of the other regulator, and determines the optimal value of the response parameter $\chi_2^j$ in the rules (22) and (30), denoted $\chi_2^{j,N}$, so that

$$\chi_2^{C,N} = \arg\min \left. \mathcal{L}_t^C \right|_{\chi_2^P = \chi_2^{P,N}}, \quad \chi_2^{P,N} = \arg\min \left. \mathcal{L}_t^P \right|_{\chi_2^C = \chi_2^{C,N}}.$$

In contrast, under coordination, national regulators—or a benevolent global policymaker acting on their behalf—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 welfare, again defined as in equation (31):

$$\chi_2^{C,O}, \chi_2^{P,O} = \arg\min [n \mathcal{L}_t^C + (1-n) \mathcal{L}_t^P].$$

Thus a lower policy loss for each region taken individually in the coordination regime relative to the uncooperative regime is a sufficient, but not necessary, condition to generate a net gain for the world as a whole; this also depends on the magnitude of the relative gain (or loss) for each region and the relative weight of each of them, as measured by $n$, in the common policy loss function.[28]

Policies are computed under commitment, that is, under the assumption that regulators (individually and jointly) have the ability to deliver on past promises—no matter what the current situation is today. As in de Paoli and Paustian (2017), for instance, under non-cooperation, we solve for the closed-loop or feedback equilibrium. Given the predetermined nature of the feedback rules (22) and (30), each regulator has full knowledge of the other regulator's reaction function; therefore their best responses reflect this knowledge.[29]

While the optimal policy response parameters are determined by minimizing a loss function (again, consistent with the institutional mandate that society bestows on regulators), the social benefit of the optimal policy is evaluated in terms of household welfare, by using a second-order approximation of the discounted present value of utility under both regimes, given by $\mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s u^{j,N}(C_{t+s}^{j,N}, N_{t+s}^{j,N}, x_{t+s}^{j,N})$ under independent policy-making, and by

$$\mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \left[ n u^{C,O}(C_{t+s}^{C,O}, N_{t+s}^{C,O}, x_{t+s}^{C,O}) + (1-n) u^{P,O}(C_{t+s}^{P,O}, N_{t+s}^{P,O}, x_{t+s}^{P,O}) \right]$$

under coordination, where $u^{j,N}(\cdot)$ and $u^{j,O}(\cdot)$ denote the region $j$ period utility function, defined in equation (1), under Nash and cooperation, respectively.

The gains from coordination are then assessed in terms of consumption-equivalent units, that is, in terms of the fraction of the (expected) consumption stream along its path under Nash that would leave households in both regions indifferent between living in a world where regions cooperate in setting countercyclical policy, and a world where they act independently. Specifically, as shown in Appendix C,[30] using second-order approximations to both the household's period utility function and the model, conditional on the initial steady state being the deterministic steady state, the gain from coordination for region $j$ is measured by the coefficient $\beta^j$, defined as

$$\beta^j = \left\{ \frac{\Gamma^{j,C}\ \mathrm{Var}(\widehat{C}_t^{i,O}) + \Gamma^{j,N}[\mathrm{Var}(\widehat{N}_t^{j,O}) - \mathrm{Var}(\widehat{N}_t^{j,N})] + \Gamma^{j,x}[\mathrm{Var}(\widehat{x}_t^{j,O}) - \mathrm{Var}(\widehat{x}_t^{j,N})]}{\Gamma^{j,C}\ \mathrm{Var}(\widehat{C}_t^{j,N})} \right\}^{1/(1-\varsigma^{-1})} - 1,$$

where, for $h = N, O$, $\widehat{\zeta}_t^{j,h}$ denotes the log-deviation of $\zeta_t^{j,h}$ from its steady-state value, $\mathrm{Var}(\widehat{\zeta}_t^{j,h})$ is the conditional variance of $\widehat{\zeta}_t^{j,h}$, calculated from period $t$ to infinity, and

$$\Gamma^{j,C} = \frac{(\tilde{C}^j)^{1-\varsigma^{-1}}}{2\varsigma}, \quad \Gamma^{j,N} = \eta_N \psi_N \frac{\tilde{N}^{j,1+\psi_N}}{2}, \quad \Gamma^{j,x} = \frac{\eta_x}{2}.$$

As also shown in Appendix C, a similar (albeit more complex) expression can be derived for the welfare gain for the world economy as a whole, in terms of a coefficient $\beta$. Therefore positive values of both $\beta^j$ and $\beta$ indicate that cooperation is Pareto-improving.

Panel A of Table 3 shows the results for the benchmark set of parameters displayed in Table 1, with equal weight to each region ($n = 0.5$). The adjustment cost parameter $\varkappa_W$ is also set initially to a uniformly low value 0.03.[31] The degree of persistence in the regulatory policy rules, $\chi_1$, is set to 0.1.[32] A grid step 0.1 is used to search for the optimal response parameters $\chi_2^C$ and $\chi_2^P$ in equations (22) and (30) within a fairly broad interval, $(-10, +10)$. Thus the possibility of a *procyclical* (negative) response to credit fluctuations is also allowed. Welfare results are reported for both individual regions and the world.

The results show, first, that an optimal policy exists because the relationship between the policy loss and the macroprudential tool has an inverted U-shape form, both under Nash and under coordination. Initially, as countercyclical regulatory policy is implemented, volatility falls at first, because it stabilizes credit, investment and aggregate demand, as well as inflation. As a result, the policy loss falls. However, as the policy becomes more aggressive, its cost increases as well. This increase in cost eventually dominates the marginal gain, therefore entailing a rise in the policy loss. The optimal value for the response parameters $\chi_2^j$ is obtained when marginal cost equals marginal gain.

Second, coordination involves a less aggressive response in the core. Indeed, while under Nash $\chi_2^{C,N} = 6.0$ and $\chi_2^{P,N} = 0.4$, under coordination $\chi_2^{C,O} = 5.6$ and $\chi_2^{P,O} = 0.4$. This is because under coordination, the core regulator internalizes the fact that its counterpart in the periphery intervenes to stabilize the domestic fluctuations (or spillovers) caused by the lending shock, and by doing so, mitigates spillback effects. Nevertheless, because $\chi_2^{P,N} = \chi_2^{P,O}$, coordination does not involve *burden sharing*—a situation in which the region where the shock originates (the core) reacts in similar fashion, or less aggressively, than under independent policy-making, whereas the region that is affected by the shock (the periphery) reacts more forcefully.

Third, although coordination is Pareto-improving, the gains differ significantly in size between regions. Indeed, the gain for the core ($\beta^C = 0.0032$) is more than a half larger than the gain for the periphery ($\beta^P = 0.002$), even though the core regulator intervenes less aggressively when countries cooperate. By implication, the world economy is also better off under coordination, compared to independent policy-making ($\beta = 0.0028$). Nevertheless, the gains are relatively small, raising standard questions regarding the viability of a cooperation agreement.

**TABLE 3** Optimal Policy Responses and Gains from Coordination: Benchmark Case and Sensitivity Analysis

| | $\varkappa_W = 0.03$ | $\varkappa_W = 0.04$ | $\varkappa_W = 0.05$ |
|---|---|---|---|
| *Panel A: Benchmark case* | | | |
| Nash: optimal $\chi_2^{C,N}$, $\chi_2^{P,N}$ | 6.0, 0.4 | 4.4, 0.3 | 3.4, 0.2 |
| Coordination: optimal $\chi_2^{C,O}$, $\chi_2^{P,O}$ | 5.6, 0.4 | 4.2, 0.3 | 3.3, 0.2 |
| Welfare gain: | | | |
| Core | 0.0032 | 0.0017 | 0.0005 |
| Periphery | 0.0020 | 0.0017 | 0.0012 |
| World | 0.0028 | 0.0017 | 0.0007 |
| *Panel B: Greater financial integration*, $\theta_0^B = 0.1$ | | | |
| Nash: optimal $\chi_2^{C,N}$, $\chi_2^{P,N}$ | 10.0, 0.4 | 8.0, 0.3 | 6.2, 0.2 |
| Coordination: optimal $\chi_2^{C,O}$, $\chi_2^{P,O}$ | 10.0, 0.3 | 7.6, 0.2 | 6.0, 0.2 |
| Welfare gain: | | | |
| Core | 0.0600 | 0.0644 | 0.0077 |
| Periphery | 0.0402 | 0.0468 | 0.0010 |
| World | 0.0502 | 0.0556 | 0.0044 |
| *Panel C: Unequal size*, $n = 0.818$ | | | |
| Nash: optimal $\chi_2^{C,N}$, $\chi_2^{P,N}$ | 6.0, 0.4 | 4.4, 0.3 | 3.4, 0.2 |
| Coordination: optimal $\chi_2^{C,O}$, $\chi_2^{P,O}$ | 5.9, 0.3 | 4.3, 0.2 | 3.4, 0.1 |
| Welfare gain: | | | |
| Core | −0.0795 | −0.0993 | −0.1267 |
| Periphery | 0.0561 | 0.0676 | 0.0815 |
| World | −0.0673 | −0.0847 | −0.1093 |
| *Panel D: Greater integration*, $\theta_0^B = 0.1$, unequal size, $n = 0.818$ | | | |
| Nash: optimal $\chi_2^{C,N}$, $\chi_2^{P,N}$ | 10.0, 0.4 | 8.0, 0.3 | 6.2, 0.2 |
| Coordination: optimal $\chi_2^{C,O}$, $\chi_2^{P,O}$ | 10.0, 0.2 | 7.7, 0.1 | 6.1, 0.1 |
| Welfare gain: | | | |
| Core | 0.1194 | 0.1078 | 0.0453 |
| Periphery | 0.0886 | 0.1026 | 0.0527 |
| World | 0.1138 | 0.1069 | 0.0466 |

*Notes*: Calculations of the optimal response parameters and the welfare gains are explained in the text. Initial values of $n$ and $\theta_0^B$ 0.5 and 0.2, respectively.

# 7 | SENSITIVITY ANALYSIS

To assess the robustness of the previous results, sensitivity analysis is performed with respect to several features of the model and its parametrization: the cost of instrument manipulation, the degree of international financial integration, the relative weight of each region in evaluating global welfare, and the case where the housing market is perfectly integrated across regions.[33]

## 7.1 | Cost of instrument use

The benchmark results discussed earlier consider a value of $\varkappa_W$, the cost of instrument manipulation, equal to 0.03. The last two columns in panel A of Table 3 display results obtained with higher values $\varkappa_W = 0.04$ and $\varkappa_W = 0.05$, using the same other parameters as in the benchmark case.

The first point to note is that a higher manipulation cost lowers the optimal values for the response parameters $\chi_2^j$, under both Nash and coordination. This negative correlation is the consequence of regulators, under both policy regimes, internalizing the effect of their policy choices on their objective function (31). In turn, a less aggressive policy (despite being optimal from the regulator's perspective) means that it does less to stabilize the economy—including, in particular, market interest rates, which drive household consumption. The second point is that the higher the cost, the more similar policies under the two regimes become. The consequences of both of these effects (a weaker impact on stability, increased similarity in setting policy instruments) is that the gains from coordination, despite remaining positive, become smaller for higher values of the cost parameter. Indeed, there is an inverse relationship, for both parties, between the instrument cost and the magnitude of the welfare gain associated with macroprudential policy coordination.

## 7.2 | Financial integration

Consider now the case where the world economy becomes more integrated financially. This is captured by assuming that the cost parameter associated with financial intermediation on world capital markets, $\theta_0^B$, falls from its benchmark value 0.2 to 0.1. Therefore changes in interest rates become more closely correlated across jurisdictions. In turn, this implies that shocks in one region are transmitted to a greater extent to the other through capital flows, implying larger financial spillovers and spillbacks, and potentially larger gains from international coordination—given that this regime allows regulators, acting together, to internalize cross-border effects.

The results are displayed in panel B of Table 3. In the benchmark case $\varkappa_W = 0.03$, they show that while the regulator in the periphery reacts in the same fashion as before under Nash ($\chi_2^{P,N} = 0.4$), under coordination it reacts less ($\chi_2^{P,O} = 0.3$). In addition, the core regulator reacts now as much as it can, given the upper bound on the response parameters, under both regimes ($\chi_2^{C,N} = \chi_2^{C,O} = 10$). Thus, compared to the benchmark case, coordination entails *burden deepening*—the region where the shock occurs does more to stabilize its economy, which allows the other to react less. Coordination is again Pareto-improving, and the gains this time are fairly substantial; indeed, the results show that now $\beta^C = 0.06$, $\beta^P = 0.04$ and $\beta = 0.05$. The fundamental reason for these outcomes is that greater integration amplifies not only spillovers but also spillbacks, and in so doing enhances the potential benefits of coordinated countercyclical policy responses for all parties—at least for the shock that we consider. As shown in Table 3, similar results hold for a higher cost of instrument manipulation, with again policy responses under both regimes (as in the benchmark case) becoming less aggressive, and more similar, as this cost increases.

To illustrate these results further, Figures 3 and 4 display how the optimal response parameters and the welfare gains change when the parameter $\theta_0^B$ is varied over the broader interval $(0.1, 0.25)$, using grid step 0.01.[34] Figure 3 shows that in the benchmark case $\varkappa_W = 0.03$, as $\theta_0^B$ falls (greater financial integration), the core's response becomes more aggressive, and the periphery's response less so, under both regimes. This is consistent with our earlier discussion. Similar results also hold for a higher instrument manipulation cost. In addition, Figure 4 shows that the gains from coordination increase exponentially with reductions in $\theta_0^B$, once a sufficiently low value of $\theta_0^B$ (about 0.15 in the figure) is reached. With a higher cost of instrument manipulation, results are essentially similar—with the exception that gains for all parties become much less significant when $\varkappa_W = 0.05$ (consistent again with the results in Table 3), particularly for the periphery. The key point, nevertheless, is that greater financial integration may generate substantial benefits if it goes far enough, provided that regulators can manipulate their instruments at a relatively low cost.

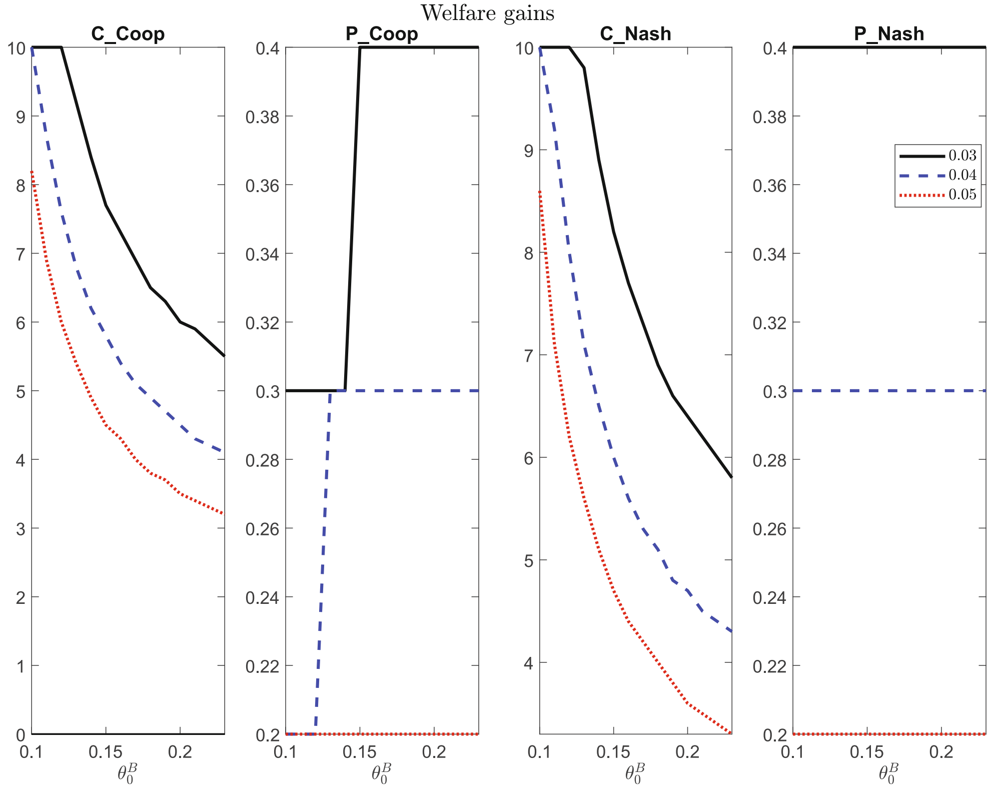


**FIGURE 3** Financial integration and optimal policy response parameters. *Notes*: The different curves measure the response of the macroprudential tax rate to credit growth, based on the rules defined in the text, for different values of the cost of instrument manipulation.

To shed some additional light on the sources of welfare gain from cooperation under greater financial integration, Table 4 presents asymptotic standard deviations (ASDs) for a set of key variables under alternative policy regimes. Columns (1) and (2) show ASD ratios, under Nash and cooperation, respectively, over the corresponding value under no activism, when $\theta_0^B = 0.2$ (again, the benchmark case). A value less than 1 indicates that activism, involving cooperation or not, mitigates volatility, compared to no macroprudential policy response. The results show that this is the case for almost all variables—particularly so for the loan-to-output ratio, as could be expected—except most notably for the real exchange rate and trade flows in both regions, consumption and employment in the periphery, and policy interest rates in both regions. Equally important, across all variables there are no major differences in relative volatility between independent policy-making and cooperation. Therefore this helps us to understand why the gain from cooperation is fairly small in the benchmark case. By contrast, the results displayed in columns (3) and (4), which now relate to the case of greater integration ($\theta_0^B = 0.1$), show that although activism, implemented jointly or not, may be less effective at stabilizing some key variables (including consumption and employment in both regions), cooperation yields significantly larger benefits than independent policy-making. In addition, compared to the Nash equilibrium, the tax on loans under cooperation is also significantly more stable under greater financial integration, thereby reducing the cost of instrument manipulation.

Overall, these results are consistent with the welfare calculations reported in Table 3. They are also broadly consistent with the recent evidence, reviewed by Agénor and Pereira da Silva (2022) and Agénor (2023), that suggests that greater financial interconnectedness in the world economy

**TABLE 4** Asymptotic Standard Deviations of Key Variables Under Alternative Policy Regimes and Degree of Financial Integration

| | $\theta_0^B = 0.2$ | | $\theta_0^B = 0.1$ | |
|---|---|---|---|---|
| | Nash[a] (1) | Coop.[a] (2) | Nash[b] (3) | Coop.[b] (4) |
| *Core* | | | | |
| Final output | 0.312 | 0.313 | 0.342 | 0.326 |
| Employment | 0.808 | 0.807 | 1.006 | 0.992 |
| Consumption | 0.839 | 0.838 | 0.869 | 0.830 |
| Investment | 0.030 | 0.032 | 0.039 | 0.037 |
| Exports | 1.072 | 1.071 | 1.436 | 1.396 |
| Current account | 1.172 | 1.171 | 1.269 | 1.181 |
| Inflation | 1.138 | 1.136 | 1.410 | 1.345 |
| Refinance rate | 1.235 | 1.233 | 1.463 | 1.363 |
| Loan rate | 0.654 | 0.654 | 0.313 | 0.301 |
| Real house prices | 0.839 | 0.838 | 0.869 | 0.830 |
| Repayment probability | 0.085 | 0.083 | 0.325 | 0.307 |
| Loan-to-output ratio | 0.005 | 0.006 | 0.003 | 0.003 |
| Holdings of periphery bonds | 1.046 | 1.045 | 1.471 | 1.453 |
| Lending to periphery | 0.943 | 0.942 | 1.495 | 1.366 |
| Tax on loans (coop./Nash)[c] | — | 0.989 | — | 0.944 |
| *Periphery* | | | | |
| Final output | 0.865 | 0.865 | 1.320 | 1.284 |
| Employment | 1.376 | 1.375 | 1.474 | 1.412 |
| Consumption | 1.157 | 1.156 | 1.480 | 1.417 |
| Investment | 0.488 | 0.487 | 0.578 | 0.651 |
| Exports | 1.082 | 1.081 | 1.309 | 1.266 |
| Current account | 1.172 | 1.171 | 1.269 | 1.181 |
| Inflation | 0.975 | 0.976 | 0.927 | 0.908 |
| Refinance rate | 1.054 | 1.054 | 1.035 | 0.985 |
| Loan rate | 0.171 | 0.172 | 0.218 | 0.270 |
| Real house prices | 1.157 | 1.156 | 1.480 | 1.417 |
| Repayment probability | 0.653 | 0.652 | 1.259 | 1.224 |
| Loan-to-output ratio | 0.408 | 0.408 | 0.458 | 0.544 |
| Holdings of core bonds | 1.046 | 1.045 | 1.471 | 1.453 |
| Real exchange rate | 1.101 | 1.099 | 1.454 | 1.413 |
| Tax on loans (coop./Nash)[c] | — | 1.000 | — | 0.667 |

*Notes*:
[a] Asymptotic standard deviations (ASDs) ratio, under Nash or cooperation, over the corresponding value under no activism, when $\theta_0^B = 0.2$. A value less than 1 indicates that activism mitigates volatility, compared to no policy response.
[b] ASD ratio, under Nash or cooperation, over the corresponding value under no activism, when $\theta_0^B = 0.1$. Interpretation is the same as in columns (1) and (2).
[c] ASD ratio under cooperation relative to Nash. A value lower than 1 indicates that the policy instrument is used less actively under cooperation. All calculations are based on an instrument cost $\varkappa_W = 0.03$.

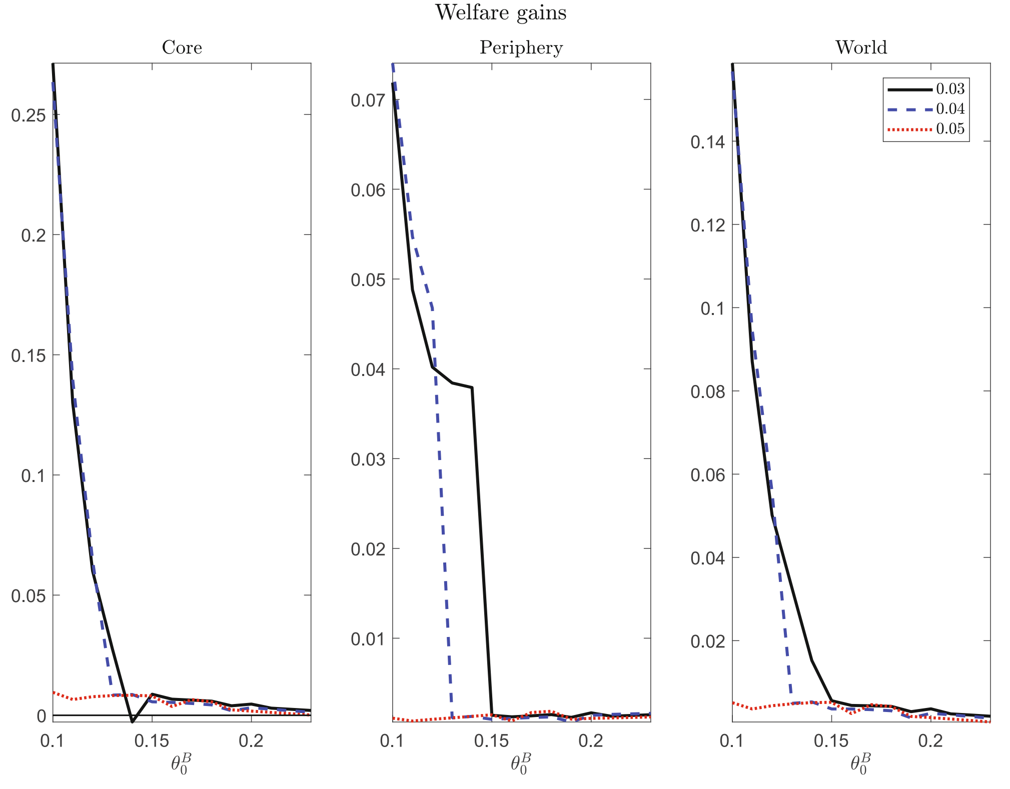


**FIGURE 4** Financial integration and the gains from coordination. *Notes*: The different curves measure the gain from coordination (relative to the Nash equilibrium) in terms of consumption equivalent units, as discussed in the text, for different values of the cost of instrument manipulation.

has increased the potential benefits of international macroprudential policy coordination—even if the possibility of *cross-border regulatory leakages*, as discussed later, has not been accounted for explicitly in our analysis.

## 7.3 | Size of regions

Suppose that instead of equal weights in the global policy loss function, weights are based on economic strength. Specifically, suppose that $n$ is calculated on the basis of the total GDP of the two regions. World Bank data indicate that SMICs accounted for an 18.2% share over the period 2010–17. Thus we set the size of the core region to $n = 1 - 0.182 = 0.818$. The results are shown in panel C of Table 3.

With respect to the optimal response parameters, there are no noticeable differences compared to the benchmark case, regardless of the instrument cost. But with respect to the welfare gains of coordination, the core region is affected adversely—regardless of the instrument cost. At the same time, the gain for the periphery is substantially higher than in the benchmark case; with $\varkappa_W = 0.03$, for instance, $\beta^P = 0.056$, compared to $\beta^P = 0.002$ initially. Nevertheless, given the magnitude of the loss for the core, and its weight in the common objective function, cooperation entails a substantial loss for the world as a whole. With $\varkappa_W = 0.03$, for instance, $\beta = -0.067$, compared to $\beta^P = 0.003$ in the benchmark case. Asymmetric effects, and the fact that the world economy may be worse off, mean that the enforcement challenges alluded to earlier with respect to cooperative agreements may become even more severe.

Panel D of Table 3 also reports the results with both greater financial integration and asymmetric weight in the global policy loss function ($\theta_0^B = 0.1$, $n = 0.818$). This time, cooperation benefits all regions, as in the case where only greater financial integration was considered. This illustrates once again the importance of financial interconnectedness in assessing the gains from cooperation—even when larger economies play a disproportionate role in setting global objectives.

## 7.4 | Integrated housing market

Finally, we consider the case where the housing market is globally integrated. In this setting, housing services can now be traded across regions, even though dwellings themselves are immovable assets. This is consistent with the growing evidence that suggests that house price fluctuations have become highly synchronized across countries, as documented by Hirata *et al.* (2013), Cesa-Bianchi (2013), Jordà *et al.* (2018), Banti and Phylaktis (2019), and, most importantly, the International Monetary Fund (2018, ch. 3), which considers a large sample of high- and middle-income economies.

A simple way to account for a globally integrated housing market in our model consists of treating households as *global property owners* and replacing the region-specific housing market equilibrium conditions—equation (A14) for the core region, and the equivalent for the periphery—by the single equilibrium condition

$$nH_t^C + (1-n)H_t^P = n\overline{H}^C + (1-n)\overline{H}^P,$$

together with the equilibrium price condition

$$p_t^{PH} = z_t p_t^{CH}, \tag{32}$$

where for simplicity we abstract from region-specific real estate transaction costs and other regulations, such as restrictions on land use or foreign buyers, limits on loan-to-value ratios, and so on.[35]

A globally integrated housing market may transmit and amplify shocks by increasing the exposure of local markets to global financial conditions. In our model, more specifically, it implies that house price changes in one region are now transmitted directly to credit markets in the other region, through collateral effects.[36] The question is whether, in a setting where regulators operate on the basis of a simple domestic credit-output policy rule to maximize welfare, this additional channel creates room for coordinated policy responses to be Pareto-improving.

As discussed earlier, a global lending shock translates into an increase in both consumption and house prices in the periphery. In turn, this raises the value of collateral that IG producers in that region can pledge to local banks, which tends to lower the loan rate (or, more precisely, amplify its initial fall), thereby magnifying the expansion in investment and output. Thus even with a segmented housing market, fluctuations in house prices in the periphery play a role in the transmission of shocks occurring in the core.

With an integrated housing market, the increase in house prices in the periphery, combined with the real exchange rate depreciation (from the perspective of the core region) documented earlier, translates into an increase in house prices in the core as well, thereby amplifying, again through the collateral channel, increases in investment and output in that region. Put differently, an integrated housing market, by generating a stronger positive co-movement in house prices across regions, also creates greater spillback effects from the periphery to the core. To the extent that these fluctuations lead to higher volatility, the regulator in the core has now stronger incentives to intervene to stabilize lending. At the same time, under non-cooperation, each regulator sets the macroprudential tax rate solely on the basis of the behaviour of the credit-to-output ratio in its own jurisdiction; neither one of them internalizes the fact that greater financial stability may benefit the other. Thus a globally integrated housing market may generate a cross-border pecuniary externality, which can be internalized under coordination.

Nevertheless, numerical experiments showed that this additional channel is relatively weak in our model, compared to the benchmark case of segmented housing markets. This is the case even with relatively large values of $\eta_H$ (the preference parameter for housing, which determines how much house prices change for a given shock) and $\varphi_1^P$ (the elasticity of the repayment probability with respect to changes in collateral values, which determines how much the loan rate changes). The results, which are not reported in detail to save space, show that while real house prices in the core increase by more, compared to the benchmark case, the opposite occurs in the periphery. The reason, as can be inferred from equation (32), is that the real appreciation puts downward pressure on these prices. Moreover, in both regions, the impact on investment is muted. The reason is that in the model, investment is (implicitly) a function of the *expected* cost of bank borrowing. But because the loan rate itself is inversely related to the repayment probability—as can be seen in equations (17) and (28)—changes in that variable have a limited impact on expected borrowing costs.

## 8 | CONCLUDING REMARKS

The purpose of this paper was to study the extent to which international coordination of macroprudential policy (in the form of a countercyclical tax on bank loans) can generate welfare gains, in a two-region, core–periphery model with a global bank, imperfect financial integration, and financial frictions occurring at both national level (between firms and banks in each region) and international level (between periphery banks and the global bank in the core region). Our key results were summarized in the Introduction.

Our contribution can be extended in a number of directions.

First, a key issue that our analysis raised relates to the need to identify what type of incentives can be used to ensure that countries do not renege on a commitment to coordinate their macroprudential policies. Such incentives relate fundamentally to side payment mechanisms and the perceived *ex post* cost of reneging on a cooperative agreement, but their practical design (including the role of a benevolent global institution) is a matter of debate.

Second, our analysis was limited to a single, albeit important, financial shock, and a particular type of financial frictions. In the real world, of course, there are a number of alternative sources of shocks and financial frictions. Aoki *et al.* (2018) and Akinci and Queralto (2018), for instance, model financial frictions along the lines of Gertler and Karadi (2011), which focuses on moral hazard between banks and depositors and enforcement constraints. As a result, both models generate a direct link between bank balance sheets and the exchange rate. In Akinci and Queralto (2018), agency frictions in banking are also more severe in the periphery for foreign borrowing (from the core) than for domestic deposits. As a result, there is imperfect arbitrage between domestic and foreign loans, and uncovered interest parity fails to hold. A deterioration in borrowers' balance sheets in the periphery raises the home currency's premium and induces a depreciation of the exchange rate. The presence of foreign currency debt amplifies the depreciation, by magnifying interactions between the exchange rate and borrowers' net worth. Their numerical experiments show that the magnitude of cross-border monetary spillovers depends significantly on the degree of currency mismatches in the balance sheets of periphery banks, which in turn could affect significantly the gains from coordination. In addition, it is possible that accounting for a *combination* of financial frictions could make the gains from coordination significantly larger than what we obtained, based on a single source of frictions.

Third, as is well known from game theory, the choice of policy instrument can matter significantly in a non-cooperative game.[37] Our focus has been on a tax on bank loans as a generic macroprudential instrument, which captures the typical cost effect on lenders associated with price-based macroprudential tools (such as capital requirements). However, there is a range of other, quantity-based tools (such as loan-to-value or debt-to-income ratios), whose effects operate through the balance sheets and spending behaviour of borrowers; it is possible that the welfare effects of these instruments may differ substantially under non-cooperation.

At the same time, focusing on coordination using a *similar* instrument in both regions, as we did, is a natural benchmark to consider, for at least three reasons. First, the nature of the shock that we considered means that a lender-based instrument is the most direct tool for regulators to use. Second, the potential for international coordination with respect to lender-based instruments is arguably much stronger (especially given the existence of the Basel III principle of reciprocity, which relates to countercyclical capital buffers) than with respect to, say, loan-to-value or debt-to-income ratios, which are sectoral, borrower-based instruments usually targeted at local real estate markets. Third, the fact that the same instrument is used means that the transmission mechanism of macroprudential regulation is the same in both regions, implying therefore that the gains from coordination (if any) cannot be ascribed to differences in the way policies operate.

Yet, it must also be recognized that in practice, periphery countries have used a wider set of instruments to manage capital flows—bank-related or not. These instruments include sterilized intervention, capital controls and balance sheet restrictions.[38] Future extensions of our analysis could fruitfully study whether the gains from cooperation associated with these alternative policy mixes—for instance, countercyclical capital buffers in the core, and reserve requirements or capital controls in the periphery—could generate higher welfare, compared to the combination studied in this paper.

Fourth, the coordination issue could be cast in the context of leadership games, which would involve one regulator leading the decision-making process. Given that these games involve within-period timing, they are difficult to model fully in standard models. As noted by de Paoli and Paustian (2017), leadership can be thought of as within-period commitment by one player, which clearly makes the leader better off. However, in general, it is not the case that a leadership setup improves welfare compared to the case where both players move simultaneously. More generally, rather than one-shot games, one could focus on modelling repeated games between regulators. From the experimental literature reviewed by Dal Bó and Fréchette (2018), for instance, one can surmise that as long as these games are sufficiently robust to strategic uncertainty—that is, uncertainty regarding the behaviour of regulators in an interactive setting—reputational gains may be large enough to make coordination a preferable strategy.

Finally, there is significant evidence that macroprudential policies are subject to leakages across countries and can generate spillover effects of their own, as a result of global banks shifting activities across countries in response to changes in prudential regulation where they are based—essentially outside the scope of the instrument's application and enforcement. These spillover effects can operate not only through direct lending to foreign country borrowers but also through lending locally to foreign branches, as well as through a 'rebooking' of loans—whereby loans are originated by subsidiaries, but then booked on the balance sheet of the parent institution.[39] If increased lending induced by cross-border regulatory arbitrage by global banks contributes to a credit boom or asset price pressures in the recipient economies, then depending on the stage of their financial cycles, a counterbalancing macroprudential response by regulators there may also be called for to mitigate systemic financial risks.[40] If delays in policy responses can magnify these risks, or if manipulating policy instruments is costly, then *ex ante* coordination may improve global welfare. The model presented in this paper could be extended to account for these effects, possibly by considering economies of scope between domestic and foreign lending by global banks.[41]

## ACKNOWLEDGMENTS

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## NOTES

1 See International Monetary Fund (2016) and Arezki and Liu (2020) for a formal empirical analysis, and Agénor and Pereira da Silva (2022) for a detailed discussion of the recent evidence on the spillover effects associated with global financial shocks.

2 The popular press has echoed these calls to some degree; see, for instance, the article 'Rate rises affect global markets—and may feed back to America' in *The Economist*, 14 June 2018.

3 Arguments in favour of international macroprudential policy coordination have also been based on other considerations, such as pecuniary externalities. See, for instance, Jeanne (2014). Agénor and Pereira da Silva (2022) and Agénor (2023) provide a more detailed discussion.

4 A number of papers on international financial spillovers assume the existence of global banks. In Kollmann *et al.* (2011) and Kollmann (2013), for instance, there is a single bank in the world economy that collects deposits from households and lends to entrepreneurs in *all* countries. Other studies include Kamber and Thoenissen (2013), Alpanda and Aysun (2014), and Cuadra and Nuguer (2018). However, none of these contributions considers the issue of cross-border policy coordination.

5 Cesa-Bianchi *et al.* (2018) also find that an expansion in credit by global banks leads to increases in loans, house prices and consumption in the rest of the world, as well as a real appreciation. However, as discussed by Aldasoro *et al.* (2020), the variable used in that study to instrument international banking claims may generate biases in estimating causal effects.

6 See, for instance, Quint and Rabanal (2014), Levine and Lima (2015), Agénor and Pereira da Silva (2017), Kiley and Sim (2017), and Agénor and Jackson (2022). Such a tax can also be implemented via time-varying reserve requirements, as argued by Kashyap and Stein (2012). A related specification is proposed by de Paoli and Paustian (2017), who model macroprudential policy directly as a tax (or subsidy) on firms' borrowing costs.

7 Because all profits (if any) made by the matched CG producer are returned as a lump sum to its owner, the assumption that the housing stock is made available free of charge is immaterial.

8 These assumptions allow us to capture in simple specifications how default risk affects the pricing of loans. Indeed, we show later that in both regions, the loan rate incorporates a premium (itself inversely related to the repayment probability) above and beyond the marginal cost of borrowing from the central bank.

9 Accounting for housing is important to allow the model to replicate the evidence regarding the spillover effects of global lending shocks, as documented in the empirical literature reviewed in the Introduction.

10 Both deposits and cash are accounted for because, as discussed later, deposits represent a source of funding for banks whereas the equilibrium condition of the market for cash is used to solve for the equilibrium bond rate.

11 These costs could reflect, to some degree, home bias in the preference for assets in both regions. We also assume implicitly that they are rebated to households through a lump-sum transfer and thus do not represent a resource cost to the economy.

12 See Agénor and Montiel (2015, ch. 13) for a discussion of the evidence, and Gabaix and Maggiori (2015) for a specification based on a micro-founded model of the foreign exchange market.

13 Note that periphery households do not hold deposits with the global bank.

14 As noted by Allen *et al.* (2011), this one-to-one relationship can be interpreted as meaning that the lender observes information about a borrower and then uses it to help to improve the borrower's performance. The important point is that greater monitoring is desirable from the borrower's perspective. See Agénor (2020, ch. 4) for a thorough discussion.

15 Because the goal of the regulator in the core region is financial stability at home only, and the base of the tax is solely credit to domestic firms, we naturally assume that the rule is specified in terms of that variable as well—thereby excluding loans to periphery banks.

16 See Taylor (2015) and Aldasoro *et al.* (2018) for a discussion. Some contributions, such as Krishnamurthy and Muir (2020), document the fact that low bond credit spreads tend also to precede episodes of financial instability.

17 As is clear from equation (22), the response parameters do not affect the steady-state level of the macroprudential tax rate, only its cyclical properties.

18 In practice, banks in large middle-income countries do have some access to forward markets for foreign exchange, and prudential requirements often impose on a permanent basis some degree of hedging of their foreign currency liabilities. However, in most cases, these markets remain underdeveloped. Accounting for partial hedging of foreign exchange rate risk would not change the main thrust of our results.

19 Alternative macroprudential instruments for the periphery could be the required reserve ratio, as in Agénor *et al.* (2018), for instance, or a direct tax on foreign borrowing, as in Agénor and Jia (2020). Both instruments have

been used frequently in middle-income countries over the years. However, for symmetry with the core region, the instrument used is also taken to be a (generic) tax on loans.

[20] Appendix B is available from the authors on request.

[21] In particular, we assume, as in Benigno and Woodford (2005), for instance, that policymakers have no access to lump-sum subsidies to correct the short- and long-run distortions created by monopolistic competition and financial frictions. The non-stochastic steady state is thus inefficient.

[22] The capital inflow to the periphery is calculated as the first-period change in the region's foreign liabilities, defined as the sum of holdings of periphery bonds by core households and foreign borrowing by periphery banks, minus holdings of core bonds by periphery households.

[23] As discussed in the Introduction, in recent years, global lending shocks have been a key driver of cross-border capital flows.

[24] A low value 0.2 gives very similar results to 0.6, whereas a high value 0.95 generates significantly more volatility in some financial variables. In the absence of specific evidence, choosing an intermediate value for $\rho^C$ is a sensible approach.

[25] Consequently, the periphery's current account deteriorates, whereas the core's current account improves.

[26] In addition, we also document a positive effect on consumption in recipient countries—which is consistent with the results of Cesa-Bianchi *et al.* (2018).

[27] These positive correlations are documented in several studies. Abbate *et al.* (2016), for instance, find that US financial shocks generate positive co-movement in output across countries.

[28] Note that the persistence parameter $\chi_1$ in equations (22) and (30) is assumed to remain the same under both regimes.

[29] Coenen *et al.* (2009), Banerjee *et al.* (2016) and Agénor *et al.* (2021) solve instead for the open-loop (Ramsey) optimal policy with commitment. In such conditions, each regulator chooses an instrument *path* at the beginning of time—as opposed to a *reaction function* under a closed-loop equilibrium—taking as given the whole future path of the other regulator's instrument.

[30] Appendix C is available from the authors on request.

[31] A positive value of $\varkappa_W$ is necessary to avoid a corner solution in which it is optimal to fully stabilize credit fluctuations. See Agénor (2020, ch. 5) for a more detailed discussion of the role of instrument manipulation costs.

[32] Using an alternative value, 0.8, to capture high persistence does not affect the results qualitatively. To simplify matters, therefore, the persistence parameter is kept constant at a low value throughout.

[33] Sensitivity analysis was also performed with respect to a number of structural parameters—within a reasonable range, to ensure that non-negativity constraints are not violated—namely, the cost parameters $\gamma^C$ and $\gamma^P$, and production parameters, such as $\Lambda_I$. In some cases, these changes did affect the impulse response functions quantitatively. This is the case, in particular, for changes in $\gamma^C$ and $\gamma^P$ (as shown in Figure 2), which affect directly the relationship between the policy rates $i_t^{CR}$ and $i_t^{PR}$, as can be inferred from combining equations (18) and (29). However, the impact on the gains from coordination is not large, compared to those obtained in the benchmark case, because these changes affect in the *same direction* the optimal simple policy under Nash and under cooperation. Details are therefore omitted to save space.

[34] In both Figures 3 and 4, smoother curves could be obtained by choosing a finer grid step than the one used. However, the value chosen is sufficient for illustrative purposes.

[35] To the extent that these costs are proportional to prices and do not change in response to the financial shocks considered here, abstracting from them has no significant bearing on the results.

[36] Cesa-Bianchi *et al.* (2018) also consider the case where house price increases, and associated movements in exchange rates, contribute to cross-border spillovers through changes in collateral values. Their mechanism, however, differs substantially from the one considered in this paper.

[37] See, for instance, Canzoneri and Henderson (1989) for an early analytical example, and Coenen *et al.* (2009) in the context of a multi-country dynamic stochastic general equilibrium model.

[38] See Agénor and Pereira da Silva (2023) for a formal analysis of how some of these instruments operate and how they can be combined with monetary and macroprudential polices to manage external shocks.

[39] See Reinhardt and Riddiough (2014), Avdjiev *et al.* (2017), Kang *et al.* (2017) and Cerutti and Zhou (2018). Buch and Goldberg (2017) provide a broad review of the evidence on the impact of cross-border lending by foreign banks on domestic credit.

[40] The need to mitigate incentives for cross-border regulatory arbitrage is precisely what underlies the Basel III principle of jurisdictional reciprocity in the setting of countercyclical capital buffers. See Agénor and Pereira da Silva (2022) for a discussion.

[41] This issue is addressed in Agénor *et al.* (2022), in a model that focuses on macroprudential policy responses to an expansionary monetary shock in the core.

[42] Defining the terms of trade for the core region as the price of imports relative to the price of exports (both in own currency) as $\tau_t = P_t^{PC}/P_t^{CC}$ yields $P_t^{PC} = \tau_t P_t^{CC}$. Substituting this result in equation (A2) yields $P_t^C = P_t^{CC}[\Lambda_I^\eta + (1-\Lambda_I)^\eta \tau_t^{1-\eta}]^{1/(1-\eta)}$. A related definition holds for $P_t^P$. By log-linearizing these two equations, it can be shown that deviations in the real exchange rate, defined in the text as $z_t = E_t P_t^C/P_t^P$, are proportional to deviations in the terms of trade between the two regions.

[43] Equation (A12) is an approximation, which boils down to the standard arbitrage condition $\mathbb{E}_t r_{t+1}^{CK} \simeq i_t^{CB} - \mathbb{E}_t \pi_{t+1}^C + \delta_K$, in the absence of bank borrowing and adjustment costs.

[44] Using the central bank balance sheet constraint (20), the last term in equation (A13) can be written as $(1+\pi_t^C)^{-1} i_{t-1}^{CR} m_{t-1}^{Cs}$, which corresponds to central bank revenue, rather than seigniorage, consistent with the distinction made by Buiter (2007). It represents the interest earned by investing the resources obtained through the issuance of base money, in the form of loans to the global bank. This revenue is, as noted, transferred to the government.

[45] Conditions (A15) and (A16) give the foreign exchange market equilibrium condition, which is solved for the exchange rate.

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## APPENDIX: PRODUCTION, GOVERNMENT AND EQUILIBRIUM CONDITIONS

This appendix describes the production of the FG, the production of IGs, and the production of CGs. The presentation is made for the core country; results for the periphery are similar.

### A.1. Final good production

To produce the core FG, $Y_t^C$, a basket of domestically produced differentiated IGs sold domestically, $Y_t^{CC}$, is combined with a basket of imported IGs produced abroad (i.e. foreign exports) $Y_t^{PC}$:

$$Y_t^C = \left[\Lambda_I (Y_t^{CC})^{(\eta_I-1)/\eta_I} + (1-\Lambda_I)(Y_t^{PC})^{(\eta_I-1)/\eta_I}\right]^{\eta_I/(\eta_I-1)},$$

where $0.5 < \Lambda_I < 1$, to capture home bias in FG production, and $\eta_I > 0$ is the elasticity of substitution between the two baskets, each of which defined as

$$Y_t^i = \left\{ \int_0^1 [Y_{jt}^i]^{(\theta^i-1)/\theta^i} \, \mathrm{d}j \right\}^{\theta^i/(\theta^i-1)}, \quad i = CC, PC.$$

In this expression, $\theta^i > 1$ is the elasticity of substitution between intermediate core goods among themselves ($i = CC$), and imported goods among themselves ($i = PC$), and $Y_{jt}^i$ is the quantity of type-$j$ IG of category $i$, with $j \in (0, 1)$.

Cost minimization by the representative FG producer yields the demand functions for each variety $j$ of IG:

$$Y_{jt}^i = \left(\frac{P_{jt}^i}{P_t^i}\right)^{-\theta^i} Y_t^i, \quad i = CC, PC, \tag{A1}$$

where $P_{jt}^{CC}$ ($P_{jt}^{PC}$) is the domestic price of core (periphery) IG $j$, and $P_t^{CC}$ and $P_t^{PC}$ are price indices, which are defined as

$$P_t^i = \left\{ \int_0^1 (P_{jt}^i)^{1-\theta^i} \, \mathrm{d}j \right\}^{1/(1-\theta^i)}, \quad i = CC, PC.$$

Demand functions for baskets of core and periphery goods by the core FG producers are

$$Y_t^{CC} = \Lambda_I^{\eta_I} \left(\frac{P_t^{CC}}{P_t^C}\right)^{-\eta_I} Y_t^C, \quad Y_t^{PC} = (1-\Lambda_I)^{\eta_I} \left(\frac{P_t^{PC}}{P_t^C}\right)^{-\eta_I} Y_t^C,$$

where $P_t^C$ is the price of core final output, defined as

$$P_t^C = \left[\Lambda_I^{\eta_I}(P_t^{CC})^{1-\eta_I} + (1-\Lambda_I)^{\eta_I}(P_t^{PC})^{1-\eta_I}\right]^{1/(1-\eta_I)}, \tag{A2}$$

with an analogous expression for the price of final output in the periphery, $P_t^P$. However, because of home bias in production, $P_t^C$ and $P_t^P$ in general differ from each other; their ratio defines the real exchange rate.

Under the assumption of producer currency pricing, and assuming no transportation costs between regions and no rigidities, the law of one price implies that the price of imported periphery good $j$ in the core economy fully reflects movements in the exchange rate:

$$P_{jt}^{PC} = E_t^{-1} P_{jt}^{PP}, \tag{A3}$$

where $P_{jt}^{PP}$ is the foreign currency price of foreign intermediates, set in the periphery.

### A.2. Production of intermediate goods

Core region output of IG $j$, $Y_{jt}^{CI}$, is sold on a monopolistically competitive market and is produced by combining labour $N_{jt}^C$ and beginning-of-period capital $K_{jt}^C$:

$$Y_{jt}^{CI} = (N_{jt}^C)^{1-\alpha}(K_{jt}^C)^{\alpha},$$

where $\alpha \in (0, 1)$.

Capital is rented from a randomly matched CG producer at the rate $r_t^{CK}$. Cost minimization yields the capital–labour ratio and the unit real marginal cost $mc_t^C$, as

$$\frac{K_{jt}^C}{N_{jt}^C} = \frac{\alpha}{1-\alpha}\,\frac{w_t^C}{r_t^{CK}}, \quad \text{for all } i,$$

$$mc_t^C = \frac{(w_t^C)^{1-\alpha}(r_t^{CK})^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}.$$

Each firm $j$ chooses a sequence of prices so as to maximize the discounted present value of its profits:

$$\left\{P_{jt+s}^{CC}\right\}_{s=0}^{\infty} = \arg\max \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda^s \lambda_{t+s} J_{jt+s}^{CI}, \tag{A4}$$

where $\Lambda^s \lambda_{t+s}$ measures the marginal utility value to the representative core region household of an additional unit of real profits, $J_{jt+s}^{CI}$, received in the form of dividends at $t+s$. In Rotemberg fashion, prices are costly to adjust; profits are thus defined as

$$J_{jt}^{CI} = \frac{P_{jt}^{CC}}{P_t^{CC}}\, Y_{jt}^{CI} - mc_t^C\, Y_{jt}^{CI} - \frac{\phi_I}{2}\left(\frac{P_{jt}^{CC}}{P_{jt-1}^{CC}} - 1\right)^2 Y_t^{CI}, \tag{A5}$$

where $\phi_I \geq 0$.

Using equation (A5) after substituting for equation (A1) with $i = CC$, the first-order condition for problem (A4) takes the standard form

$$(1-\theta^{CC})\left(\frac{P_{jt}^{CC}}{P_t^{CC}}\right)^{-\theta^{CC}}\frac{1}{P_t^{CC}}+\theta^{CC}\left(\frac{P_{jt}^{CC}}{P_t^{CC}}\right)^{-\theta^{CC}-1}\frac{mc_t^C}{P_t^{CC}}$$
$$-\phi_I\left\{\left(\frac{P_{jt}^{CC}}{P_{jt-1}^{CC}}-1\right)\frac{1}{P_{jt-1}^{CC}}\right\}+\Lambda\phi_I\,\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{P_{jt+1}^{CC}}{P_{jt}^{CC}}-1\right)\frac{P_{jt+1}^{CC}}{(P_{jt}^{CC})^2}\,\frac{Y_{t+1}^{CI}}{Y_t^{CI}}\right\}=0. \tag{A6}$$

Under symmetry, the price adjustment equation (A6) becomes

$$mc_t^C=\frac{\theta^{CC}-1}{\theta^{CC}}+\frac{\phi_I}{\theta^{CC}}\left[\pi_t^{CC}(1+\pi_t^{CC})\right]-\frac{\phi_I}{\theta^{CC}}\,\mathbb{E}_t\left\{\rho_{t,t+1}\pi_{t+1}^{CC}(1+\pi_{t+1}^{CC})\,\frac{Y_{t+1}^{CI}}{Y_t^{CI}}\right\},$$

where $\rho_{t,t+1}=\Lambda\lambda_t/\lambda_{t+1}$.

Under producer currency pricing, the law of one price implies once again that the price of core IGs sold on the periphery market (that is, the market price of core exports in the periphery), $P_t^{CP}$, is equal to the core price adjusted for the exchange rate:[42]

$$P_t^{CP}=E_tP_t^{CC}. \tag{A7}$$

As noted earlier, trade between the two regions occurs only at the level of IGs. The market-clearing condition therefore equates total output of core IG $j$ with world demand for that good, that is, the sum of the core and periphery demands for core good $j$:

$$Y_{jt}^{CI}=Y_{jt}^{CC}+Y_{jt}^{CP}, \tag{A8}$$

with, similar to equation (A1), $Y_{jt}^{CP}=(P_{jt}^{CP}/P_t^{CP})^{-\theta_i}\,Y_t^{CP}$ denoting core exports. A similar condition holds for periphery production of each IG $j$:

$$Y_{jt}^{PI}=Y_{jt}^{PP}+Y_{jt}^{PC}, \tag{A9}$$

with $Y_{jt}^{PC}$ (core region imports) given by equation (A1).

Note that we also have in value terms $P_t^{CI}\,Y_t^{CI}=P_t^{CC}\,Y_t^{CC}+P_t^{CP}\,Y_t^{CP}$, where $P_t^{CI}$ is the implicit output price of IGs. Given equation (A7), and equation (A8) under symmetry, this expression gives $P_t^{CI}=P_t^{CC}(Y_t^{CC}+E_tY_t^{CP})/(Y_t^{CC}+Y_t^{CP})$.

### A.3. Capital good production

The aggregate capital stock $K_t^C=\int_0^1K_{jt}^C\,\mathrm{d}j$ is obtained by combining gross investment, $I_t^C$ with the existing capital stock, adjusted for depreciation and adjustment costs:

$$K_{t+1}^C=I_t^C+\left\{1-\delta_K-\frac{\Theta_K}{2}\left(\frac{K_{t+1}^C-K_t^C}{K_t^C}\right)^2\right\}K_t^C, \tag{A10}$$

where $\delta_K\in(0,1)$ is the depreciation rate, and $\Theta_K>0$.

Investment goods must be paid for in advance. The representative CG producer must therefore borrow from commercial banks:

$$l_t^{CK}=I_t^C. \tag{A11}$$

The representative household makes its exogenous housing stock $H_t^C$ available without any direct charge to the representative CG producer, who uses it as collateral to secure loans.

Repayment is uncertain and occurs with probability $q_t^C \in (0, 1)$. Expected repayment is thus $q_t^C(1 + i_t^{CL})l_t^{CK} + (1 - q_t^C)\kappa\, \mathbb{E}_t p_{t+1}^{PH} H_t^C$, where $\kappa \in (0, 1)$ is the share of the housing stock that can be effectively pledged as collateral.

Subject to equations (A10) and (A11), the representative CG producer chooses the level of capital $K_{t+1}^C$ so as to maximize the value of the discounted stream of dividend payments to the matched household. As shown in Agénor *et al.* (2020, ch. 4), the solution to this problem yields[43]

$$\mathbb{E}_t r_{t+1}^{CK} \simeq q_t^C (1 + i_t^{CL})\, \mathbb{E}_t \left\{ \left[ 1 + \Theta_K \left( \frac{K_{t+1}^C}{K_t^C} - 1 \right) \right] \frac{1 + i_t^{CB}}{1 + \pi_{t+1}^C} \right\} \\ - \mathbb{E}_t \left[ q_{t+1}^C (1 + i_{t+1}^{CL}) \left\{ 1 - \delta_K + \frac{\Theta_K}{2} \left[ \left( \frac{K_{t+2}^C}{K_{t+1}^C} \right)^2 - 1 \right] \right\} \right]. \tag{A12}$$

## A.4. Government

Income received by the central bank on its lending to the global bank is transferred to the government, whereas (as noted earlier) revenue from the macroprudential tax is returned lump-sum to the global bank. The core government budget constraint is thus given by[44]

$$b_t^C = G_t^C - T_t^C + \frac{1 + i_{t-1}^{CB}}{1 + \pi_t^C}\, b_{t-1}^C - i_{t-1}^{CR}\, \frac{l_{t-1}^{CB}}{1 + \pi_t^C}, \tag{A13}$$

where $b_t^C = b_t^{CC} + b_t^{PC}$ is the real stock of core riskless one-period bonds held by core ($b_t^{CC}$) and periphery ($b_t^{PC}$) households, and $G_t^C$ is real expenditure on FGs, which represents a fraction $\psi^G \in (0, 1)$ of final output:

$$G_t^C = \psi^G Y_t^C.$$

The government in each region is assumed to keep its real stock of debt constant and to balance its budget by adjusting lump-sum taxes.

For the periphery, interest income received by the central bank is also assumed to be transferred to the government. The periphery government budget constraint therefore takes the same form as equation (A13), with now $b_t^P = b_t^{PP} + b_t^{CP}$ and interest payments $(1 + \pi_t^P)^{-1}(1 + i_{t-1}^{PB})b_{t-1}^P$.

## A.5. Equilibrium conditions

In a symmetric equilibrium, all IG firms produce the same output, and prices are the same across firms. Thus the market-clearing conditions (A8) and (A9) for good $j$ also imply that total output of core and periphery IGs be equal to world demand for those goods:

$$Y_t^{CI} = Y_t^{CC} + Y_t^{CP}, \quad Y_t^{PI} = Y_t^{PP} + Y_t^{PC}.$$

Equilibrium in the market for FGs requires that output be equal to domestic absorption, inclusive of price adjustment costs:

$$Y_t^C = C_t^C + G_t^C + I_t^C + \frac{\phi_I}{2} \left( \frac{P_t^{CC}}{P_{t-1}^{CC}} - 1 \right)^2 \frac{P_t^{CC}}{P_t^C}\, Y_t^{CI},$$

and analogously for the periphery.

The equilibrium condition of the market for cash in the core region is thus

$$m_t^{Cs} = m_t^C,$$

which can be solved for the equilibrium bond rate.

Equilibrium in the market for periphery loans requires equating (18) and (29), that is, $l_t^{CP} = l_t^{PC}$, which can be solved for the equilibrium loan rate on these loans. Alternatively, rewriting equation (18) as

$$1 + i_t^{CP} = (1 + i_t^{CR}) + \gamma^C z_t^{-1} l_t^{PC}$$

shows that, holding other variables constant, an increase in the amount borrowed by periphery banks, as defined in equation (29), raises the cost at which they borrow from the global bank.

The equilibrium condition of the housing market is

$$H_t^C = \overline{H}^C, \tag{A14}$$

which can be solved, using equation (10), to determine the dynamics of real house prices.

In equilibrium, net trade in government bonds (or equivalently, the world net supply of bonds) must be zero, so that

$$nb_t^{CC} + (1-n)b_t^{PC} = 0, \quad (1-n)b_t^{PP} + nb_t^{CP} = 0.$$

Analogously, in a two-region world, current account surpluses and deficits must be zero, that is,

$$n\, CA_t^C + (1-n)E_t^{-1} CA_t^P = 0,$$

with the core region's current account (at prevailing local prices) defined in conventional manner as

$$\begin{aligned} CA_t^C = {} & P_t^{CC} Y_t^{CP} - P_t^{PC} Y_t^{PC} \\ & + i_{t-1}^{CP} P_{t-1}^C l_{t-1}^{PC} + i_{t-1}^P E_{t-1}^{-1} P_{t-1}^P b_{t-1}^{CP} - i_{t-1}^C P_{t-1}^C b_{t-1}^{PC}. \end{aligned} \tag{A15}$$

In this expression, $P_t^{CC}$ is the price of core IGs sold to the periphery (that is, the price of core exports), $Y_t^{CP}$ are core exports of IGs, which correspond also to the periphery's imports of these goods, $P_t^{PC} = E_t^{-1} P_t^{PP}$ is the price of periphery IGs sold to the core (equal to the price of periphery IGs adjusted for the nominal exchange rate, corresponding to equation (A3) in a symmetric equilibrium), and $Y_t^{PC}$ are core imports of IGs, which correspond also to the periphery's exports. The third term in equation (A15) is the interest income from loans to the periphery by the global bank, and the fourth (fifth) term is interest income (payment) on holdings of periphery (core) bonds by core (periphery) households. By definition, the current account is also given by (minus) the net change in foreign assets:[45]

$$CA_t^C = (E_t^{-1} P_t^P b_t^{CP} - E_{t-1}^{-1} P_{t-1}^P b_{t-1}^{CP}) + (P_t^C l_t^{PC} - P_{t-1}^C l_{t-1}^{PC}) - (P_t^C b_t^{PC} - P_{t-1}^C b_{t-1}^{PC}). \tag{A16}$$

Finally, note that the current account for the periphery at current local prices (the analogue of equation (A15)) can be written as

$$\begin{aligned} CA_t^P = {} & P_t^{PP} Y_t^{PC} - P_t^{CP} Y_t^{CP} \\ & - i_{t-1}^{CP} E_{t-1} P_{t-1}^C l_{t-1}^{PC} - i_{t-1}^{PB} P_{t-1}^P b_{t-1}^{CP} + i_{t-1}^C E_{t-1} P_{t-1}^C b_{t-1}^{PC}, \end{aligned} \tag{A17}$$

where $P_t^{CP} = E_t P_t^{CC}$ is the price of core goods sold in the periphery region (equal to the price of core IGs adjusted for the exchange rate, corresponding to equation (A7) in a symmetric equilibrium), $Y_t^{CP}$ are periphery imports of intermediates, which correspond also to the core's exports, $P_t^{PP}$ is the price of periphery IGs sold on the core market (i.e. the price of periphery exports), and $Y_t^{PC}$ are periphery exports of IGs, which correspond also to the core's imports. The third term in equation (A17) is the interest payment on loans to the periphery by the global bank, and the fourth (fifth) term is interest payment (income) on holdings of periphery (core) bonds by (periphery) core households.

In terms of changes in foreign assets, $CA_t^P$ can also be written, similar to equation (A16), as

$$\begin{aligned} CA_t^P = {} & E_t P_t^C b_t^{PC} - E_{t-1} P_{t-1}^C b_{t-1}^{PC} \\ & - (E_t P_t^C l_t^{PC} - E_{t-1} P_{t-1}^C l_{t-1}^{PC}) - (P_t^P b_t^{CP} - P_{t-1}^P b_{t-1}^{CP}). \end{aligned}$$

Appendices B and C are available from the authors on request.