Macroprudential Policy Leakages in Open Economies: A Multiperipheral Approach*

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Abstract

To understand the international nature of the macroprudential policy and the potential cross-border regulatory leakages these imply we develop a three-country center-periphery framework with financial frictions and limited financial intermediation in emerging economies. Each country has a macroprudential instrument to smooth credit spread distortions; however, the banking regulations can leak to other economies and be subject to costs. Our results show the presence of cross-border regulation spillovers that increase with the extent of financial frictions, which are driven by the capacity of the regulation to limit aggregate intermediation, and that can be magnified if policymakers are forward-looking. We discuss the policy implications of the resulting macroprudential interdependence and the potential scope for policy design that improves the management of the trade-off between mitigating the financial frictions and curtailing intermediation.

JEL Codes: F38, F42, E44, G18

Keywords: Macroprudential policy, macroprudential policy leakages, financial frictions.

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1 Introduction

Over the past few decades there has been a global trend toward financial globalization, which despite being driven by the intention to direct resources to their most productive destinations, has led to higher volatility in financial markets, global imbalances, and a global financial cycle that disproportionately affects emerging economies (Rey, 2013; Miranda-Agrippino and Rey, 2020). To address these issues, policymakers have implemented new macroprudential regulations such as those in the Basel Accords, and established new institutions, including the Financial Stability Board. The effectiveness of these regulations has been extensively evaluated, along with their broader effects, leakages and externalities.[1] However, although observed empirically, these leakages are less understood in terms of their functioning and driving mechanisms (Forbes, 2020), for example, it would be relevant to understand their nature or what generates them, and whether they create additional unaccounted vulnerabilities or, perhaps, the space for welfare improving policy adjustments.

In this study, we develop a macroeconomic framework to explore these regulatory leakages and related questions. We focus on an open economy environment where several emerging economies interact with a common financial center in global markets.[2] For these economies, the international consequences of nationally implemented regulations are particularly relevant, given their increased fragility to the shocks of global markets (Chang and Velasco, 2001; Reinhart and Rogoff, 2009). As policymakers recognize the borderless effects of their implementation, regulations in different locations may become interdependent, prompting policymakers to react with their own toolkit in response. As a result, policy frameworks that internalize such cross-border linkages could be better poised for managing the fluctuations dictated by global financial while better balancing the costs and trade-offs of regulation.[3]

We investigate the nature of international policy spillovers and how they are shaped by the presence of financial frictions and the direction of the policy leakages. Our study is innovative in that we explore a framework with multiple peripheries that jointly, can become a relevant entity for their common financial center but that still depend financially on the latter economy given it acts —through their banking sector—as a global creditor. In this setup, the regulators trade-off their incentives to mitigate their financial frictions with those of boosting financial intermediation,

[1]See for example Hahm, Mishkin, Shin, and Shin (2011), and Akinci and Olmstead-Rumsey (2018), among others, for a review on their effectiveness; and Aiyar, Calomiris, and Wieladek (2014), Aizenman, Chinn, and Ito (2017), Coimbra and Rey (2017), and Buch and Goldberg (2017) for discussions on empirical evidence for their external spillovers.

[2]Although the most salient examples of potentially coordinated policies at the emerging level are situated around the financial regulatory framework of the peripheral European economies and their reporting to the European Systemic Board (ESRB) —see Dennis and Ilbas (2023), our study is more generally concerned with the stance of any set of emerging economies that face interactions with a common financial center and that, for example, may choose or not to abide by a common set of recommendations by global institutions outside their domestic jurisdiction.

[3]The costs of these regulations are attributed to their implementation, increases in operational costs of the financial sector, and subsequent effect on lending rates (see, for example Eling and Pankoke, 2016; Elliott and Santos, 2012), but are also given in terms of their macroeconomic impact as discussed in Richter, Schularick, and Shim (2019); Kim and Mehrotra (2022).

and their resulting actions will potentially impact the economic conditions in other locations.

We consider the presence of the banking sector explicitly in our framework along the lines of Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Adrian and Shin (2010), but extended to an open economy environment as in Céspedes, Chang, and Velasco (2017), with the difference that we allow for a multi-peripheral economic structure.[4] Therefore, this work is related to the studies exploring whether changing financial conditions increase the extent of policy interdependency (e.g., in Fujiwara and Teranishi, 2017; Banerjee, Devereux, and Lombardo, 2016; Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva, 2021).[5] We build on these studies with a focus on macroprudential interventions and potential cross-border linkages between different types of financially integrated economies.

To introduce a meaningful role for prudential policies, we consider a setup with financial frictions caused by a limited enforcement agency distortion as described by Gertler and Karadi (2011) and Mendoza (2010), which will be more prevalent in emerging markets and leads to a default premium on interbank lending relationships, amplifying the scale of financial intermediation, and potentially shaping the international financial spillovers. We examine the existence and nature of cross-border policy spillovers and evaluate the effectiveness of several policy regimes in mitigating this distortion and smoothing the credit spreads. Specifically, we consider a macroprudential instrument that taxes banking sector revenues, similar to Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva (2021). It is worth noting that this policy tool may impact capital flows across borders and could be seen as a form of capital control. However, we argue that it is better described as a macroprudential tool with potential capital flows implications. To see this, we first demonstrate that it is equivalent to a leverage-ratio requirement, and secondly, we note that it primarily regulates the scale of financial intermediation, which could be international or domestic, without significant effects on capital flows.[6]

Our framework is set as a large open economy model similar to Banerjee, Devereux, and Lombardo (2016), or Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva (2021), but with the abstraction from monetary policy concerns. This simplification enables us to extend the environment to that of a multi-peripheral financially integrated economy, facilitating the

[4]See Brunnermeier, Eisenbach, and Sannikov (2013) for a literature survey on the macroeconomic implications of financial frictions and the existing approaches to model the banking sector.

[5]A related literature preceding this question and our paper (e.g., Obstfeld and Rogoff, 2002; Devereux and Engel, 2003; Corsetti and Pesenti, 2001; Fujiwara and Wang, 2017) study monetary policy linkages and their potential for generating gains from policy coordination under nominal rigidities and conclude that the welfare gains, if present, are small. However, subsequent studies (Sutherland, 2004; Corsetti and Pesenti, 2005; Banerjee, Devereux, and Lombardo, 2016; Bodenstein, Corsetti, and Guerrieri, 2020) revisit this question, and the potential for more sizable welfare gains, in presence of changing financial conditions. Our work aligns closer to this second group of studies.

[6]The separation line between these two types of policies has become less clear over time, as both in the literature (e.g., Farhi and Werning, 2016; Cesa-Bianchi et al., 2018; Korinek, 2022) and policy work (IMF, 2017) has been stated that the capital controls have systemic risk and financial stability effects and thus could be set with those effects in mind and not only with the goal of stabilizing the exchange rates. Moreover, our setup is that of a real economy in which the exchange rate fluctuations play no role, and the only implications of policy are those of mitigating a financial accelerator mechanism.

examination of strategic interactions between macroprudential regulators in different types of economies. The consideration of a large open economy is relevant when studying potential prudential leakages; even under the standard assumption that financial centers' regulators are not concerned with the policy actions of smaller countries (e.g., as in Jin and Shen, 2020), as it may be the case that emerging countries decide to synchronize their policies at the regional level and generate non-trivial policy leakages in both directions —financial center to peripheral block and viceversa— that planners in each location would want to internalize. Having mentioned this, it should be noticed that the financial center still plays a prevalent role in the global market we consider. Hence, by accounting for such international spillovers dictated by financial centers, our study is also related to the global financial cycle literature (Rey, 2013, 2016) and to studies on the stabilizing role of financial regulations for emerging economies (Nuguer, 2016; Cuadra and Nuguer, 2018).

International policy externalities manifest through several channels. First, the profits of exiting bankers are directly affected by domestic and foreign policy tools, and these changes enter the households' budgets due to ownership. Second, firms fund their input acquisitions with banking loans, and the costs of these loans depend on the policy instruments. Moreover, there is another relevant externality mechanism that implies an interlink between financial distortions at different locations. This mechanism consists of the general equilibrium effects of implementing a policy action. For example, if a center regulator implements a tightening to decrease the external finance premium locally, she inadvertently decreases the cost of debt in other locations since its creditor banks must be indifferent between funding local and foreign projects in equilibrium; this has the unintended effect of increasing the implied financial frictions, credit spread, and external finance premia abroad, prompting foreign regulators —in debtor countries— to make additional policy adjustments.[7]

Additionally, we find that the impact of policy measures increases with the extent of financial distortions, an outcome that aligns with the conventional wisdom that these policies are more useful in emerging markets (Alam, Alter, Eiseman, Gelos, Kang, Narita, Nier, and Wang, 2019; Boz, Unsal, Roch, Basu, and Gopinath, 2020). Other factors influencing these effects include the net foreign asset positions, the price and demand changes in the interbank sector, and the disruption in real production activities, which is a prevalent concern in regulation circles and recent empirical studies (e.g., Richter, Schularick, and Shim, 2019; Kim and Mehrotra, 2022). Importantly, all of these features reflect a policy trade-off faced by the financial regulators—they must balance their intention to mitigate the financial frictions with the impact of more stringent policies on financial regulation. Moreover, the open economy setup allows us to see that such trade-off extends beyond the border of the planner's jurisdiction. For example, a tighter regulation on an emerging country that curtails intermediation domestically will affect negatively the center economy whose banks'

[7]This type of inter-dependent friction effects are normally not internalized by nationally-oriented regulators, similarly to how borrowers may fail to account for the pecuniary effects of their debt in other setups, and may make the case for coordinated policy actions along the lines discussed in Jeanne (2014, 2021) and Blanchard (2017).

act as a creditor of the former economy.

To inquire further into the nature of these leakages, we apply another extension where repeated financial intermediation with profits retaining is incorporated into the framework to allow for richer—and more empirically plausible—policy dynamics. In this case, the policy decisions become dynamic in the sense that current policy changes have effects on future balance sheets (and profits) of the banking sector. In this context the policy effects —direct and leaked across borders— can be magnified, increasing the interdependency of policy across economies.

Finally, we explore the implications of our framework for policy design. We find that optimal policy configurations prompt emerging economies to prioritize mitigating their frictions, while the center reacts by attempting to steer higher intermediation flows towards the peripheries through tighter domestic policies (which in relative terms implies looser lending conditions towards other lenders abroad). These nationally-oriented policies imply strong interventions that can be socially costly, which we illustrate by reporting optimal policies for alternative regimes where regulators internalize their effect on the rest of the world's welfare. In such centralized cases, planners can afford to minimize regulatory wasteful actions by enacting the same effects with more conservative interventions. Importantly, we verify that policies are impactful enough to mitigate the financial friction in all regimes, an outcome that hinges heavily in the flexibility of the policy toolkit in each regime as illustrated by Korinek (2016). However, when regulation costs potentially affect the toolkit flexibility, the decentralized (nationally-oriented) policies, requiring more interventionism, become less capable of achieving a constrained efficient outcome, opening the scope for welfare-inducing coordinated policy frameworks.

There are several strands of literature related to our work. First, our study intends to provide a framework consistent with the empirical findings on macroprudential linkages across borders; these consider the studies on how financial regulation can affect foreign agents and markets (Buch and Goldberg, 2017; Forbes et al., 2017; Forbes, 2020), as well to how prudential policies implementations can leak financial (in)stability to other economies (Aiyar, Calomiris, and Wieladek, 2014; Tripathy, 2020). On the other hand, related literature has produced two-country large open economy frameworks to explore the interdependency of macroprudential regulators; for example for interactions between regulators in a monetary union (e.g., Rubio and Carrasco-Gallego, 2016; Agénor et al., 2021; Dennis and Ilbas, 2023), or for interactions between emerging and advanced economies (e.g., Nuguer, 2016; Cuadra and Nuguer, 2018); our framework is similar in exploring regulatory interactions, but differs in that it considers a multiperipheral structure that permits us to see which effects arise between seemingly disconnected (emerging) countries that share a common financial center.[8]

[8]Less closely, our work also relates with studies on macroprudential policies in small open economies such as Reyes-Heroles and Tenorio (2020), and Jeanne and Korinek (2019), as well as to studies exploring how changing financial conditions leading to stronger financial interlinkages, such as those stemming from sovereign debt issuance choices, may shape the policy spillovers from advanced to emerging economies (see for example Gilchrist et al., 2019; Liu et al., 2024; Borri and Shakhnov, 2021).

On the other hand, to study the implications of the leakages, we explore potential policy design implications for interconnected countries that in principle may choose to coordinate their policy decisions. In that sense, although performing a comprehensive welfare accounting exercise is beyond the scope of our setup, some implications are similar to studies on macroprudential policy cooperation (e.g., Davis and Devereux, 2022; Korinek, 2016; Bengui, 2014; Jin and Shen, 2020; Kara, 2016, among others).[9] [10]

The rest of the paper is organized as follows: section 2 explains the baseline model, sections 3 and 5 explore the model analytically, initially in our baseline setup and then in an extended version respectively. Then in section 4 we describe the numerical solution of the model and in section 6 we discuss the policy implications. Finally we conclude.

2 The Model

Our framework is based on Banerjee, Devereux, and Lombardo (2016), meaning that it essentially follows the banking sector modelation of Gertler and Karadi (2011) applied to an open economy setup. In this paper, however, we introduce a multiperipheral environment, where the peripheric block of the economy is allowed to have several emerging economies that interact with one financial center. At the same time we include a macroprudential policy in the form of a tax to the return on capital as in Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva (2021) and Aoki, Benigno, and Kiyotaki (2018), among others. The advantage of this formulation is that the policy instrument will be attached directly to the credit spreads that are augmented by the friction and drive the capital flows at the cross country level. On the other hand, to keep the model simple, our initial formulation will only consider a simple financial intemediation period, but this is extended in the later sections.[11]

[9]Another branch of the literature related to this study emphasizes the possibility of interdependencies between the actions of different types of policymakers and the macroprudential regulators. For example, De Paoli and Paustian (2017) explores potential regulatory coordination between monetary and financial regulators in a closed economy context, while Quint and Rabanal (2014) explore the implications of macroprudential regulatory actions for monetary policy coordination in the Euro area in the context of currency unions.

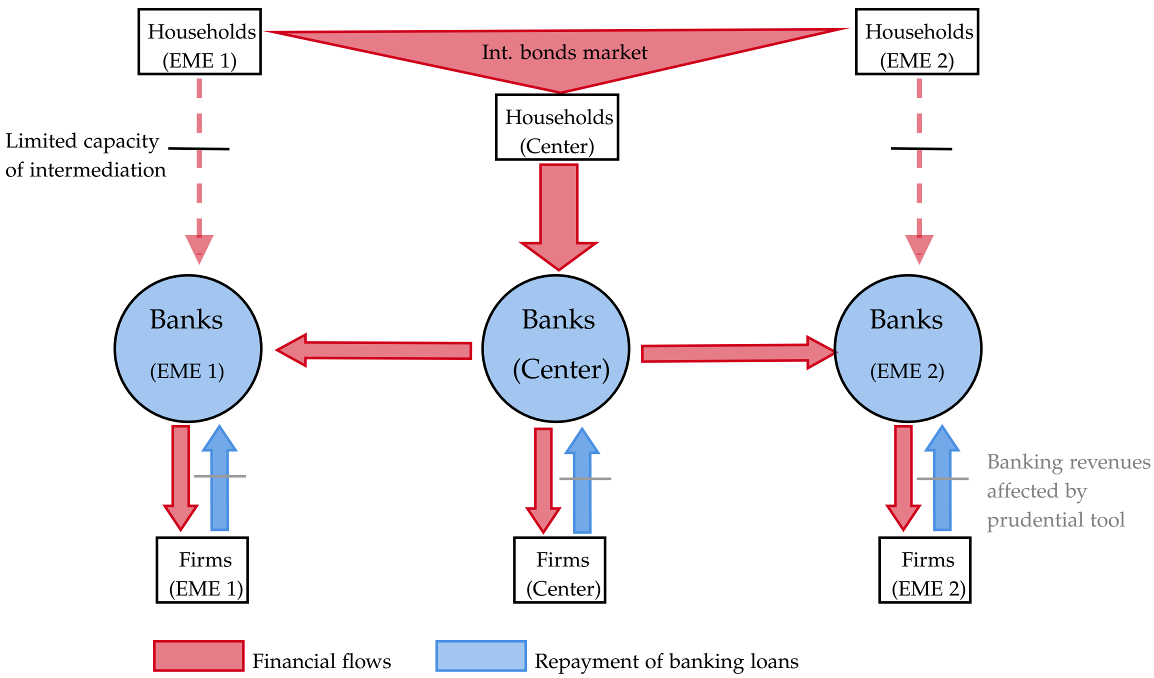
[10]As the type of instrument we consider takes the form of a tax instrument and has capital accumulation implications, it could also be argued that this study also relates to the literature on capital taxation considering the trade-off of taxing different production inputs as well as capital income. Compared the most seminal studies (Chamley, 1985, 1986) this paper favors regimes with more conservative interventions although for different reasons, and at the same time, and in line other recent studies (Biljanovska and Vardoulakis, 2019; Straub and Werning, 2020) we still find optimal to implement active policymaking despite its downward effect on capital accumulation.

[11]To allow for a simpler analytical exposition, our setup simplyfies the features in Banerjee, Devereux, and Lombardo (2016) that are not critical for the representation of financial frictions. For example, our model features inelastic labor, and abstract from other types of policies (monetary) and rigidities (nominal). At the same time, this implies retaining all the characteristics related to the capital dynamics, and, on the other hand our model still adds one layer of complexity by allowing for a repeated periphery. The latter ingredient implies a larger menu of potential policy regimes as depicted in Section 6.

2.1 Economic Environment

The main feature defining whether a country is an emerging economy is that its financial sector has a limited intermediation capacity, meaning it is unable to issue deposits claims for their households to some extent. As a consequence, it will have to resort to the international financial banking sector to make up for the difference and being able to meet their firms' funding needs. This environment is depicted in Figure 1, where the red arrows represent financial flows.

Figure 1: Financial flows environment in the model



Note: All arrows denote financial flows. The blue arrows, in addition, refer to flows that are paid to the banks by their borrowers. This latter type of flow —or specifically the associated rate of return perceived by financial intermediaries— is the one affected by the prudential regulations in the model.

Such structure implies that the emerging economies are financially dependent on the funding from center banks, and in an environment of imperfect information in the lending contracts this could imply a double layer of agency frictions in the economy: that between center households and banks and another one between global banks and emerging country banks. We also we assume the friction is more accentuated in the peripheries.[12]

For simplicity, the real sector will consist only on one consumption good and there will be no deviations from the law of one price. Preferences are identical between agents, implying the parity or purchasing power holds and the real exchange rate will be constant (equal to one), playing no

[12]Although more than a single feature characterizes the emerging markets, the financial dependence property not only is the most relevant one for our purposes, but also has a clear empirical appeal. To illustrate this see the Figure 3 in Appendix A, where it is shown how the local deposits to GDP ratio is emerging economies is substantially lower relative to advanced economies.

role in this version of the model. Additionally, the households will have access to an international market of non-contingent bonds. This is relevant as it implies that, despite the limited capacity to hold deposits, the saving decisions of emerging economies' households are not curtailed in any way once they trade these assets.

Finally, the lending relationships are subject to a limited enforceability friction which induces an external finance premium and augments the scale of intermediation and credit cycles. The external premium takes the form of an increased return rate for the banks which raises their —expected and eventual— revenues. Such revenues will be targeted by the macroprudential regulation, meaning it will attack the financial friction at its origin.

2.2 Timing and Countries Setup

The world consists of three economies that live for two periods $t = 1, 2$. The economies are indexed by $i = a, b, c$, the first two will be emerging countries (a and b) and the third one is a developed economy that acts as financial center (c). The relative population sizes of the economies are n_i with $1 - (n_a + n_b) \geq \frac{1}{2}$. Each economy has five types of agents: Households, final consumption good producers, capital producers, banks and a government sector.

As mentioned before, preferences across countries' households are identical and there is only one final consumption good worldwide that is freely traded and produced in all locations. In terms of notation, superindexes denote the country, while subindexes refer to other features such as the sector of the economy and time periods. Additionally, if a superindex is ommited it normally means that the variable or equation applies to the three countries.

2.3 Investors

For simplicity, the investment decision is separated from the other household decisions and will be subject to adjustment costs. Physical capital is produced in a competitive market by using old capital and investment. The investment will be subject to convex adjustment costs, with the total cost of investing I_1 being:

$$C(I_1) = I_1 \left(1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2\right),$$

where $\bar{I}$ represents the reference level for defining the adjustment cost; The reference level is usually set at the steady state, the previous level of investment or a combination. In any case, it must hold that $C(0) = 0,\ C''(\cdot) > 0$. The capital producing firms (investors) buy back the old capital stock from the firms at price Q_1 and produce new capital subject to the adjustment costs (proportional to the parameter ζ).

The investor solves:[13]

$$\max_{I_1} \; Q_1 I_1 - I_1 \left(1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2\right),$$

the optimality condition (F.O.N.C.) is,

$$[I_1]: \qquad Q_1 = 1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2 + \zeta\left(\frac{I_1}{\bar{I}} - 1\right)\frac{I_1}{\bar{I}}, \tag{1}$$

2.4 Firms

Each period the firms will operate with a Cobb-Douglas technology that aggregates capital predetermined at the end of the period before. This technology of aggregation is given by $Y_t = A_t(\xi_t K_{t-1})^\alpha$, where A_t is the aggregate productivity, and ξ a capital specific productivity or quality term. The capital in $t = 1$ follows standard dynamics with depreciation as,

$$K_1 = I_1 + (1-\delta)\xi_1 K_0. \tag{2}$$

The capital in the initial period will be provided directly by the households in the quantity K_0. However, after that, the firm funds physical capital acquisitions for future production (K_1) using lending from the banking sector. Given the model's timing, there is only one period of intermediation ($t = 1$) when lending is extended to acquire capital for production in the final period ($t = 2$).

In this setup, the firms solve a slightly different problem each period. First they decide how much capital to rent from households:

$$\max_{K_0} \; \pi_{f,1} = Y_1 - r_1 K_0,$$
$$s.t. \quad Y_1 = A_1(\xi_1 K_0)^\alpha,$$

where r_1 is the rental rate of capital, which, from the optimality condition is: $r_1 = \alpha A_1 \xi_1^\alpha K_0^{\alpha-1}$. For the second period, the firms take into account the cost of funding and the revenue of selling the remaining capital stock to capital good producers that carry out the necessary investment to build the capital stock for the next period. Thus, in the second period the firm will solve:

$$\max_{K_1} \; \pi_{f,2} = Y_2 + Q_2(1-\delta)\xi_2 K_1 - R_{k,2} Q_1 K_1,$$
$$s.t. \quad Y_2 = A_2(\xi_2 K_1)^\alpha.$$

With F.O.N.C.,

$$[K_1]: \qquad \alpha A_2 \xi_2^\alpha K_1^{\alpha-1} + (1-\delta)\xi_2 Q_2 = R_{k,2} Q_1.$$

[13] The investor can choose either the investment as depicted here or the new physical capital as one pins down the other given the law of motion for capital and the cost of acquiring pre-existing (undrepreciated) capital.

To facilitate the model notation, we follow the same definition for r_2, that is, $r_2 = \alpha A_2 \xi_2^{\alpha} K_1^{\alpha-1}$.

Substituting in the optimality condition for K_1 we obtain that the rate paid to the banks by the firms is given by $\tilde{R}_{k,2} = \frac{r_2 + (1-\delta)\xi_2 Q_2}{Q_1}$. Moreover, by taking into account the possibility of a macroprudential tax on the marginal return on capital, such as in Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva (2021), we have that the effective rate obtained by the banks, that is, after paying the macroprudential taxes ($\tau r_2 K_1$) to the government is given by:

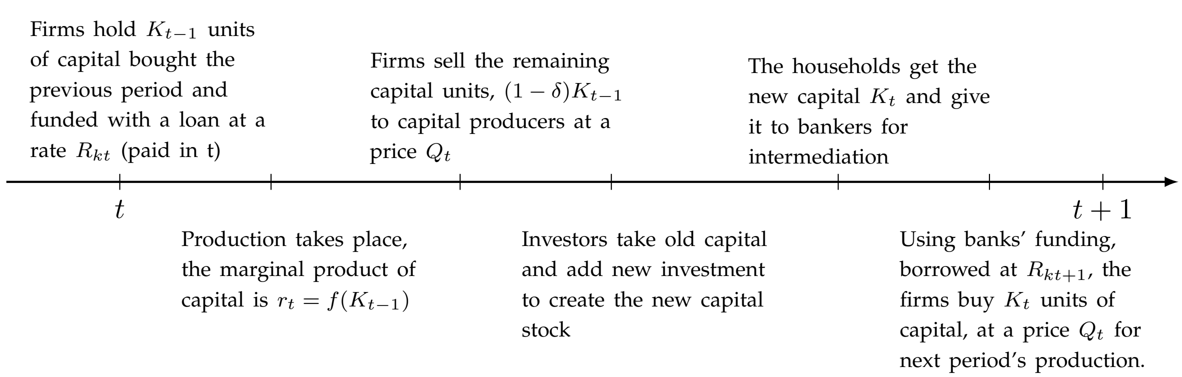
$$R_{k,2} = \frac{(1-\tau) r_2 + (1-\delta)\xi_2 Q_2}{Q_1}. \tag{3}$$

For the sake of clarity, it is important to notice that the firms will pay the pre-taxes banking rate. Only afterwards, the banks will consider the effect of the taxes in their profits.[14] We elaborate on the policy tool and the role of this return rate in later subsections.[15]

2.4.1 Capital dynamics and ownership

The dynamics of the model will be driven (within and cross-country) by the capital flows. For that reason, it is relevant to clarify how capital is held, and profited from, by several types of agents in a single period.

Figure 2: Capital ownership within a period



Note: This figure describes the ownership of capital across the agents of the model for a generic period t. In terms of our baseline model $t = 1$; similarly, $t = 1, 2$ for the second setup with two periods of intermediation.

There is only one period of capital accumulation ($t = 1$). The initial capital will be given for

[14] With that in mind, we can obtain that the profits of the firms in the second period, after replacing the rate they pay to banks will have the usual form ($\pi_{f,2} = A_2(\xi_2 K_1)^{\alpha} - r_2 K_1$), consistent with a zero-profit competitive firm, and therefore, the net effect of the the taxes, after the rebate to the households will be zero as usual.

[15] Besides the policy tool, and the effect of the after-policy rate of return on the banking decisions, it can already be noted in (3) the role played by the adjustment costs and the capital quality shock; namely, the former is needed in order to have a relative price of capital (Q) different from one —which, as we will see, is meaningful in shaping the profits of the banking sector and the effects of policy— while the latter may generate changes in the gross rate through excessive depreciation that the policy maker may or not want to mitigate.

that period as K_0. Then, by the end of the accumulation period the capital in the economy will be given by K_1. That capital will be used for the following period's production. The capital ownership between agents throughout each period is shown in Figure 2, which explains a typical period with intermediation.

It should be noticed that the capital used for production in the period $t = 1$ cannot be subject to intermediation since there are no banks before the rest of the agents exist (the banks themselves are owned household agents). Therefore, the pre-existing capital stock (K_0) will be provided directly from households to firms without explicit an financial intermediation.[16]

2.5 Banks

This is the target sector of the macroprudential policies. The set up is largely based on Gertler and Karadi (2011). There is a financial intermediation sector in the first period that facilitates funding for firms at the local level. In addition, the bank at the center is also a global creditor and extends loans to banks in other locations. In terms of its functioning, the bank receives a start-up capital by their owner household and will try to maximize the value of the banking actitivies, given by the present value of its profits. Finally, at the end of its life, the bank will give back their net worth to the households as profits.

There will be a costly enforcement agency friction where it is possible for the banks to divert a portion of the assets they intermediate. The eventual implication of this is the imposition of an external finance premium to the banking revenue rates, which is imposed to prevent the banks from absconding assets and to align their incentives with those of the assets' owners. This is the financial friction in this environment that augments the credit cycles.

Starting from this section, it will be useful in some cases to use a super index e for denoting variables from emerging economies ($e = \{a, b\}$), whereas as before, variables that apply for all countries are either left without superindex, or labeled with an index i when necessary (e.g., when the same expression involves variables from various locations).

2.5.1 Emerging Countries

The financial system of the emerging countries will have a limited capacity of intermediation of deposits from local households. For simplicity, we assume that there are not any local deposits in these economies, impliying that they rely almost entirely on foreign lending from the center banks for providing funding to firms for production. Therefore, the balance sheet of the bank includes, on the asset side, the lending provided to firms, and on the liability and equity side, the foreign lending from center banks and a start-up capital they receive from local households.

The lending relationship between foreign and local banks will be subject to agency frictions,

[16]Similarly, in terminal periods the undepreciated capital is consumed by households. This is later displayed in the budget constraints and profit functions at the end of the section 2.7.

arising from the fact that creditor banks could default on their debt repayment and divert a portion κ of their intermediated assets.[17] In either case (default or not) the gross return from intermediation for the bank is $R_{k,2}$ as defined in equation (3).

The emerging market bank maximizes its franchise value in the period 1 (J_1):

$$\max_{F_1^e, L_1^e} J_1^e = \mathbb{E}_1 \Lambda_{1,2}^e \pi_{b,2}^e = \mathbb{E}_1 \Lambda_{1,2}^e (R_{k,2}^e L_1^e - R_{b,1}^e F_1^e),$$

$$s.t. \quad L_1^e = F_1^e + \delta_b Q_1^e K_0^e, \tag{4}$$

$$J_1^e \geq \kappa \mathbb{E}_1 \Lambda_{1,2}^e R_{k,2}^e L_1^e, \tag{5}$$

where $L_1^e = Q_1^e K_1^e$ is the total intermediated lending, F_1^e is the foreign interbank lending borrowed from the center bank at a gross rate $R_{b,1}^e$, $\delta_b Q_1^e K_0^e$ is the start-up capital received from households, and $\Lambda_{1,2}^i = \beta u'(C_2^i)/u'(C_1^i)$ is the stochastic discount factor for a household in country i. At the same time, the constraints correspond to the balance sheet of the bank and an incentive compatibility constraint (ICC) imposing that the value of the bank equals or exceeds the value from defaulting.

The F.O.N.C. with respect to the foreign debt is:

$$[F_1]: \qquad (1 + \mu^e)\mathbb{E}_1 \Lambda_{1,2}^e (R_{k,2}^e - R_{b,1}^e) = \mu^e \mathbb{E}_1 \kappa \Lambda_{1,2}^e R_{k,2}^e, \tag{6}$$

where μ^e is the Lagrange multiplier of the ICC. This expression is already informative about some implications of the frictions that we explore in propositions at the end of this section.[18]

2.5.2 Advanced Economy

To simplify, we assume there is no agency problems at the center.[19] Then, the center bank solves:

$$\max_{F_1, L_1, D_1} J_1 = \mathbb{E}_1 \Lambda_{1,2} \pi_{b,2}^c = \mathbb{E}_1 \Lambda_{1,2} (R_{b,1}^a F_1^a + R_{b,1}^b F_1^b + R_{k,2}^c L_1^c - R_{D,1} D_1),$$

$$s.t. \quad F_1^a + F_1^b + L_1 = D_1 + \delta_b Q_1^c K_0^c. \tag{7}$$

The only restriction will be the balance sheet of the bank that now counts with the foreign interbank flows on the asset side and the local center deposits on the liability side (D_1). Additionally, the deposits from households are subject to a gross rate $R_{D,1}$.

[17] A bank could divert assets as soon as they get the foreign funding or after the firms pay them the loan in the last period. In this case, we assume it considers diverting after being paid by the firms. Nevertheless, the constraint and implications are very similar in the alternative case with instantaneous absconding even if in one case —as reflected in the ICCs— the bank compares two future values while in the other it compares one future value (the value of the bank) with the current value of the assets. It should be noted the effect in either case is eliciting is a higher credit spread in equilibrium. For completeness, we still consider this other case in the extended version of the model in Section 5.

[18] The expression in equation (6) is later further simplified after implementing a perfect-foresight assumption in the analytical and numerical exercises, leading to the associated equation shown in Table A1.

[19] This assumption is relaxed as an exercise and documented in the online appendix.

The associated F.O.N.C.s are:

$$[F_1^a]: \quad \mathbb{E}_1(R_{b,1}^a - R_{D,1}) = 0, \qquad [F_1^b]: \quad \mathbb{E}_1(R_{b,1}^b - R_{D,1}) = 0, \qquad [L_1^c]: \quad \mathbb{E}_1(R_{k,2}^c - R_{D,1}) = 0.$$

An important consequence of these optimality conditions is that a policy that affects the revenue rate $R_{k,2}^c$ will have general equilibrium effects and inadvertently lower the cost of debt for debtor economies ($R_{b,1}^a, R_{b,1}^b$). This implies an interaction between the credit spreads and financial frictions between countries that is overlooked by nationally-oriented planners.[20]

2.6 Macroprudential policy and public budget

Among the number of possible prudential policies[21] (VaR regulations, leverage caps, loan/value ratios, etc.) we consider a general type of policy that, as explained by Agénor, Jackson, Kharroubi, Gambacorta, Lombardo, and Silva (2021), encompasses a broad set of macroprudential regulations: a tax (τ) on the return to capital ($R_{k2} = [(1-\tau^i)r_t + (1-\delta)\xi_2 Q_2]/Q_1$). This will be a tax levied on the banking sector, as shown in Equation (3).

Although prudential in nature —as it is implemented on the intermediation sector—the policy tool can also be thought in practice as a device to impose controls on capital flows. This is the case because the tax has the advantage of affecting directly the wedge between the return on capital and borrowing rate (cost of funds for the bank), i.e., the credit spread, which in turn drives financial flows at the interbank level. Thus, we are taxing the source of inefficiencies directly.[22]

On the public budget level this is reflected as a distortionary tax funded with lump-sum taxes (T) in each period, i.e., we assume a balanced fiscal budget,

$$\tau^i r_2 K_1 + T = 0.$$

When setting the taxes optimally, each social planner might consider whether to maximize her national welfare or to join cooperative arrangements which would dictate policy centrally.[23] We explore these cases as an additional exercise in Section 6.

[20]In a subsequent section we explore the case of incorporating frictions at the Center. In such case this effect is also present even if not as evidently.

[21]see Cerutti, Claessens, and Laeven (2017) for a detailed classification of macroprudential policies

[22]The equivalence between this prudential policy that lowers financial intermediation and a capital flows regulation can also be understood as a general equilibrium phenomenon. The prudential tax (increase) implies lower intermediation which in turns leads to lower capital accumulation as the the latter is funded with foreign interbank funds. On the demand side, this implies that Center households will buy fewer bonds from EME households and provide fewer deposits to the banks. The connection between a financial regulation tool and the typical —less observed— capital controls is also made in other papers such as Davis et al. (2021).

[23]This would be an analogous to the empirically plausible case of centralized regulations at the regional or multinational level as those implied by monetary unions of policy recommendations by multilateral institutions.

2.7 Households

The households derive utility from consumption and its lifetime utility is given by $U = u(C_1) + \beta u(C_2)$ with $u(C) = \frac{C^{1-\sigma}}{1-\sigma}$. The budget constraints in each period are the following:

Emerging markets:

$$C_1^e + \frac{B_1^e}{R_1^e} = r_1^e K_0^e + \pi_{f,1}^e + \pi_{inv,1}^e - \delta_b Q_1^e K_0^e, \tag{8}$$

$$C_2^e = \pi_{f,2}^e + \pi_{b,2}^e + B_1^e - T^e, \quad for\ e = \{a, b\}, \tag{9}$$

where C is the final consumption good, B a non-contingent internationally traded bond, r_1 the rental rate of capital, Q the relative price of capital, K the capital stock and T is a lump-sum tax. Additionally, π stands for profits which can come from production activies in final goods (f), capital goods (inv) or banking services (b).

Advanced Economy:

$$C_1^c + \frac{B_1^c}{R_1^c} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_b Q_1^c K_0^c, \tag{10}$$

$$C_2^c = \pi_{f,2}^c + \pi_{b,2}^c + B_1^c + R_{D,1} D_1 - T^c, \tag{11}$$

where the advanced economy also includes local deposits D in the budget constraint as these are intermediated by their banks. Additionally, the profits are given by:[24]

$$\begin{aligned}
\pi_{f,1} &= A_1 \xi_1^\alpha K_0^\alpha - r_1 K_0 \\
\pi_{f,2} &= A_2 \xi_2^\alpha K_1^\alpha + Q_2(1-\delta)\xi_2 K_1 - R_{k,2} Q_1 K_1 \\
\pi_{inv,1} &= Q_1 I_1 - I_1 \left(1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2\right) \\
\pi_{b,2}^e &= R_{k,2}^e Q_1^e K_1^e - R_{b,1}^e F_1^e, \quad for\ e = \{a, b\} \\
\pi_{b,2}^c &= R_{b,1}^a F_1^a + R_{b,1}^b F_1^b + R_{k,2}^c Q_1^c K_1^c - R_{D,1} D_1
\end{aligned}$$

In the first period, households maximize their life-time utility stream subject to the budget constraints for the first and second periods. The F.O.N.C. for the three countries' households are:

$$u'(C_1) = \beta R_1 \mathbb{E}_1[u'(C_2)], \qquad u'(C_1^c) = \beta R_{D,1} \mathbb{E}_1[u'(C_2^c)], \tag{12}$$

where the first equation is the Euler equation for bonds and applies to the three economies, while the second is the Euler equation for local deposits and holds only for country c.

[24] The firm's profits are zero for both periods. Moreover, given the value of r_2 we can get from the firm optimality condition that the profits in the second period are also equivalent to $\pi_{f,2} = A_2 K_1^\alpha - r_2 K_1$.

2.8 Market Clearing

At the world level bonds are characterized by zero-net-supply,

$$n_a B_1^a + n_b B_1^b + n_c B_1^c = 0. \tag{13}$$

The goods market clearing conditions for each period are

$$n_a\left(C_1^a + I_1^a\left(1+\frac{\zeta}{2}\left(\frac{I_1^a}{\bar{I}}-1\right)\right)\right) + n_b\left(C_1^b + I_1^b\left(1+\frac{\zeta}{2}\left(\frac{I_1^b}{\bar{I}}-1\right)\right)\right)$$
$$+n_c\left(C_1^c + I_1^c\left(1+\frac{\zeta}{2}\left(\frac{I_1^c}{\bar{I}}-1\right)\right)\right) = n_a Y_1^a + n_b Y_1^b + n_c Y_1^c,$$

$$n_a C_2^a + n_b C_2^b + n_c C_2^c = n_a Y_2^a + n_b Y_2^b + n_c Y_2^c$$

Finally, given that there is only one final good and the law of one price holds (so that the real exchange rate in all cases is one), we have by an uncovered interest rate parity argument that: $R_1^a = R_1^b = R_1^c = R_1$, where R_1 denotes the world interest rate on bonds in period 1.[25]

2.9 Equilibrium

Given the policies $\{\tau^a, \tau^b, \tau^c\}$, the equilibrium consists of prices $\{Q_t^i\}$, rates $\{R_1, R_{k,2}^e\}$ and quantities $\{B_1^i, K_1^i, F_1^e, D, C_t^i, I_t^i\}$ for $t = \{1, 2\}$, with $i = \{a, b, c\}$, $e = \{a, b\}$, such that the households solve their utility maximization problem, the firms solve their profits maximization problems, banks maximize their franchise value, and the goods and bonds markets clear. This allocation is characterized by the solution to the system of equations (1)-(13) where some equations apply for the three economies, other show up by country type, and the clearing condition is considered once (26 equations and variables in total). The simplified system of equations we use to solve the model is summarized in table A1 in Appendix A.

2.10 Some relevant implications of the model

From this setup we can already derive a number of important results that can be helpful in understanding the policy implications of the model. First, we can can link the extent of the inefficiency —captured by the credit spread— and financial friction to a specific parameter (κ):

Proposition 1: *If the ICC binds the credit spread is positive and increases in* κ

[25]We can also consider shocks affecting the two sources of productivity in the model. First, a technology shock $\epsilon_{A,t}$ entering aggregate productivity as: $A_t^i = \rho_A A_{t-1}^i + \sigma_A \epsilon_{A,t}$ with $\epsilon_{A,t} \sim N(0,1)$, and a capital-quality specific shock $\epsilon_{\xi,t}$ that increases capital utilization ξ_t exogenously, thereby affecting the stock of capital in the production function and the depreciation rate: $\xi_t = \rho_\xi \xi_{t-1} + \sigma_\xi \epsilon_{\xi,t}$ with $\epsilon_{\xi,t} \sim N(0,1)$. In the baseline numerical exercises, we abstract from activating these shocks as the productivities and capital efficiency are set at their expected values for simplicity. We still leave these in the analytical expressions, however, to denote that the way productivity and efficiency affects the expressions may still be affected by shocks' realizations.

Proof: W.L.O.G. we will work in a perfect foresight setup, otherwise the same result applies to the expected credit spread. From the F.O.N.C. in equation (6), we can obtain:

$$R^e_{k,2} = \underbrace{\frac{1+\mu^e}{1+(1-\kappa)\mu^e}}_{\Phi} R_{b,1}.$$

$\Phi > 1$ represents the proportionality scale between $R_{k,2}$ and $R_{b,1}$ and guarantees the credit spread is positive in the model. The larger Φ the greater the spread. At the same time, $\mu > 0$ by definition of the ICC (and the fact that it binds). Hence, it follows that,

$$\frac{\partial \Phi}{\partial \kappa} = \frac{\mu(1+\mu)}{(1-(1-\kappa)\mu)^2} > 0$$

■

The results and exercises in later sections will exploit extensively this result to draw lessons on the role of the extent of financial frictions in shaping the policy leakages of prudential regulations.[26]

On the other hand, we can derive another result to elaborate on how general is our framework in representing the prudential toolkit in real life:

Proposition 2: *An increase in the macroprudential tax decreases the leverage ratio of banks*

Proof: W.L.O.G. we will work in a perfect foresight setup, otherwise the same result applies to the expected value of the leverage. In the ICC (binding) we substitute the total foreign lending $F^e_1 = Q^e_1 K^e_1 - \delta_B Q^e_1 K^e_0$ for any emerging economy $e = \{a, b\}$ and solve for the total assets $L^e_1 = Q^e_1 K^e_1$ in terms of the initial net worth of banks:

$$L_1 = \underbrace{\frac{R^e_{b,1}}{R^e_{b_1} - (1-\kappa^e)R_{k,2}}}_{\phi_L:\ \text{leverage ratio}} \delta_B Q^e_1 K^e_0,$$

We can substitute $R^e_{k,2} = [(1-\tau^e)r^e_2 - (1-\delta)\xi^e_2 Q_2]/Q_1$ and differentiate with respect to τ^e:

$$\frac{\partial \phi_L}{\partial \tau^e} = -\frac{(1-\kappa^e)R^e_{b,1}(r^e_2)}{(R^e_{b,1} - (1-\kappa^e)R^e_{k,2})^2 Q^e_1} < 0$$

This result takes into account that the denominator is never zero given the ICC is binding and the credit spread is positive. ■

A direct implication of this result is that, as mentioned above, the tool we assume has analogous implications in terms of the standard macroprudential policy toolkit (e.g., leverage ratios).[27]

[26]A similar result can be established for μ which could be interpreted as having an spread that increases when the financial friction is more relevant in the model.

[27]The actual prudential toolkit has been growing in terms of number of policy instruments, frequency and number

3 Policy Welfare Effects Between Economies

As a first approximation we can verify analytically the welfare spillover effects between economies from prudential policy actions. We set the welfare based on a social planner problem along the lines of Davis and Devereux (2022) in order to find the equilibrium welfare effects of a change in the policy tools: Let the welfare of country i be expressed as $W^i = U^i + \lambda_1^i BC_1^i + \beta\lambda_2^i BC_2^i$:

$$
\begin{aligned}
W^e = U^e + \lambda_1^e &\left(r_1^e K_0^e + \pi_{f,1}^e + \pi_{inv,1}^e - \delta_b Q_1^e K_0^e - C_1^e - \frac{B_1^e}{R_1^e} \right) \\
&+ \beta\lambda_2^e \left(\pi_{f,2}^e + \pi_{b,2}^e + B_1^e - T^e - C_2^e \right), \qquad \text{for } e = \{a, b\} \\
W^c = U^c + \lambda_1^c &\left(r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_b Q_1^c K_0^c - C_1^c - \frac{B_1^c}{R_1^c} - D_1 \right) \\
&+ \beta\lambda_2^c \left(\pi_{f,2}^c + \pi_{b,2}^c + B_1^c + R_{D,1} D_1 - T^c - C_2^c \right).
\end{aligned}
$$

where all variables are defined as before, and λ_t^i is the Lagrange multiplier associated to the budget constraint of each period. This problem is analogous to a standard planner problem. Nonetheless, the optimality conditions (equilibrium allocations) for other agents are accounted for by the planner. We substitute the profits for banks and firms in accordance with the private equilibrium (ICCs included), the tax rebates and some of the interest rates (equalized in equilibrium):

$$
\begin{aligned}
W^e = u(C_1^e) + \beta u(C_2^e) + \lambda_1^e &\left(A_1^e (\xi_1^e K_0^e)^\alpha + Q_1^e I_1^e - C(I_1^e) - C_1^e - \frac{B_1^e}{R_1} \right) \\
&+ \beta\lambda_2^e \Big(\phi(\tau^e) A_2^e (\xi_2^e K_1^e)^\alpha + \kappa^e (1-\delta) \xi_2^e Q_2^a K_1^a + B_1^a - C_2^a \Big), \quad \text{for } e = \{a, b\} \\
W^c = u(C_1^c) + \beta u(C_2^c) + \lambda_1^c &\left(A_1^c (\xi_1^c K_0^c)^\alpha + Q_1^c I_1^c - C(I_1^c) - C_1^c - D_1^c - \frac{B_1^c}{R_1^w} \right) \\
&+ \beta\lambda_2^c \Big(A_2^c (\xi_2^c K_1^c)^\alpha + R_{b,1}^a F_1^a + R_{b,1}^b F_1^b + (1-\delta) \xi_2^c Q_2^c K_1^c + B_1^c - C_2^c \Big).
\end{aligned}
$$

with $\phi(\tau^e) = 1 + (\kappa^e - 1)(1 - \tau^e)\alpha$. for $e = \{a, b\}$.

We can see that, for the emerging markets, the direct effect of the regulation tax is not inmediately eliminated from the welfare, even from the perspective of the planner. This occurs due to the effect of accounting for a binding ICC in the profits. Conversely, in the advanced economy and in absence of financial frictions, the rebate cancels out with the taxed revenue in the second period.

From these welfare expressions we will obtain the effects of taxes, via implicit differentiation, and will simplify our resulting expressions by substituting additional optimality conditions from the private equilibrium. It is also worth noting that the convenience of this method relies on the decrease in the number of variables that we must consider as we can ignore the effects on decision

of countries using them. As of 2019, there are about 18 macroprudential instruments, that include direct taxes, leverage ratios and capital requirements, among others. See Alam, Alter, Eiseman, Gelos, Kang, Narita, Nier, and Wang (forthcoming) for a comprehensive summary of the number of macroprudential tools used in practice.

variables of the households. For the latter, the optimality conditions (that are equal to zero) will always be a factor of the tax effect on each variable and hence will be canceled out.

3.1 Domestic Effects of Policy

The direct —or domestic— welfare effect of the tax for the emerging economies is given by,

$$\frac{dW^a}{d\tau^a} = \beta\lambda_2^a \left\{ R_1 I_1^a \frac{dQ_1^a}{d\tau^a} + \frac{B_1^a}{R_1}\frac{dR_1}{d\tau^a} + \left(\phi(\tau^a) r_2^a + \kappa^a(1-\delta)\xi_2^a Q_2^a\right)\frac{dK_1^a}{d\tau^a} + \alpha(1-\kappa^a)Y_2 \right\},$$

where the d is the total derivative operator. The same functional form applies for country b. Each term in this expression is associated with a source of variations on welfare:[28]

Changes in investment profits: The first term corresponds to changes in the investment profits and its sign depends on whether the country is investing above or below the reference level in the adjustment cost function. For our parameters and initial state values the sign is positive.

Changes in external assets position: The second term, reflects the welfare effects from changes in the international debt position. $\frac{dR_1}{d\tau^a}$ is negative as there is a lower demand for funds by the levied banks. The sign of the whole term, however, depends on the sign of $\frac{B_1^a}{R_1}$ (net foreign assets) which is positive for emerging markets (and negative for the center).

Change in welfare by distorting capital accumulation: The third term reflects the change in welfare after hindering capital accumulation, hence, it will be proportional to the change in physical capital holdings and to the sources of profit from holding capital, i.e., the marginal product of capital as well as its after-depreciation resale value. The sign of this term is negative as capital accumulation lowers with a tax raise.

Finally the last term reflects the direct effect of the policy tool on welfare. Even from a planners' perspective, this effect will not cancel out for the emerging markets (as in the center) because of the presence of a binding ICC for these economies. Its sign is positive. Importantly, we can see there are offsetting welfare effects in the entire expression, and at the same time the signs and magnitudes depend on the reference point and scale of the policy change that each country planner would plan to implement.[29]

For the center economy the effect is:

$$\frac{dW^c}{d\tau^c} = \beta\lambda_2^c \left\{ R_1 I_1^c \frac{dQ_1^c}{d\tau^c} + \frac{B_1^c}{R_1}\frac{dR_1}{d\tau^c} + \left(r_2^c + (1-\delta)\xi_2^c Q_2^c\right)\frac{dK_1^c}{d\tau^c} + R_{b,1}^e\left(\frac{dF_1^a}{d\tau^c} + \frac{dF_1^b}{d\tau^c}\right) + \frac{dR_{b,1}^e}{d\tau^c}F_1^{ab} \right\},$$

where $F_1^{ab} = F_1^a + F_1^b$ is the total intermediation to emerging economies, and $R_{b,1}^e$ is the interest

[28]The derivation of these results is shown in detail in Appendix B.

[29]Still, In a later section we approximate the welfare effects numerically around the no policy equilibrium to gauge their relative importance. Although we also explain that to obtain the actual optimal policies we must introduce the Ramsey Planner Problem as a solution criterion as done in the final sections.

rate paid by emerging banks (these equalize in equilibrium). The interpretations for the first three terms are analogous to those of the emerging country mentioned above. The final two terms corresponds to:

Welfare effect from changes in intermediation profits: this is an effect coming from the change of the tax on the funding quantities or gross rates related to cross-border lending. In the context of the model, this is also related to the scale of aggregate intermediation. This scale affects the centers, as the latter contains the creditor banks for global markets. Notice the emerging markets can also be affected by the dynamics of financial intermediation, but mostly through their implications for their capacity to fund physical capital.

To the risk of being repetitive, it is still important to reiterate that the signs of these effects are not trivial and may lead to varied —and potentially conflicting— welfare effects. For example, depending on the debt position, the country may benefit from higher taxes, which in itself may provide incentives to national policymakers to alter their policy setup to induce changes in the interest rate that improve the financial position of their economy. This in itself may lead to an increased regulatory activity that may disrupt financial stability.

3.2 Cross-border Policy Effects

The welfare effect between emerging countries is,

$$\frac{dW^a}{d\tau^b} = \beta\lambda_2^a \left\{ R_1 I_1^a \frac{dQ_1^a}{d\tau^b} + \frac{B_1^a}{R_1}\frac{dR_1}{d\tau^b} + \left(\phi(\tau^a) r_2^a + \kappa^a (1-\delta)\xi_2^a Q_2^a\right) \frac{dK_1^a}{d\tau^b} \right\},$$

with an analogous counterpart following for the effect in W^b when τ^a is changed. Notice this expression is similar to the within country effect of their own tax. Although, in contrast, the last term is absent given there is not a direct welfare effect from a tax at the cross-country level.

The emerging country welfare effect from a change in the center country tax is,

$$\frac{dW^a}{d\tau^c} = \beta\lambda_2^a \left\{ R_1 I_1^a \frac{dQ_1^a}{d\tau^c} + \frac{B_1^a}{R_1}\frac{dR_1}{d\tau^c} + \left(\phi(\tau^a) r_2^a + \kappa^a (1-\delta)\xi_2^a Q_2^a\right) \frac{dK_1^a}{d\tau^c} \right\}.$$

On the other hand, the effect of a change in an emerging tax in the welfare of the center is,

$$\frac{dW^c}{d\tau^e} = \beta\lambda_2^c \left\{ R_1 I_1^c \frac{dQ_1^c}{d\tau^e} + \frac{B_1^c}{R_1}\frac{dR_1}{d\tau^e} + \left(r_2^c + (1-\delta)\xi_2^c Q_2^c\right) \frac{dK_1^c}{d\tau^e} + R_{b,1}^e \left(\frac{dF_1^a}{d\tau^e} + \frac{dF_1^b}{d\tau^e} \right) + \frac{dR_{b,1}^e}{d\tau^a} F_1^{ab} \right\},$$

where as before F_1^{ab} is the total intermediation to the emerging economies, and $R_{b,1}^e = R_{b,1}^a = R_{b,1}^b$ is the interest rate paid by emerging banks to the center intermediary. The interpretations of each term follow analogous intuitions to those explained in the subsection 3.1.

3.2.1 Optimal Toolkit and its Drivers

We can use these effects expressions as first-order conditions for national planners and derive the optimal taxes (i.e., setting $dW^i/d\tau^i = 0$ and solve for τ^i). The optimal emerging tax would be:

$$\tau^{e\,*} = \frac{-1}{\alpha(1-\kappa^e)}\left\{\frac{1}{r_2^e}\left[\left(R_1 I_1^e \frac{dQ_1^e}{dK_1^e} + \frac{B_1^e}{R_1}\frac{dR_1}{dK_1^e}\right) + \kappa^a(1-\delta)\xi_2^e Q_2\right] + 1 + \alpha(\kappa^e - 1)\right\}, \quad \text{for } e = \{a, b\}.$$

Similarly, for the financial center (c):

$$\tau^{c\,*} = \frac{Q_1^c}{r_2^c}\left\{R_1 I_1^c \frac{dQ_1^c}{dF_1^{ab}} + \frac{B_1^c}{R_1}\frac{dR_1}{dF_1^{ab}} + (r_2^c + (1-\delta)\xi_2^c Q_2)\frac{dK_1^c}{dF_1^{ab}} + (F_1^a + F_1^b)\frac{dR_{b,1}^e}{dF_1^{ab}} + (1-\delta)\xi_2^c \frac{Q_2}{Q_1^c}\right\} + 1,$$

with $dF_1^{ab} = dF_1^a + dF_1^b$.

From these expressions we get an idea about the effects driving the optimal taxes. The peripheral tax depends on the effect on prices and interest rates from changes in the capital stock, which is proportional to the investment and foreign bonds position. Other relevant features are the resale price of capital and the marginal product of capital whose increases lead to lower tax values. The intuition here is that, if capital becomes more productive, it is better to distort the economy by less. We will see in later sections that this is a feature distinguishing policy regimes with different levels of decentralization: The more internationally centralized —or coordinated— policies can achieve the same effects with lower interventionism.

Here is useful to remember that, in equilibrium the marginal product of capital is directly taxed by the tool. As a result, we could interpret that in order to have a meaningful effect, the tax (or subsidy) will have to be set more strongly in countries with lower marginal product of capital. Finally, it is noticeable that the extent of the financial distortion (κ^e) plays an amplifying role—for a stronger financial friction, a more stringent policy stance would have to be implemented.

On the other hand, the financial center optimal tool is driven by the effect of the changed aggregate international intermediation (F_1^{ab}) on both the sources of revenue for the banking sector (prices and revenue rate), and on domestic capital intermediation. (K^c). Both features reflect the global creditor role of the center; on one side the former —international lending volume effect—leads to direct changes in profits, but the latter effects reflects a substitution of ocal for global intermediation as more resources that would go to domestic firms are instead flowing to other locations. In either case, notice how the effects of policy, both at center and peripheries, are pinned down at first by the effect on interbank intermediation and later by how this affects each banks' profitability.[30]

[30] It should be noticed that both sides of these expressions still depend on the taxes, so even if we can approximate the effects on the right-hand-side of the equations around points of interest, or characterize their drivers (analytically), we would still need to introduce an additional solution criterion to find the optimal taxes for a given parametrization (and initial values). A feasible route is to consider a Ramsey policy problem. An application of such method is done in Section 6.

4 Numerical exploration of the policy effects in the model

We also can approximate the effects of policy (domestic and cross-border) numerically for the baseline setup. Numerical solutions can be useful to complement the insights indicated in the expressions in the previous section and to gauge the impact of the policy instrument in other variables in the model. Here, for example, we show the effects on capital accumulation and banking intermediation. The results are reported in Table 1.[31]

Table 1: Policy effects in the model

		Baseline	Increased frictions everywhere (by 25%)	Increased friction in country a (by 25%)
			Effect on capital	
Direct effect	$\tau^a \rightarrow K_1^a$	-0.168	-0.121	-0.120
	$\tau^b \rightarrow K_1^b$	-0.168	-0.121	-0.169
	$\tau^c \rightarrow K_1^c$	-0.441	-0.437	-0.439
Cross-border effect	$\tau^a \rightarrow K_1^b$	0.004	0.002	0.002
	$\tau^a \rightarrow K_1^c$	-0.012	-0.009	-0.008
	$\tau^b \rightarrow K_1^a$	0.004	0.002	0.003
	$\tau^b \rightarrow K_1^c$	-0.012	-0.009	-0.014
	$\tau^c \rightarrow K_1^a$	0.012	0.009	0.009
	$\tau^c \rightarrow K_1^b$	0.012	0.009	0.012
			Effect on financial intermediation	
Direct effect	$\tau^a \rightarrow Int_1^a$	-0.049	-0.040	-0.038
	$\tau^b \rightarrow Int_1^b$	-0.049	-0.040	-0.052
	$\tau^c \rightarrow Int_1^c$	-0.035	-0.044	-0.039
Cross-border effect	$\tau^a \rightarrow Int_1^b$	0.012	0.006	0.008
	$\tau^a \rightarrow Int_1^c$	-0.008	-0.010	-0.010
	$\tau^b \rightarrow Int_1^a$	0.012	0.006	0.009
	$\tau^b \rightarrow Int_1^c$	-0.008	-0.010	-0.010
	$\tau^c \rightarrow Int_1^a$	0.036	0.031	0.027
	$\tau^c \rightarrow Int_1^b$	0.036	0.031	0.041

Note: The effects shown in the table correspond to the numerical approximate to the derivative of each variable with respect to the prudential instrument (τ) in each location. The measure is obtained by solving the model with an increased tax (from the location indicated in the row), with no taxes, and then computing the change in the variable between the tax-distorted allocation and the no-taxes equilibrium ($\tau = 0$). The resulting number is divided by the change in the tax ($\frac{\Delta Variable}{\Delta \tau}$). The solution in each case is obtained with a non-linear solver applied to the equations system in Table A1. The superindexes refer to the countries with a: EME-A, b: EME-B and c: center. Banking intermediation is measured based on the left-hand-side of the balance sheet of the banks, that is, $L_1^e = Q_1 K_1^e$ for EM countries ($e = \{a, b\}$) and $F_1^a + F_1^b + L_1$ for the center. The first column reports the effects for the baseline parameters (Table A.2), the second for all frictions parameters increased by 25%, and the third for a parameter for a increased by 25%.

To obtain the numerical solutions we solve non-linearly (with a standard numerical search routines) the system of equations characterizing the private equilibrium of the model (shown

[31] Note that the effects can differ substantially relative to the impact of implementing an optimal policy, which we measure in Section 6 and based on the Ramsey problems associated to the private equilibrium of this model.

in Table A1) using the parameters from table A.2. This solution will not activate the shocks at particular levels and also requires the provision of values for the taxes as these are taken as given by the agents. We proceed by solving for the equilibrium with no taxes, and then by applying an increase in each tax instrument by different amounts. Then, we approximate the change in the economic variables by their numerical derivative, that is, by the change in the variable after the tax increase divided by the applied change in the tax.

The results are consistent with the notion that tighter macroprudential regulations are, in their effects, similar to capital controls. We can see, for example that the local effects of the instrument always lead to a lower capital accumulation which can be rationalized from the negative effect of the tax on the banking returns (and credit spread). At the same time, we can see that the effect of the policy on capital is stronger at the center which can be attributed to substitution effects in intermediation where a lower return in local intermediation actitivies stimulates a substitution toward foreign lending.

At the same time, we see that the cross border effect for capital is rather small relative to the direct one which may lead to underestimating the cross-border effects of policy. However, if we focus on the effects on banking intermediation, we can see that a policymaker that cools down intermediation locally is *de-facto* increasing the lending to other economies. This substitution is also consistent with the fact that the financial frictions are potentially interdependent in general equilibrium, and thus, lowering the credit spread at the center (if any) can inadvertently lead to an increased spread and intermediation in other (financially) interconnected economies. Finally, similar results follow for the case of welfare spillovers, even if a quantitative gauge of such variable is less accurate in a simplified setup as the one we exploit here analytically than in a stochastic infinite time environment. We still show some welfare effects in Appendix A that reflect that the cross-border leakages are stronger when stemming from center policies and in environment with stronger financial frictions.

5 The Role of Dynamic Policymaking: An Extended Model

The baseline framework so far, introduces a number of interesting features that, together with a number of simplifications, allowed us to explore the drivers of the policy effects analytically. However, once we understand some of these drivers, it is natural to think how would the insights of the model be shaped in other plausible environments. In particular, it can be relevant to understand how the lessons from a setup with static policy decisions extrapolate to the context of dynamic decision making by regulators.

For this, the most natural extension is to consider a framework where intermediation occurs more than once. In that setup, the policy outlook may change substantially, for if we allow the policies to have a long-lasting effect on the banking profits, and the agents are aware of it, then the policymakers become forward-looking agents. We apply such change to see how relevant —-for the presense and nature of the policy spillovers— it is to consider a dynamic decision making by regulators. We do this by increasing the horizon of the model by one period, and by including two new properties common in the the literature: retained profits, and, an entry-exit setup for banks (e.g., Gertler and Karadi, 2011; Aoki et al., 2018, among others).

In the rest of this section, we highlight the most salient changes relative to the baseline model —the banking sector and policies— and leave the (mostly analogous) explanations on the setup for each agent in Appendix E.

General economic environment. The setup is analogous to the previous one, but now there are three periods $t = \{1, 2, 3\}$. The world consists of three countries, two emerging countries and one center, and each economy is populated by five types of agents: households, final goods firms, investors, the government and a representative bank. As before, the initial capital endowments are given (K_0) and afterward, physical capital is acquired by firms for production with banking funding. In that sense there are now two periods of intermediation, the first at the end of the first period, and one more a period later. Importantly, as long as there are intermediation activities in the future the banks may continue in business and in that case retain profits, thus, the banking decisions are dynamic or forward looking in $t = 1$, while in $t = 2$ the banking problem is static. In what follows, we emphasize on the differences in the decision making of the bankers and policy-makers between these two periods.

5.1 Banks

EME-Banks The problem of the bank is extended to account for the probability of continuation in the intermediation activities. This is also reflected in the constraints that now include the balance sheet period of future periods, which is affected by the net worth of the bank that now includes the profits from previous periods.[32]

In the first period of intermediation (end of t=1) the bank aims to maximize its expected franchise value, given by J_1 and solves:

$$J_1^e = \max_{F_1^e, L_1^e} \mathbb{E}_1 \left\{ (1-\theta)\Lambda_{1,2}^e (R_{k,2}^e L_1^e - R_{b,1}^e F_1^e) + \theta \Lambda_{1,3}^e (R_{k,3}^e L_2^e - R_{b,2}^e F_2^e) \right\},$$

$$s.t \quad L_1^e = F_1^e + \delta_B Q_1^e K_0^e, \qquad \text{[Balance sheet in t=1]}$$

$$L_2^e = F_2^e + \delta_B Q_2^e K_1^e + \theta[R_{k,2}^e L_1^e - R_{b,1}^e F_1^e], \qquad \text{[Balance sheet in t=2]}$$

$$J_1^e \geq \kappa Q_1^e K_1^e, \qquad \text{[ICC, t=1]}$$

where the country index for emerging economies is e with $e = \{a, b\}$, $L_t = Q_t K_t$ is the total lending intermediated with the local firms, F_t is the cross-border borrowing they obtain from

[32] In the previous model there was no need to consider the net worth as a variable, or better put, banks had no wealth at first and only counted with their startup funds from their household owners. Now, in contrast, in the second period of intermediation surviving banks will count with a net worth given by the last term in the balance sheet.

the center, $R_{k,t}$ is the gross revenue rate of the banking services, paid by the firms, $R_{b,t}$ is the interbank borrowing rate for the banks, Q_t is the price of capital, $\delta_B Q_t K_{t-1}$ a start-up capital the bankers get from their owner households, and $\Lambda_{t,t+j}$ is the stochastic discount factor between periods t and $t+j$. It can be noted that the last term in the objective function, and the second constraint are the new terms relative to the previous setup of the bank's problem while the third constraint is the ICC, imposed to align the incentives of banks with lenders in a way that the former doesn't abscond assets. This friction will lead to amplified credit spreads.

The present value of the bank will be given by the expected profits in the next period, which now include the possibility of exit from the banking business, with an associated probability of survival θ.[33] Thus, with probability $(1-\theta)$ the bank will fail and transfer back its profits to the household, and with probability θ the bank will be able to continue and pursue future profits.

In this new setup, a key property is that of profits retention. That is, the banks will retain any profits and reinvest them for as long as they remain in business. They continue doing this until they exit the business and report the accumulated profits to the households. This feature will boost the effects of policy in these economies because now a prudential tool has a longer lasting effect on the balance sheets of surviving banks.[34]

In the second period, the banks solve a simpler problem as their objective will not depict a continuation value, making their decisions static:

$$\begin{aligned} J_2^e &= \max_{F_2^e, L_2^e} \mathbb{E}_2 \left\{ \Lambda_{2,3}^e (R_{k,3}^e L_2^e - R_{b,2}^e F_2^e) \right\}, \\ s.t. \quad L_2^e &= F_2^e + \delta_B Q_2^e K_1^e + \theta [R_{k,2}^e L_1^e - R_{b,1}^e F_1^e], \\ J_2^e &\geq \kappa Q_2^e K_2^e. \end{aligned}$$

It can be noticed the problem they solve is not entirely analogous to the simpler model —even if also static—as the resources of the bank are now affected by their previous intermediation decisions, because the balance sheet constraint includes retained profits from the last period.

From these two problems, we can obtain the following first-order conditions:

$$[F_1^e]: \quad \mathbb{E}_1 \Omega_1^e (1+\mu_1^e)(R_{k,2}^e - R_{b,1}^e) = \kappa \mu_1^e, \qquad [F_2^e]: \quad \mathbb{E}_2 (1+\mu_2^e)(R_{k,3}^e - R_{b,2}^e) = \kappa \mu_2^e,$$

where μ_t^e is the Lagrange multiplier of the ICC of the bank in country e in each period and $\Omega_1^e = (1-\theta)\Lambda_{1,2}^e + \theta^2 R_{k,3}^e \Lambda_{1,3}^e$ is the effective stochastic discount factor of the bankers that accounts

[33]This feature is critical in the main model framework as it allows the incentive compatibility constraint to bind and will prevent the presence of Ponzi schemes in the model

[34]Given these assumptions, the net worth of a surviving bank j is given by their previous profits ($N_{j,2}^e = R_{k,2}^e L_{j,1}^e - R_{b,1}^e F_{j,1}^e$) while the total net worth of the banking sector is given by the sum of the mass of banks that survived plus the new startup funds (new banks): $\theta N_{j,t}^e + \delta_B Q_2^e K_1^e$. Notice however, that to simplify on notation, in alignment with the literature (e.g., Gertler and Karadi, 2011; Banerjee et al., 2016), and for a better comparability with the baseline model where the net worth was not relevant (as there was no entry-exit of banks) we are not adding the net worth as additional variables and just express these in terms of their already defined parts.

for the probability of a bank failure in the future. With these conditions the results of the Proposition 1 also apply here, i.e., a binding ICC leads to a positive credit spread that grows with the extent of the friction κ.[35]

Center-Banks In $t = 1$ the center-bank solves:

$$J_1^c = \max_{F_1^a, F_1^b, L_1^c, D_1} \mathbb{E}_1 \Big\{ (1-\theta)\Lambda_{1,2}^c (R_{k,2}^c L_1^c + R_{b,1}^a F_1^a + R_{b,1}^b F_1^b - R_{D,1} D_1) \\ + \Lambda_{1,3}^c \theta (R_{k,3}^c L_2^c + R_{b,2}^a F_2^a + R_{b,2}^b F_2^b - R_{D,2} D_2) \Big\},$$

$$s.t \quad L_1^c + F_1^a + F_1^b = D_1 + \delta_B Q_1^c K_0^c, \qquad \text{[Balance sheet in t=1]}$$

$$L_2^c + F_2^a + F_2^b = D_2 + \delta_B Q_2^c K_1^c \\ + \theta [R_{k,2}^c L_1^c + R_{b,1}^a F_1^a + R_{b,1}^b F_1^b - R_{D,1} D_1], \qquad \text{[Balance sheet in t=2]}$$

this problem is dynamic as it accounts for the potential profits and balance sheets of every intermediation period. These profits also reflect that the bank is a global creditor. In contrast, in the next period the bank will solve a simpler (static) problem consisting of maximizing the profits of a single —terminal intermediation— period,

$$J_2^c = \max_{F_2^a, F_2^b, L_2^c, D_2} \mathbb{E}_2 \Big\{ \Lambda_{2,3}^c (R_{k,3}^c L_2^c + R_{b,2}^a F_2^a + R_{b,2}^b F_2^b - R_{D,2} D_2) \Big\},$$

$$s.t. \quad L_2^c + F_2^a + F_2^b = D_2 + \delta_B Q_2^c K_1^c + \theta [R_{k,2}^c L_1^c + R_{b,1}^a F_1^a + R_{b,1}^b F_1^b - R_{D,1} D_1].$$

As in the baseline model, the resulting first-order conditions just reflect that the expected credit spread is zero for all of the assets considered by the center (F_2, L_2, D_2). By using that result and the perfect foresight assumption, we can drop the borrowing cross-border rates ($R_{b,t}$) as they are all equal to the rate for deposits ($R_{D,t}$).

5.2 Macroprudential Policy

The policy setup is analogous to the baseline setup. The effective revenue rate perceived by the banks after paying their taxes is $R_{k,t} = \frac{(1-\tau_t) r_t + (1-\delta) Q_t}{Q_{t-1}}$, where τ_t is the macroprudential tax. What differs now, however, is that τ_2 affects directly the first intermediation period when the banks' decisions are forward-looking, and τ_3 the terminal period where the decisions are static. Hence, it follows that τ_2 and τ_3 are respectively a forward-looking and a static policy tool.[36]

Analytical Welfare Effects We can derive the analytical welfare effects in this case using an analogous procedure based on Davis and Devereux (2022). However, a key difference here is that

[35] The proof for this extended setup is shown in Appendix E.

[36] Analogously, Proposition 2 also follows in this context, i.e., an increase in the macroprudential tool decreases the leverage ratio of the banking sector. The proof for this result is shown in Appendix E.

we can track the effect of one more tax, namely, the tool with persistent effects on the balance sheets, which depicts dynamic welfare effects too.

A social planner will consider the following welfare expressions.

$$W_0^a = u\left(C_1^a\right)+\beta u\left(C_2^a\right)+\beta^2 u\left(C_3^a\right)+\lambda_1^a\left\{A_1^a K_0^{a\ \alpha}+Q_1^a I_1^a-C(I_1^a,I_0^a)-\delta_B Q_1^a K_0^a-C_1^a-\tfrac{B_1^a}{R_1}\right\}$$
$$+\beta\lambda_2^a\left\{\varphi(\tau_2^a)A_2^a K_1^{a\ \alpha}+Q_2^a I_2^a-C(I_2^a,I_1^a)-\delta_B Q_2^a K_1^a+\kappa\left(\tfrac{Q_1^a K_1^a}{\Lambda_{12}}-\Lambda_{23}\theta Q_2^a K_2^a\right)+B_1^a-C_2^a-\tfrac{B_2^a}{R_2}\right\}$$
$$+\beta^2\lambda_3^a\left\{\left(1-\alpha\left(1-\tau_3^a\right)\right)A_3^a K_2^{a\ \alpha}+\kappa\tfrac{Q_2^a K_2^a}{\Lambda_{12}}+B_2^a-C_3^a\right\},$$

where $\varphi(\tau)=\left(1-\alpha\left(1-\tau\right)\right)$ and with an analogous expression for the economy b, and

$$W_0^c = u\left(C_1^c\right)+\beta u\left(C_2^c\right)+\beta^2 u\left(C_3^c\right)+\lambda_1^c\left\{A_1^c K_0^{c\ \alpha}+Q_1^c I_1^c-C(I_1^c,I_0^c)-\delta_B Q_1^c K_0^c-C_1^c-\tfrac{B_1^c}{R_1}-D_1\right\}$$
$$+\beta\lambda_2^c\Big\{\left(1-\alpha\theta\left(1-\tau_2^c\right)\right)A_2^c K_1^{c\ \alpha}+Q_2^c I_2^c-C\left(I_{2,}^c I_1^c\right)$$
$$+(1-\theta)\left((1-\delta)Q_2^c K_1^c+R_{b1}^a F_1^a+R_{b1}^b F_1^b\right)-\theta R_1 D_1-\delta_B Q_2^c K_1^c+B_1^c-C_2^c-\tfrac{B_2^c}{R_2}-D_2\Big\}$$
$$+\beta^2\lambda_3^c\Big\{A_3^c K_2^{c\ \alpha}+(1-\delta)Q_3 K_2^c+R_{b2}^a F_2^a+R_{b2}^b F_2^b+B_2-C_3^c\Big\}.$$

These expressions are obtained by setting the welfare plus the budget constraints in each period and imposing the private equilibrium conditions. These are equivalent to the usual welfare as the constraints are binding, however, this setup allows to gauge the effects of policy more broadly.

As before, we can obtain the welfare effects from changing the taxes. Here, a planner setting the tax in the last period takes the taxes and variables from the previous period as given, and hence, we just need to differentiate with respect to $R_2, Q_2, I_2.K_2$ for both types of countries plus $R_{b,2}, F_2$ for the center. In contrast, we must also consider the lagged versions of these variables for the first period.[37]

The welfare effects of the taxes are:

For the EMEs' instruments,

$$\frac{dW_0^a}{d\tau_2^a}=\beta\lambda_2^a\Bigg\{\overbrace{\alpha_1(\kappa)\frac{dK_1^a}{d\tau_2^a}+\alpha_2(\kappa)\frac{dQ_1^a}{d\tau_2^a}+\frac{B_1^a}{R_1}\frac{dR_1}{d\tau_2^a}+\alpha Y_2^a}^{\text{static effects}}+\overbrace{\alpha_3(\kappa)\frac{dK_2^a}{d\tau_2^a}+\alpha_4(\kappa)\frac{dQ_2^a}{d\tau_2^a}+\frac{B_2^a}{(R_2)^2}\frac{dR_2}{d\tau_2^a}}^{\text{dynamic effects}}\Bigg\},$$

$$\frac{dW_0^a}{d\tau_3^a}=\beta\lambda_2^a\Bigg\{\overbrace{\alpha_5(\kappa)\frac{dK_2^a}{d\tau_3^a}+\alpha_4(\kappa)\frac{dQ_2^a}{d\tau_3^a}+\frac{B_2^a}{(R_2)^2}\frac{dR_2}{d\tau_3^a}+\alpha\frac{Y_3^a}{R_2}}^{\text{(only) static effects}}\Bigg\},$$

with $\alpha_1(\kappa)=\kappa R_1 Q_1^a+\varphi\left(\tau_2^a\right)r_2^a$, $\alpha_2(\kappa)=R_1\left(I_1^a+\kappa K_1^a\right)$, $\alpha_3(\kappa)=\kappa\left(1-\theta\Lambda_{23}\right)Q_2^a+\varphi\left(\tau_3^a\right)\Lambda_{12}r_3^a$, $\alpha_4(\kappa)=I_2^a+\kappa\left(1-\theta\Lambda_{23}\right)K_2^a$, $\alpha_5(\kappa)=\kappa\left(1-\theta\Lambda_{23}\right)Q_2^a+\varphi\left(\tau_3^a\right)\Lambda_{23}r_3^a$, and $\frac{\partial\alpha_s}{\partial\kappa}>0$ for $s=\{1,...,5\}$.

[37]The time index of the tax corresponds to the period in which the banks pay it, i.e., the initial tax is τ_2 and the one for the final intermediation period is τ_3.

And for the center's tools,

$$\frac{dW_0^c}{d\tau_2^c} = \overbrace{\beta\lambda_2^c\left\{\gamma_1\frac{dK_1^c}{d\tau_2^c} + \left(\tfrac{B_1^c}{R_1} - \theta D_1\right)\frac{dR_1}{d\tau_2^c} + \tfrac{K_1^c}{R_1}\frac{dQ_1^c}{d\tau_2^c} + \alpha\theta Y_2^c + (1-\theta)\left(F_1^{ab}\frac{dR_{b,1}^{eme}}{d\tau_2^c} + R_{b,1}^{eme}\frac{dF_1^{ab}}{d\tau_2^c}\right)\right\}}^{\text{static effects}}$$
$$\underbrace{+\beta^2\lambda_3^c\left\{\gamma_2\frac{dK_2^c}{d\tau_2^c} + \tfrac{B_2^c}{R_2}\frac{dR_2}{d\tau_2^c} + \gamma_3\frac{dQ_2^c}{d\tau_2^c} + F_2^{ab}\frac{dR_{b,2}^{eme}}{d\tau_2^c} + R_{b,2}^{eme}\frac{dF_2^{ab}}{d\tau_2^c}\right\}}_{\text{dynamic effects}},$$

$$\frac{dW_0^c}{d\tau_3^c} = \beta^2\lambda_3^c\left\{\gamma_2\frac{dK_2^c}{d\tau_3^c} + \frac{B_2^c}{R_2}\frac{dR_2}{d\tau_3^c} + \gamma_3\frac{dQ_2^c}{d\tau_3^c} + F_2^{ab}\frac{dR_{b,2}^{eme}}{d\tau_3^c} + R_{b,2}^{eme}\frac{dF_2^{ab}}{d\tau_3^c}\right\},$$

with $\gamma_1 = (1-\alpha\theta(1-\tau_2^c))\, r_2^c + (1-\theta)(1-\delta)Q_2^c$, $\gamma_2 = (r_3^c + (1-\delta)Q_3)$, $\gamma_3 = R_2\left(I_2^c + (1-\theta)(1-\delta)K_1^c\right)$, and $F_t^{ab} = F_t^a + F_t^b$.

The interpretation of these effects goes as follows: First, we can see that there are more sources of variations for taxes that are forward-looking in nature (τ_2), whereas for the terminal taxes we only get the static drivers —described in the simpler baseline; this alone might explain why the former instruments may have stronger welfare effects than the latter.

On the other hand, there are four drivers of the static welfare effects of the tax, as pointed out in previous sections: these are changes in welfare from (i) hindering capital accumulation; (ii) changes in the global interest rate, which are proportional to the net foreign asset position; (iii) changes in the prices of capital; and, in addition for the center, (iv) changes in the cross-border lending rates and quantities. The welfare effects (i) and (iv) are negative and capture a halting in banking intermediation, while the sign of (ii) and (iii) depends, respectively, on whether an economy is a net creditor or on the investment growth. We expect (ii) to be positive for an emerging economy and negative for the center.

To reflect on the compared effects relative to our baseline, we can see that the dynamic toolkit effects will have similar drivers but also include effects on future variables, for instance, (i) would include the effect on future capital accumulation and (ii) on the future net assets position. The signs for the dynamic effects may not be as straightforward as we may expect similar signs but with potential corrections, for example, when tighter initial taxes imply delaying investment or capital accumulation plans for future periods. Simultaneously, and similar to the static case, it can be noticed that the welfare effects interact with the extent of the financial frictions (captured by κ), and, as before, the effects are stronger for a larger extent of the frictions. This can be seen by checking that $\alpha_j(\kappa)$ increases in κ for all $j = \{1, 2, 3, 4, 5\}$.

Optimal taxes We can obtain expressions for the optimal taxes by taking these welfare effects as first-order conditions for the planner as in prior sections. The features driving each tool are analogous to the ones described in the static baseline. As before, we have that regulators at the center trade-off local intermediation for global lending, a relevant feature for understanding the importance of the center's instrument in generating cross-border policy leakages and welfare effects abroad. At the same time, and in addition to the previous findings, now we have that the forward-looking taxes are driven by the changes in future variables, e.g., capital accumulation after changes in the level of banking intermediation. The expressions for these optimal taxes are shown in Appendix E.

Finally, unlike the static version of the optimal tool, in this case is not as straightforward to determine if a larger extent of the friction calls for a more stringent policy setting. On top of the static amplification effect, the dynamic effect takes into account the expected relative performance of the economy in future periods, which is captured by the interaction between stochastic discount factors (SDF) on different dates. In that sense, if the friction is such that intermediation implies stronger economic fluctuations (current or future) these additional effects activate.

6 Implications for Policy Design

We have obtained that there are potentially sizable policy leakages from the prudential policy tool, which depends on how regulation can impact intermediation —mostly at the center but also in peripheral locations. Some of the drivers are related to the capital accumulation, and net foreign assets implications of the resulting capital flows (for all locations) but also to how the toolkit may affect the profits in the banking sector itself (for the center, a global creditor). Importantly, the welfare effects can be magnified if the environment undergoes stronger financial frictions, and if the policies are set in an environment of dynamic banking activities where policy-driven changes in contemporaneous profits may remain in the balance sheet of financial agents in the future.

With this in mind, one can also explore what can these policies achieve if they are set optimally. That is, whether they can undo the financial distortions, how similarly are the instruments across different policy regimes —for example, with different degrees of international coordination—and relatedly, whether there is a scope for welfare improvements from centralized regulation setups. We explore these questions by solving for the optimal toolkit of the model.[38]

6.1 Welfare effects in different policy regimes

Before setting the planning problem and solving for the tools it is useful to understand the welfare effect of the taxes on the policy objective of the planners. For the standard case of a planner that takes decisions at the central level —or a nationally-oriented planner— the domestic welfare effect dictates the total effect on her objective function. On the other hand, as we are dealing with several planners we could also consider that these decide to form coalitions and set their policies

[38]Similar results hold if the model used for this exercise is the extended setup of Section 5.

with different levels of centralization. The possible combination of cases we consider, the effect of policy changes on their objectives, and the toolkit each planner has at hand are shown in Table 2.

Table 2 summarizes the effect of any policy change on the objective of each type of planner. To understand the possible effects, we can consider the example of a coalition of two countries, the associated policy makers may decide to cooperate and set their toolkit jointly, and in that case, the policy objective function would be a combination of the welfare of both economies.

Table 2: Welfare spillovers in the model

Case	Planners	Effect of taxes	Prudential Toolkit
Cooperation (all countries)	World	$\frac{dW}{d\tau^i} = n_a \frac{dW^a}{d\tau^i} + n_b \frac{dW^b}{d\tau^i} + n_c \frac{dW^c}{d\tau^i}$	τ^a, τ^b, τ^c
Semi-Cooperation (EMEs vs. Center)	Emerging block A+B	$\frac{dW^{ab}}{d\tau^i} = n_a \frac{dW^a}{d\tau^i} + n_b \frac{dW^b}{d\tau^i}$	τ^a, τ^b
	Center	$\frac{dW^c}{d\tau^i}$	τ^c
Semi-Cooperation (EME A + C vs. EME B)	Cooperative A+C	$\frac{dW^{ac}}{d\tau^i} = n_a \frac{dW^a}{d\tau^i} + n_c \frac{dW^c}{d\tau^i}$	τ^a, τ^c
	EME B	$\frac{dW^b}{d\tau^i}$	τ^b
Nationally-oriented (non-cooperative)	EME A	$\frac{dW^a}{d\tau^i}$	τ^a
	EME B	$\frac{dW^b}{d\tau^i}$	τ^b
	Center	$\frac{dW^c}{d\tau^i}$	τ^c

Notes: i denotes the country index that also establishes the policy jurisdiction of each tool. For example, τ^i with $i = c$ denotes the policy tool set in country c that affects the financial intermediation activities of banks operating in such economy. Additionally, in general $i = a, b, c$ as the effect on welfare may originate in any economy —and affect welfare through their local or international effects.

With no individual null effects, we have that the total spillover effects between Nash and centralized (or cooperative) cases will differ. As a result, when solving the Ramsey Planning Problems we should obtain different optimal tool levels across policy setups.[39]

The associated Ramsey planner problem is solved for each of the planners in the four cases. This policy problem consists of maximizing a welfare objective subject to the conditions characterizing the private equilibrium of other agents. The objective and problem to solve in each regime are explained in detail in Appendix C. Similar to the private equilibrium case, the numerical solutions reported here are solved non-linearly, but with a system of equations accounting for the first order necessary conditions of the involved policy makers in each regime. With this, now we can also solve for the taxes as these are no longer taken as given.

[39]As standard in the literature, we consider a weighted average of the welfare of participating economies with weights given by their relative population sizes.

6.2 Implied Optimal Policies

The results, shown in Table 3, reflect the policy trade-off the planners face: they can implement a tax to undo the financial friction or increase financial intermediation and production by subsidizing the banking sector. In the baseline or nationally-oriented case, the emerging planners focus on undoing the friction with a tax. The same is true for the center planner. However, the latter taxes the local banking sector heavily to favor intermediation abroad—where its banks could profit at a higher rate—rather than mitigating the friction, a pattern that aligns with the assumption that the friction is present mostly in peripheral countries, as specified in our baseline setup.[40]

Table 3: Ramsey-Optimal taxes under each policy setup

	Policy Scheme			
Country tool	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	0.38	-0.11	0.15	0.30
τ^b	0.38	-0.11	0.15	0.34
τ^c	1.19	0.96	1.11	1.14

Units: proportional tax on banking rate of return
Notes: The solution is obtained using a non-linear numerical solver of the system of equations characterizing the Ramsey problem allocation of each regime.

When allowing for different levels of cooperation, or of centralization of the policies, we see (from the absolute value of the instruments) that cooperation allows the planner to regulate with more conservative taxes to deliver—as will be shown below—a comparable effect. Interestingly, by internalizing the effect of domestic policies to other locations a globally cooperative arrangement gives space to subsidize intermediation in emerging economies, while the center taxes are set more loosely which indirectly mitigates the extent of the friction at the peripheries.[41] Thus, in a fully cooperative case, each country-specific tool is designed with a greater leaning towards generating *prosper-thy-neighbor* effects. The intuition in this case is that, as long as the frictions are attended in any way (with any country's toolkit), countries can benefit from higher levels of global intermediation in a similar fashion to how money expansions can be welfare improving for other countries in Obstfeld and Rogoff (1995), and Corsetti and Pesenti (2001).

[40]This case depicts a higher than 100% tax rate on the instrument of country c. Although such a tax can be thought of as prohibitive, it should be noted that country c is special as it derives profits from intermediation to all locations, and as a consequence, such a tax rate does not have to imply negative profits (as would happen for emerging banks). At the same time, this is a proportional tax on the dividend part of the banking return, so profits can still be large for high values of τ due to the ex-dividend part of the banking return.

[41]This can be seen in the expression for the country spread at the emerging economies, whose repayment rate depends on the tax on the creditor country in general equilibrium.

6.3 Effects of Policy

We can compare the regimes in terms of other economic outcomes. For example, how effective they are at mitigating the frictions, and the implied welfare they deliver. For that, in Table 4 we show the equivalent compensation changes —in terms of consumption increases— that agents undergo from transitioning from a benchmark allocation to one of the regimes (with optimal policies). For example, if the number is $\phi > 1$ and the benchmark is the no policy equilibrium, we say that agents benefit from the policy in a way that would allow them to expand consumption by $(\phi - 1) \times 100\%$.[42]

The results indicate that all regimes are capable of mitigating the financial frictions. We can see this in the fact that all countries can improve welfare relative to the no-policy equilibrium. Moreover, they can fully undo the effect of the frictions since the welfare improvement is such that the policies can mimic the first-best allocation (equilibrium in the absence of financial frictions).

Table 4: Welfare comparison across policy schemes with respect to the First Best allocation (left panel) and with respect to the no policy equilibrium (right panel)

	Bechmark: No Policy equilibrium				Bechmark: First Best			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.06	1.06	1.06	1.06	1.01	1.01	1.01	1.01
A	1.02	1.03	1.02	1.02	0.99	0.99	0.99	0.99
B	1.02	1.03	1.02	1.02	0.99	0.99	0.99	0.99
World	1.04	1.04	1.04	1.04	1.00	1.00	1.00	1.00
EME Block	1.02	1.03	1.02	1.02	0.99	0.99	0.99	0.99

Units: Proportional steady state consumption increase in the benchmark model. That is, by how much consumption in the benchmark should be scaled to match welfare in the column's regime.

A second salient result is that all regimes deliver similar welfare outcomes even if they imply different combinations of prudential tools. This could be deemed surprising given the interpretations provided before. However, this can be the case, as explained by Korinek (2016), because the conditions for a first-welfare theorem of financial regulations are met. That is, either the cross-border policy spillovers are efficient, the policies are too flexible, or the costs of regulations are trivial. Our setup, has at least the two last properties as we don't constrain the range of possible taxes and the cost of excessive regulation does not affect the policy objective directly.[43]

[42]It is relatively trivial to obtain this compensation as long as we count with the welfare of each regime. This is due to the simplified utility we consider (with only consumption as an argument). For example, if in regime 1 the agents get $W_1 = \frac{C_1^{1-\sigma}}{1-\sigma} + \beta \frac{C_2^{1-\sigma}}{1-\sigma}$ as welfare, then the scale change in consumption that they undergo to match the welfare of a baseline regime 0 with welfare W_0 would be ϕ such that $\frac{(\phi C_1)^{1-\sigma}}{1-\sigma} + \beta \frac{(\phi C_2)^{1-\sigma}}{1-\sigma} = W_0$ and the compensation just $\theta = (W_0/W_1)^{1/(1-\sigma)}$.

[43]The effect of potential constraints in the range of the toolkit may prevent the instrument from taking on too high values that may be deemed prohibitive or excessive. We still allow for this in our baseline because, the intermediators derive profits from several locations —and thus prohibitive taxes to either can be tolerated to some extent— and to give

To explore this we also carry a calculation of the welfare effects in the presence of policy costs in the spirit of Dedola, Karadi, and Lombardo (2013) and Agénor et al. (2021).

6.4 Policy Costs of Prudential Interventions

To consider the case of costly interventions we solve the modified Ramsey problems where we include a convex cost of policy implementation. The objective function of the planner becomes

$$\max_{\mathbf{x_t},\tilde{\tau}_t} \quad W_t^{objective} = f(\alpha^i, W_t^i) - \Gamma(\tau^i),$$
$$s.t. \qquad \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta),$$

with $\tilde{\tau} \subseteq \tau$ and welfare weights $\alpha^i \geq 0$. Here, $f(\alpha^i, W_t^i)$ corresponds to the same objective functions considered before and $\Gamma(\tau^i) = \psi(\tau^i)^2$ denotes a quadratic policy implementation cost.[44]

Table 5: Welfare comparison across policy schemes with respect to the non-cooperative Nash Equilibrium and policy implementation costs.

	Policy Scheme		
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.02	1.02	1.02
A	1.01	1.01	1.01
B	1.01	1.01	1.01
World	1.01	1.01	1.01
EME Block	1.01	1.01	1.01

Units: Proportional steady state consumption increase in the baseline non-cooperative regime.

The results, reported in Table 5, suggest the presence of gains from policy centralization for every country and globally. In addition, the high cost of policy implementation leads the countries to set their tools much more conservatively compared to the baseline. Finally, every cooperative setup matches the first best.[45] Put in perspective, these results imply that if regulation is costly, the nationally oriented policies (non-cooperative) can mitigate only about half of the welfare cost of financial frictions that in our baseline amounted to about 4% of consumption losses per period.

a fair chance to high-interventionism regimes to mimic the first-best. On the other hand, part of the costs of excessive regulations are still accounted for through welfare, for example, through more volatile business cycles. However, we still could account for a higher aversion from financial regulation to interventionism as they may be aware of the potential long-run macroeconomic costs of the prudential policies documented in studies such as Richter et al. (2019).

[44]The results reported correspond to one with $\psi = 1$.

[45]The comparison with respect to the first best allocation and the policy toolkit they imply is shown in Appendix D (tables D4 and D5). The result that in centralized frameworks there is an emphasis on limiting the extent to which policy curtails intermediation while giving more responsibility to the creditor for fighting the distortion in other locations holds in these cases as well.

In contrast, the cooperative regimes can bring the economy even closer to the first-best allocation, effectively undoing the remaining welfare cost implied by the friction.

Taking stock, a preliminary view to the regimes' outcomes may hint we should favor the idea that coordination gains are nil. However, the welfare equivalency result is overturned once we introduce regulatory costs. The prudential regulation costs can be easily rationalized and are subject of recent studies (e.g., Richter et al., 2019; Boar et al., 2017). Furthermore, the inclusion of these is meaningful in our framework, as the simplifications —finite horizon and perfect foresight— may undermine the welfare cost of volatile regulations. Due to this, a comprehensive welfare accounting of these gains goes beyond the scope of this paper that instead focuses on the analytical and numerical exploration of the prudential leakages. Nonetheless, although only indicative, the presence of gains based on the higher interventionism of decentralized regulations still aligns with the findings of studies (for alternative instruments and environments) such as Davis and Devereux (2022), Jin and Shen (2020), Agénor, Jackson, and Jia (2021) among others.[46][47]

More importantly for our main research question, the presence of non-trivial policy leakages leads to interdependencies between policymakers in different locations that allow for a wide menu of regulatory combinations to manage the trade-off between undoing financial frictions and curtailing financial intermediation given the costs of regulation. Clearly, and in line with empirical studies, these policies do leak beyond their jurisdiction which can have consequences for policy design adjustments.

7 Conclusions

We study the international policy leakages at the macroprudential level for economies that are financially integrated. The environment we consider is one with a financial center that acts as a global creditor for a set of emerging economies. We aim to verify the existence of these spillovers in different types of economies, their drivers and associated trade-offs, the policies they generate, and the implications for policy design in environments with financial frictions. For that, we propose a multilateral open economy framework in which financial frictions create a wedge between the cost of capital and the deposits rate (or return on non-banking activities) that creates a role for macroprudential interventions. The regulator may want to mitigate the local financial friction by adopting a tighter policy stance, but due to the leakages, the domestic pursuit of financial stability goals may be detrimental to other economies.

Our setup is simplified and allows us to find analytical expressions for the welfare effects of

[46] At the same time, this finding contrasts with the findings of Kara (2016) where, unlike most studies, indicates that gains arise because a cooperative policy implements more interventionism for the case of systemic risk and capital requirements. Despite the difference, we can still draw a parallel with our results if we consider that unlike the case of systemic risk, in our environment the financial frictions have explicit "domestic" locations and thus the decentralized regulator may be tempted to act quick on these without internalizing the global effects of their policies.

[47] A more comprehensive welfare accounting analysis exercise is done in Granados (2021) for a multiperipheral environment similar to the one considered here.

policies and optimal national tools, as well as to obtain numerical solutions for the equilibria in a menu of policy regimes. Our findings suggest that policy spillovers exist and are stronger when stemming from financial centers, but can also originate at emerging economies. Additionally, the effects of the macroprudential toolkit (and leakages) are magnified by the extent of the frictions or in environments involving forward-looking policy decisions.

We inquire into these results and verify that the effects of prudential policymaking are governed by the trade-off between mitigating financial distortions and facilitating financial intermediation. Furthermore, the presence of non-trivial leakages —when internalized— potentially allows regulators to set policies in a *prosper-thy-neighbor* fashion; in such scenario, emerging economies can set looser financial regulations while financial centers help them deal with the mitigation of financial frictions. Notably, the latter type of economy also benefits from such a strategy given its financial sector acts as a global creditor.

Finally, we explore implications for policy design. In particular, as both the interlinkages and financial distortions may influence the scale and effects of the policy instruments, we compare decentralized (nationally-oriented) regimes with alternatives —centralized to a given degree— where countries coordinate their regulations. We find that both can mitigate the financial frictions, but the decentralized regimes must incur in higher interventionism to achieve efficiency. We then, consider an extension with explicit costs of interventionism to make the case that leakages may open the scope for internationally coordinated regulations, for which a comprehensive welfare accounting in an stochastic framework beyond our baseline could be carried out. We consider such endeavor a promising venue for future research.

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A Baseline model description and results

A.1 Summary of baseline model equations

The small-scale model after simplifications features 29 variables in total (for the three economies). Each equation "Common to all countries" enters the system thrice (each with different country variables) for each period indicated. The second group of equations "for EMEs" enters the system twice (one for each EME country $\{a, b\}$); the rest of equations are counted only once.[48].

Table A1: Summary of equilibrium equations of the small scale model

Common to all countries:		
	$Q_t = 1 + \frac{\zeta}{2}\left(\frac{I_t}{\bar{I}} - 1\right)^2 + \zeta\left(\frac{I_t}{\bar{I}} - 1\right)\frac{I_t}{\bar{I}}$	[Price of Capital, t=1]
	$K_1 = I_1 + (1-\delta)K_0$	[Capital Dynamics]
	$R_{k,2} = \frac{(1-\tau_2)\alpha A_2 K_1^{\alpha-1} + (1-\delta)Q_2}{Q_1}$	[Banks rate of return]
	$C_1^{-\sigma} = \beta R_1 C_2^{-\sigma}$	[Euler Equation, bonds]
for EMEs:		
	$Q_1 K_1 = F_1 + \delta_B Q_1 K_0$	[bal. sheet of banks]
	$R_{k,2} Q_1 K_1 - R_1 F_1 = k R_{k,2} Q_1 K_1$	[ICC]
	$(1+\mu)\left(R_{k,2} - R_1\right) = \mu \cdot \kappa R_{k,2}$	[Credit spread]
	$C_1 + \frac{B_1}{R_1} = r_1 K_0 + \pi_{f,1} + \pi_{inv,1} - \delta_B Q_1 K_0$	[BC for t=1]
	$C_2 = \pi_{f,2} + \pi_{b,2} + B_1 - T_2$	[BC for t=2]
for the center:		
	$Q_1^c K_1^c + F_1^a + F_1^b = D_1 + \delta_B Q_1^c K_0^c$	[Bal. sheet of banks]
	$C_1^c + \frac{B_1^c}{R_1} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{1nv,1}^c - \delta_B Q_1^c K_0^c$	[BC for t=1]
	$C_2^c = \pi_{f,2}^c + \pi_{b,2}^c + R_1 D_1 + B_1^c - T_2^c$	[BC for t=2]
International Links:	$n_a B_1^a + n_b B_1^b + n_c B_1^c = 0$	[Net Supply of Bonds]

Note: when solving the model we normalize the initial world capital to 1 and distribute it across countries according to their population sizes. The initial investment is set as $I_0 = \delta K_0$, and an additional simplification is considered (but not substituted) as $R_{k,2}^c = R_1$.

Auxiliary definitions:

Stochastic discount factor: $\Lambda_{1,2} = \beta\left(\frac{C_2}{C_1}\right)^{-\sigma}$,

Lump-sum taxes: $T_2 = -\tau_2 r_2 K_1$,

Marginal product of capital: $r_2 = \alpha A_2 K_1^{\alpha-1}$,

Profits of firms: $\pi_{f,t} = (1-\alpha)A_t K_{t-1}^{\alpha}$, for $t = \{1, 2\}$,

Profits of investors: $\pi_{inv,1} = Q_1 I_1 - C(I_1, I_0) = Q_1 I_1 - I_1\left(1 + \frac{\zeta}{2}\left(\frac{I_1}{I_0} - 1\right)^2\right)$,

Profits of bankers in EMEs, t=2: $\pi_{b,2}^e = R_{k,2}^e Q_1^e K_1^e - R_1 F_1^e$,

[48] The Appendix F.1 shows how the simplified final system is obtained from the equations described in section 2.

Profits of bankers in the center, t=2: $\pi^c_{b,2} = R^c_{k,2} Q^c_1 K^c_1 + R^a_1 F^a_1 + R^b_1 F^b_1 - R_1 D_1$.

Finally, due to the optimality conditions we can equalize several related rates: $R^c_{k,2} = R^a_1 = R^b_1 = R_{D,1} = R_1$

The system of 29 equations is further simplified as the solution for Q_2 is trivial given there is no investment in the final period.[49] Thus, the final system of equations above consists then on 26 equations (the first panel of equations repeats three times, one for each country, the second twice, one for each emerging country, the third and fourth only appear once) that solve for: $Q^a_1, Q^b_1, Q^c_1, I^a_1, I^b_1, I^c_1, K^a_1, K^b_1, K^c_1, D_1, R^a_{k,2}, R^b_{k,2}, C^a_1, C^b_1, C^c_1, C^a_2, C^b_2, C^c_2, B^a_1, B^b_1, B^c_1, R_1, \mu^a, \mu^b, F^a_1, F^b_1$.

A.2 Parameters of the models

The table contains the parameters used in the baseline and extended model.

Parameter		Value	Comment/Source
Adjustment costs of investment	ζ	4.65	Chang, Fernández, and Gulan (2017)
Start-up transfer rate to banks	δ_b	0.005	Gertler and Karadi (2011), Gertler and Kiyotaki (2010)
Divertable fraction of capital	$\kappa^a = \kappa^b$	0.399	Aoki, Benigno, and Kiyotaki (2018)
Discount factor	β	0.99	Standard
Risk Aversion parameter	σ	2	Standard
Country size	$n_a = n_b$	0.25	
Depreciation rate	δ	0.6	Targets a longer period duration than quarterly
Capital share	α	0.333	Standard
Survival rate of banks	θ	0.9	Gertler and Karadi (2011)

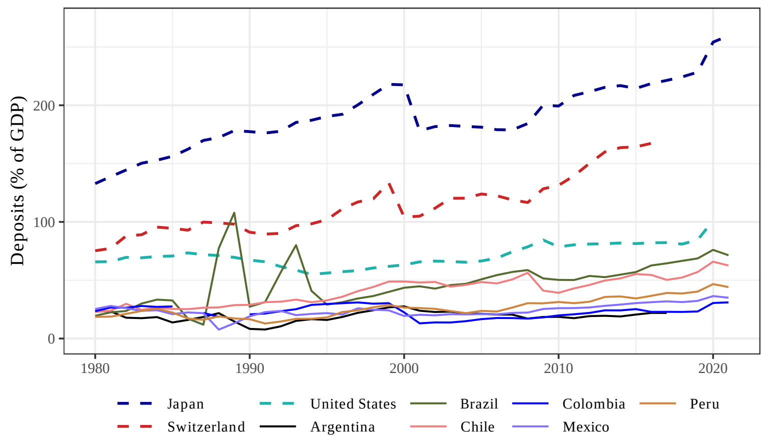
Table A2: Parameters in the model

A.3 Data on Deposits to GDP

Here we show some data providing support to some of our assumptions and modeling design choices. In particular, we want to support our assumption of a lower financial intermediation capacity and deposits holding in emerging economies (compared to advanced), we do this by showing data of deposits to GDP ratio in a selection of economies that include both developed (advanded) and emerging markets.

[49] We assume this price is still given by the decision under convex costs but with the investment level set at zero as there are no futher accumulation of capital. Such investment, dictates the price, and the relative value of undepreciated capital when rebated as a resource for consumption to the households. Further discussion and a detailed system of equations for the solution are shown in the Online Appendix.

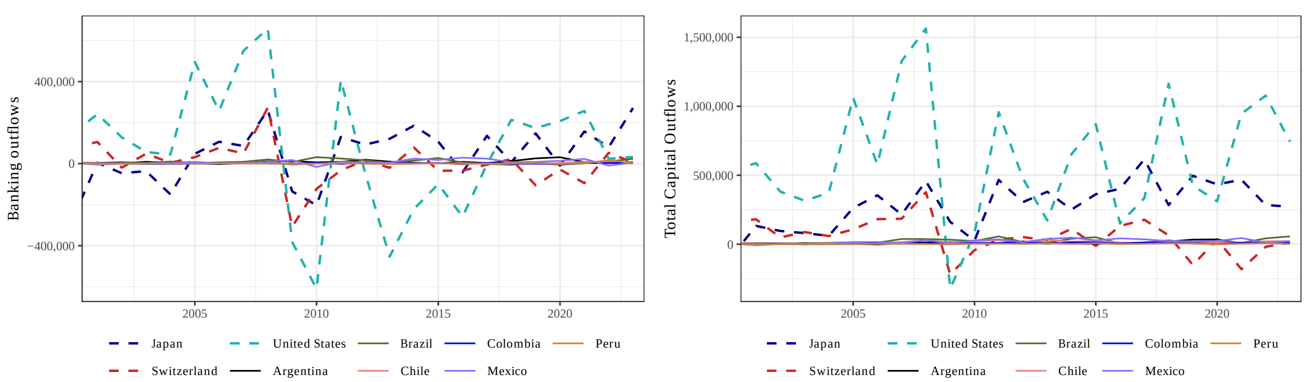
Figure 3: Deposits to output ratio in selected economies



Source: World Bank, Global Financial Development Database (GFDD, 2022).
Note: This figure shows the Deposits in the financial system as percentage of GDP ("DI08" in the GFDD database) for a selection of advanced and emerging economies. The dashed lines correspond to the advanced economies.

Additionally, we show some balance of payments statistics on the international capital outflows to support our claim and focus that the main global creditors are advanced economies, and that the typical direction of banking flows are from these economies to emerging markets as depicted in our model.

Figure 4: Capital outflows



(a) Banking capital outflows (million USD)

(b) Total capital outflows (million USD)

Source: IMF–International Finance Statistics (IFS) database.
Note: The total gross outflows are computed as the sum of foreign direct investment, portfolio, and other (banking) flows. The banking flows correspond to the “other” category. In both cases, we report gross outflows as defined by the IMF: the net acquisition of foreign assets by domestic residents.

We can see that the banking (and other capital outflows) originating from advanced economies have a greater scale and volatility, which help motivate our focus on the bilateral flows from financial centers located in these developed economies to other types of economies such as the emerging ones. The flows of this latter type of economies, on the other hand, are not necessarily zero but seem minor in comparison.

A.4 Numerical approximate to the welfare effects in the baseline model

Here we show the approximated numerical derivatives of welfare after changes in the macroprudential instruments in the model.

Table A3: Policy effects in the model

		Baseline	Increased frictions everywhere (by 25%)	Increased friction in country a (by 25%)
			Effect on welfare	
Direct effect	$\tau_2^a \to W^a$	-1.759	-2.049	-2.019
	$\tau_2^b \to W^b$	-1.759	-2.049	-2.019
	$\tau_2^c \to W^c$	-1.109	-1.187	-1.146
Cross-border effect	$\tau_2^a \to W^b$	-0.095	-0.076	-0.058
	$\tau_2^a \to W^c$	-0.088	-0.063	-0.056
	$\tau_2^b \to W^a$	-0.095	-0.076	-0.121
	$\tau_2^b \to W^c$	-0.088	-0.063	-0.097
	$\tau_2^c \to W^a$	-0.277	-0.348	-0.341
	$\tau_2^c \to W^b$	-0.277	-0.348	-0.281

Note: The effects shown in the table correspond to the numerical approximate to the derivative of welfare with respect to the prudential instrument (τ) in each location. The measure is obtained by solving the model with an increased tax (indicated by the row) and computing the change in the variable relative to the no-taxes ($\tau = 0$) equilibrium, and then dividing the resulting number by the change in the tax ($\frac{\Delta W}{\Delta \tau}$). The solution in each case is obtained with a non-linear solver applied to the equations system in A1. The superindexes refer to the countries with a: EME-A, b: EME-B and c: center. Banking intermediation is measured based on the left-hand-side of the balance sheet of the banks, that is, $L_1^e = Q_1 K_1^e$ for EM countries ($e = \{a, b\}$) and $F_1^a + F_1^b + L_1$ for the center. The first column reports the effects for the baseline parameters (Table A.2), the second for frictions parameters increased by 25%, and the third for a parameter for country a increased by 25%.

B Analytic welfare effects derivations

This section explains the derivations of the expressions shown in the section 3.

We differentiate the welfare expression for the EME-A social planner:

$$\frac{dW^a}{d\tau^a} = \lambda_1^a \left[\frac{dQ_1^a}{dI_1^a} I_1^a + Q_1^a - C'(I_1^a) \right] \frac{dI_1^a}{d\tau^a} + \frac{\lambda_1^a}{R_1} \frac{B_1^a}{R_1} \frac{dR_1}{d\tau^a}$$
$$+ \beta \lambda_2^a \left(\phi(\tau^a) \alpha A_2^a \xi_2^a{}^{\alpha} K_1^a{}^{\alpha-1} + \kappa^a (1-\delta) \xi_2^a Q_2 \right) \frac{dK_1^a}{d\tau^a} + \beta \lambda_2^a \alpha (1-\kappa^a) A_2^a (\xi_2^a K_1^a)^{\alpha}$$

To obtain the direct welfare effect of the tax we substitute the equilibrium expression for the price of capital for the competitive investor ($Q_1^a = C'(I_1^a)$) and the Euler equation for the consumer

($\lambda_1 = \beta R_1 \lambda_2$). After rearranging we obtain the expression shown in the main section:

$$\frac{dW^a}{d\tau^a} = \lambda_1^a I_1^a \frac{dQ_1^a}{d\tau^a} + \beta\lambda_2^a \frac{B_1^a}{R_1}\frac{dR_1}{d\tau^a} + \beta\lambda_2^a \left(\phi(\tau^a)\alpha A_2^a \xi_2^{a\ \alpha} K_1^{a\ \alpha-1} + \kappa^a(1-\delta)\xi_2^a Q_2^a\right)\frac{dK_1^a}{d\tau^a}$$
$$+\beta\lambda_2^a \alpha(1-\kappa^a)A_2^a(\xi_2^a K_1^a)^\alpha$$

The derivation of $\frac{dW^b}{d\tau^b}$ is analogous.

For $\frac{dW^c}{d\tau^c}$ we make the same substitutions for the first two terms and obtain,

$$\frac{dW^c}{d\tau^c} = \lambda_1^c \frac{dQ_1^c}{d\tau^c} I_1^c + \beta\lambda_2^c \frac{B_1^c}{R_1}\frac{dR_1}{d\tau^c} + \beta\lambda_2^c \left(\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2\right)\frac{dK_1^c}{d\tau^c}$$
$$+ \beta\lambda_2^c \left(R_{b,1}^a \frac{dF_1^a}{d\tau^c} + F_1^a \frac{dR_{b,1}^a}{d\tau^c} + R_{b,1}^b \frac{dF_1^b}{d\tau^c} + F_1^b \frac{dR_{b,1}^b}{d\tau^c}\right)$$

In the last term, we use the private equilibrium result: $R_b^a = R_b^b = R_b^{eme}$

$$\frac{dW^c}{d\tau^c} = \lambda_1^c I_1^c \frac{dQ_1^c}{d\tau^c} + \beta\lambda_2^c \frac{B_1^c}{R_1}\frac{dR_1}{d\tau^c} + \beta\lambda_2^c \left(\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2\right)\frac{dK_1^c}{d\tau^c}$$
$$+ \beta\lambda_2 \left[R_{b,1}^{eme}\left(\frac{dF_1^a}{d\tau^c} + \frac{dF_1^b}{d\tau^c}\right) + \frac{dR_{b,1}^{eme}}{d\tau^c}\left(F_1^a + F_1^b\right)\right]$$

We follow the same procedure for the cross country effects. Notice that the last term of the EME effects will be absent since there is not any direct tax welfare effect at the international level.

To obtain the optimal taxes we set $\frac{dW^a}{d\tau^a} = 0$ and solve for $\phi(\tau^a)$:

$$\phi(\tau^a) = -\frac{1}{\alpha A_2^a \xi_2^{a\ \alpha} K_1^{a\ \alpha-1}}\left[R_1 I_1^a \frac{dQ_1^a}{dK_1^a} + \frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a} + \kappa^a(1-\delta)\xi_2^a Q_2\right]$$

Where we assumed that $\frac{d\tau^a}{dK_1^a} = 0$. Assuming taxes exogeneity works here because these calculations are based on the private equilibrium and not on the Ramsey planner equilibrium where the taxes are endogenous.

Now we substitute, $\phi(\tau^a) = 1 + (\kappa^a - 1)(1-\tau^a)\alpha$ and solve for τ^a:

$$\tau^{a\ *} = -\frac{1}{\alpha(1-\kappa^a)}\left\{\frac{1}{\alpha A_2^a \xi_2^{a\ \alpha} K_1^{a\ \alpha-1}}\left[\left(R_1 I_1^a \frac{dQ_1^a}{dK_1^a} + \frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a}\right) + \kappa^a(1-\delta)\xi_2^a Q_2\right] + 1 + \alpha(\kappa^a - 1)\right\}$$

The result for b is analogous.

For c, τ^c will not show up in this case because there are not direct tax welfare effects terms for the center. We work around it by using the equilibrium outcome $R_{b,1}^{eme} = R_{k,2}^c(\tau^c)$. Then we set $\frac{dW^c}{d\tau^c} = 0$ and solve for $R_{k,2}^c$:

$$-R_{k,2}^{c} = R_1 I_1 \frac{dQ_1^c}{dF_1^S} + \frac{B_1^c}{R_1}\frac{dR_1}{dF_1^S} + (\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2)\frac{dK_1^c}{dF_1^S} + (F_1^a + F_1^b)\frac{dR_{b,1}^{eme}}{dF_1^S}$$

We substitute $R_{k,2}^c = [(1-\tau^c)\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2]/Q_1^c$ and solve for τ^c:

$$\tau^{c\,*} = \frac{Q_1^c}{\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1}} \left\{ R_1 I_1^c \frac{dQ_1^c}{dF_1^S} + \frac{B_1^c}{R_1}\frac{dR_1}{dF_1^S} + (\alpha A_2^c \xi_2^{c\ \alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2)\frac{dK_1^c}{dF_1^S} \right.$$
$$\left. + (F_1^a + F_1^b)\frac{dR_{b,1}^{eme}}{dF_1^S} + (1-\delta)\xi_2^c \frac{Q_2}{Q_1^c} \right\} + 1$$

with $dF_1^S = dF_1^a + dF_1^b$

C Ramsey Policy Problems in the Baseline Model

In the previous sections, we set up a framework to explore the welfare spillovers from setting the macroprudential tools, including the within effect and the effect between economies. The objective was to understand what drives the welfare effect of setting the tools in general and across policy frameworks with different degrees of cooperation between planners.

It should be noted that in such an analysis, there is a substantial endogeneity given that all the equations (on both sides) depend on the taxes. Hence, other than studying the structure of the effects, or the numerical effect at a pre-defined level of the taxes, it is difficult to solve for the actual optimal policy instruments and thus for the policy distorted equilibrium under each regime.

For carrying out such task it is more convenient to set a Ramsey problem consisting of maximizing a welfare objective function subject to the private equilibrium optimality conditions.

First, we will use the same country-wise welfare definition as before: $W^i = u(C_1^i) + \beta u(C_2^i)$ with $i = \{a, b, c\}$ and $u(C) = \frac{C^{1-\sigma}}{1-\sigma}$.

Second, let $F(\cdot)$ be the set of equations representing the optimality constraints of private agents that characterize the private equilibrium, $\mathbf{x}$ the system of endogenous or decision variables for the agents, θ the parameters of the model and $\tau = \{\tau^a, \tau^b, \tau^c\}$ the vector of policy instruments for all countries. In general, we solve the following problem for each Ramsey planner involved:

$$\max_{\mathbf{x_t}, \tilde{\tau}_t} \quad W_t^{objective} = f(\alpha^i, W_t^i),$$
$$s.t. \qquad \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta),$$

with $\tilde{\tau} \subseteq \tau$ and welfare weights $\alpha^i \geq 0 \quad \forall i$.

The set up of this problem will vary in each policy framework by changing the objective function, whereas the constraints will always refer to all the equations defining the equilibrium of the model (i.e., the system of equations in table A1). The latter assumption is set for consistency with an open economy setup and implies that the planners acknowledge they have an effect in the endogenous variables of the other countries.[50]

C.1 Non-Cooperative Framework

Without cooperation we will have one planner for each country, each one solving:

$$\max_{\mathbf{x_t^i}, \tau_t^i} \quad W^{i,Nash} = W^i,$$
$$s.t. \quad \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta), \qquad \text{for } t = 1.$$

The first-order conditions for the three planners will be used to solve for the Ramsey Nash equilibrium.

C.2 Cooperative Frameworks

We will consider three types of cooperative frameworks. Full cooperation, where the tools for all countries are set cooperatively by a single central planner, and two semi-cooperative cases where regional coalitions are formed. First, between emerging economies, and second between the center and one emerging economy. In the semi-cooperative regimes, each coalition will have a central planner setting the participants' toolkit.

C.2.1 World Cooperation

The cooperative Ramsey planner solves:

$$\max_{\mathbf{x_t}, \tau_t} \quad W^{Coop} = n_a W^a + n_b W^b + n_c W^c,$$
$$s.t. \quad \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta), \qquad \text{for } t = 1.$$

Thus, it sets all the tools in order to maximize global (weighted) welfare. The welfare weights correspond to the relative population sizes of the economies.

[50]This assumption is standard for Ramsey problem solutions and guarantees the optimization will yield enough equations as unknowns to solve for. Other ways to go about this would be to make small open economy assumptions. However, we take the standard path while accounting for smaller economy effects by adjusting the population size of the economies.

C.2.2 Regional cooperation between emerging countries

A coalition between emerging economies implies a regional level planner solving:

$$\max_{\mathbf{x_t^a},\mathbf{x_t^b},\tau_t^a,\tau_t^b} \quad W^{Coop,EMEs} = n_a W^a + n_b W^b,$$
$$s.t. \quad \mathbb{E}_t F(\mathbf{x_{t-1}},\mathbf{x_t},\mathbf{x_{t+1}},\tau_t,\theta), \qquad \text{for } t=1.$$

In this framework there is a second planner, in the center country, that chooses the decision variables and policy tool for its country in order to maximize W_1^c, analogously to the nationally-oriented non-cooperative planner.

C.2.3 Coalition between the advanced economy and one emerging country

The coalition between the center (or advanced economy) and one emerging economy (EME-A) implies a semi-cooperative Ramsey planner that solves:

$$\max_{\mathbf{x_t^a},\mathbf{x_t^c},\tau_t^a,\tau_t^c} \quad W^{Coop,ac} = n_a W^a + n_c W^c,$$
$$s.t. \quad \mathbb{E}_t F(\mathbf{x_{t-1}},\mathbf{x_t},\mathbf{x_{t+1}},\tau_t,\theta), \qquad \text{for } t=1.$$

In this case, there is a second planner in the second emerging country (B), i.e., the economy outside the coalition, that chooses the B country decision variables and policy tool in order to maximize W_1^b, analogously to one of the Nash emerging planners.

D Numerical simulation results for model extensions

Here we show the additional results for the model with costly policy implementation. In this particular case, the model also depicts frictions in all locations, but as in the baseline, these distortions are considerably more severe in emerging economies and hence, in relative terms, the key modification would be the aversion to policy intervention introduced for the planners.[51]

[51] Results for the model wth no costs of intervention but frictions in all locations are shown in the Online Appendix F.1.

Table D4: Welfare comparison for model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$) and policy implementation costs $\psi = 1$

	Bechmark: Nash			Bechmark: First Best			
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.02	1.02	1.02	1.00	1.02	1.02	1.02
A	1.01	1.01	1.01	0.97	0.98	0.98	0.98
B	1.01	1.01	1.01	0.97	0.98	0.98	0.98
World	1.01	1.01	1.01	0.99	1.00	1.00	1.00
EME Block	1.01	1.01	1.01	0.97	0.98	0.98	0.98

Units: Proportional steady state consumption increase in the benchmark model

Table D5: Ramsey-Optimal taxes for the model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$) and policy implementation costs $\psi = 1$

	Policy Scheme			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	0.20	-0.30	-0.04	0.15
τ^b	0.20	-0.30	-0.04	0.16
τ^c	1.29	1.09	1.23	1.25

Units: proportional tax on banking rate of return.
Notes: This case depicts a higher than 100% tax rate on the instrument of country c. Although such a tax can be thought of as prohibitive, it should be noted that country c is special in that it derives profits from the intermediation to all locations, and as a consequence, such a tax rate does not have to imply negative profits (as would happen for emerging banks). At the same time, this is a proportional tax on the dividend part of the banking return, so profits can still be large for high values of τ due to the ex-dividend part of the banking return.

E Results from Extended Three-Periods Model

E.1 Description of model environment for non-bank agents

Here we discuss the environment for non-bank agents in the context of the environment with multiple periods of intermediation.

E.1.1 Production Sectors

There are two types of firms. Here we describe them briefly as the structure is analogous to the main (baseline) model and the detailed formulation is explained in the main document.

Final Good Firm. There is a firm that maximizes its profits, given by the value of the production, plus the sales of undepreciated capital after production, minus the payment of banking loans. The only constraint it faces is the production technology. From the first order condition with respect to the capital, we can pin down the gross rate of return paid to the banks as $R_{k,t} = \frac{r_t+(1-\delta)Q_t}{Q_{t-1}}$ with $t = \{2, 3\}$. Here , $r_t = \frac{\alpha Y_t}{K_{t-1}}$ is the marginal product of capital.

Capital Producers. There is a firm carrying out the investments in each economy. They buy the undepreciated capital from the final good firms and produce the new physical capital for future production. They are subject to adjustment costs relative to the previous investment level.

E.1.2 Households

The households own the three types of firms (final goods, capital and banks), and use their profits for consumption, saving, and supplying bequests to their banks. They don't pay the banking taxes directly, instead, these are paid by the banks before distributing profits. However, they receive a lump sum transfer from the government.Since the capital is already predetermined in the initial period, there is no intermediation for K_0. Instead, and only for that period, the households rent the capital to the firms directly.

EME-households. The households maximize the present value of their life-stream of utility:

$$\max_{\{C_t^e\}_{t=1}^3,\{B_t^e\}_{t=1}^2} u(C_1^e) + \beta u(C_2^e) + \beta^2 u(C_3^e),$$

$$\begin{aligned} s.t. \quad & \\ C_1^e + \frac{B_1^e}{R_1^e} &= r_1^e K_0^e + \pi_{f,1}^e + \pi_{inv,1}^e - \delta_B Q_1^e K_0^e, \\ C_2^e + \frac{B_2^e}{R_2^e} &= \pi_{f,2}^e + \pi_{inv,2}^e + \pi_{bank,2}^e - \delta_B Q_2^e K_1^e + B_1^e - T_2^e, \\ C_3^e &= \pi_{f,3}^e + \pi_{bank,3}^e + B_2^e - T_3^e, \qquad for\ e = \{a, b\}, \end{aligned}$$

here B_t denotes the bonds or net foreign assets position, R_t the interest rate on bonds, and T_t the lump sum taxes. As for the profits terms, $\pi_{f,t}$ corresponds to the final goods firms profits, $\pi_{inv,t}$ to the capital firms profits, and $\pi_{bank,t}$ to the banking profits.

Center-households. The households at the center solve a similar problem. The only difference is that they do have access to local deposits and that their banking profits account for the fact that their banks act as creditors of the EMEs:

$$\max_{\{C_t^c\}_{t=1}^3,\{B_t^c\}_{t=1}^2} u(C_1^c) + \beta u(C_2^c) + \beta^2 u(C_3^c),$$

$$\begin{aligned} s.t. \quad & \\ C_1^c + \frac{B_1^c}{R_1^c} + D_1 &= r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_B Q_1^c K_0^c, \end{aligned}$$

$$C_2^c + \frac{B_2^c}{R_2^c} + D_2 = \pi_{f,2}^c + \pi_{inv}^c + \pi_{bank,2}^c - \delta_B Q_2^c K_1^c + B_1^c + R_{D,1} D_1 - T_2^c,$$
$$C_3^c = \pi_{f,3}^c + \pi_{bank,3}^c + B_2^c + R_{D,2} D_2 - T_3^c.$$

E.1.3 Equilibrium

Market Clearing and International Links. The bonds market depicts a zero-net-supply in the first two periods. The uncovered parity holds, which allows us to equate the interest rate of bonds in each location $R_t^a = R_t^b = R_t^c = R_t$. Furthermore, from the Center's Euler equations for the deposits and bonds, we can determine that $R_{D,t} = R_t$ for $t = \{1, 2\}$.

Equilibrium. Given the policies $\tau_t = \{\tau_t^a, \tau_t^b, \tau_t^c\}_{t=2,3}$, the equilibrium consists of the prices $\{Q_t^i\}$, rates $\{R_1, R_2, R_{k,2}^i, R_{k,3}^i\}$ and quantities $\{B_1^i, B_2^i, K_1^i, K_2^i, F_1^e, F_2^e, D_1, D_2\}$ and $\{C_t^i\}$ for $t = \{1, 2, 3\}$, with $i = \{a, b, c\}$ and $e = \{a, b\}$ such that: in each period, the households solve their utility maximization problem, the firms solve their profit maximization problems, the banks maximize their value, the government runs a balanced budget, and the goods and bonds markets clear.[52]

[52] A summary of the final set of equilibrium conditions used for solving the model can be found in table E6. We solve this system of equations non-linearly and using a perfect foresight approximation.

E.2 Final System of equations

Table E6: Summary of equilibrium equations of the three-period model

Common to all countries:	
$Q_t = 1 + \frac{\zeta}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \zeta\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} - \Lambda_{t,t+1}\zeta\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2$	[Price of Capital, t={1,2}]
$K_t = I_t + (1-\delta)K_{t-1}$	[Capital Dynamics, t={1,2}]
$R_{k,t} = \frac{(1-\tau_t)\alpha A_t K_{t-1}^{\alpha-1} + (1-\delta)Q_t}{Q_{t-1}}$	[Banks rate of return, t={2,3}]
$C_t^{-\sigma} = \beta R_t C_{t+1}^{-\sigma}$	[Euler Equation, bonds, t={1,2}]
for EMEs:	
$Q_1 K_1 = F_1 + \delta_B Q_1 K_0$	[bal. sheet of banks, t=1]
$Q_2 K_2 = F_2 + \delta_B Q_2 K_1 + \theta\left[R_{k,2} Q_1 K_1 - R_{b,1} F_1\right]$	[bal. sheet of banks, t=2]
$(1-\theta)\Lambda_{1,2}\left(R_{k,2} Q_1 K_1 - R_1 F_1\right) + \Lambda_{1,3}\theta\left(R_{k,3} Q_2 K_2 - R_2 F_2\right) = k Q_1 K_1$	[ICC, t=1]
$\Omega_1 (1+\mu_1)\left(R_{k,2} - R_1\right) = \mu_1 \kappa$	[Credit spread, t=2]
$\Lambda_{2,3}\left(R_{k,3} Q_2 K_2 - R_2 F_2\right) = k Q_2 K_2$	[ICC, t=2]
$(1+\mu_2)\Lambda_{2,3}\left(R_{k,3} - R_2\right) = \mu_2 \kappa$	[Credit spread, t=3]
$C_1 + \frac{B_1}{R_1} = r_1 K_0 + \pi_{f,1} + \pi_{inv,1} - \delta_B Q_1 K_0$	[BC for t=1]
$C_2 + \frac{B_2}{R_2} = \pi_{f,2} + \pi_{inv,2} + \pi_{b,2} - \delta_B Q_2 K_1 + B_1 - T_2$	[BC for t=2]
$C_3 = \pi_{f,3} + \pi_{b,3} + B_2 - T_3$	[BC for t=3]
for the Center:	
$Q_1^c K_1^c + F_1^a + F_1^b = D_1 + \delta_B Q_1^c K_0^c$	[Bal. sheet of banks, t=1]
$Q_2^c K_2^c + F_2^a + F_2^b = D_2 + \delta_B Q_2^c K_1^c + \theta\left[R_{k,2}^c Q_1^c K_1^c + R_1^a F_1^a + R_1^b F_1^b - R_1 D_1\right]$	[Bal. sheet of banks, t=2]
$C_1^c + \frac{B_1^c}{R_1} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{1nv,1}^c - \delta_B Q_1^c K_0^c$	[BC for t=2]
$C_2^c + \frac{B_2^c}{R_1} + D_2 = \pi_{f,2}^c + \pi_{inv,2}^c + \pi_{b,2}^c - \delta_B Q_2^c K_1^c + R_1 D_1 + B_1^c - T_2^c$	[BC for t=2]
$C_3^c = \pi_{f,3}^c + \pi_{b,3}^c + B_2^c + R_2 D_2 - T_3^c$	[BC for t=3]
International Links:	
$n_a B_t^a + n_b B_t^b + n_c B_t^c = 0$	[Net Supply of Bonds, t = {1,2}]

Note: when solving the model normalize the initial world capital to 1 and distribute it across countries according to their population sizes. The initial investment is set as $I_0 = \delta K_0$, and since $I_3 = 0$ the price Q_3 is a constant.

Auxiliary definitions:

Stochastic discount factor: $\Lambda_{t,t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}$

Effective discount factor of banks: $\Omega_1 = (1-\theta)\Lambda_{1,2} + \theta^2 R_{k,3}\Lambda_{1,3}$

Taxes: $T_t = -\tau_t r_t K_{t-1}$

Marginal product of capital: $r_t = \alpha A_t K_{t-1}^{\alpha-1}$

Profits of firms: $\pi_{f,t} = (1-\alpha)A_t K_{t-1}^{\alpha}$

Profits of investors: $\pi_{inv,t} = Q_t I_t - C(I_t, I_{t-1}) = Q_t I_t - I_t\left(1 + \frac{\zeta}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right)$

Profits of bankers in EMEs, t=2: $\pi^e_{b,2} = (1-\theta)\left(R_{k,2}Q^e_1K^e_1 - R_1F^e_1\right)$

Profits of bankers in EMEs, t=3: $\pi^e_{b,3} = R^e_{k,3}Q^e_2K^e_2 - R_2F^e_2, \qquad$ e = {a,b}

Profits of bankers in Center, t=2: $\pi^c_{b,2} = (1-\theta)\left(R^c_{k,2}Q^c_1K^c_1 + R^a_1F^a_1 + R^b_1F^b_1 - R_1D_1\right)$

Profits of bankers in Center, t=3: $\pi^c_{b,3} = R^c_{k,3}Q^c_2K^c_2 + R^a_{b2}F^a_2 + R^b_2F^b_2 - R_2D_2$

E.3 Proof of propositions for extended model

Proof of proposition 1 for extended model.

Proof. W.L.O.G. we will work in a perfect foresight setup, otherwise the same result applies to the expected credit spread.

The time index of the spread is given by the time in which the revenue rate is paid. We can obtain the credit spreads from the EME-Banks F.O.C. with respect to F_1 and F_2.

For $t = 2, 3$ the spreads are given by:

$$Spr_2 = R_{k,2} - R_{b,1} = \frac{\mu_1\kappa}{(1+\mu_1)\Omega_1}$$
$$Spr_3 = R_{k,3} - R_{b,2} = \frac{\mu_2\kappa}{(1+\mu_2)\Lambda_{2,3}}$$

if the ICCs bind we have $\mu_t > 0$ and it follows that:

$$\frac{\partial Spr_2}{\partial \kappa} = \frac{\mu_1}{(1+\mu_1)\Omega_1} > 0$$
$$\frac{\partial Spr_3}{\partial \kappa} = \frac{\mu_2}{(1+\mu_2)\Lambda_{2,3}} > 0$$

■

Proof of proposition 2 for extended model.

Proof: W.L.O.G. we will work in a perfect foresight setup, otherwise the same result applies to the expected value of the leverage.

From the ICC of the EME-Banks for each period we obtain the leverage, defined as total assets over net worth. Then we differentiate the resulting expression with respect to the tax.

For the last period:

The ICC is: $\qquad J_2 = \Lambda_{2,3}(R_{k,3}L_2 - R_{b,2}F_2) = \kappa_2 L_2$

By substituting the foreign lending $F_2 = L_2 - N_2$, where N_2 is the net worth in the last period (bequests plus retained previous profits) and solving for L_2:

$$L_2 = \overbrace{\frac{-\Lambda_{2,3} R_{b,2}}{\Lambda_{2,3}(R_{k,3} - R_{b,2}) - \kappa}}^{\phi_2} N_2$$

where ϕ_2 denotes the leverage. Now, we substitute $R_{k,3}(\tau_3) = [(1-\tau_3)r_3 + (1-\delta)Q_3]/Q_2$ and differentiate with respect to the policy instrument:

$$\frac{\partial \phi_2}{\partial \tau_3} = -\frac{(\Lambda_{2,3})^2 R_{b,2} \cdot r_3}{(\Lambda_{2,3}(R_{k,3} - R_{b,2}) - \kappa)^2 Q_2} < 0$$

For the first period:

The procedure is the same but the algebra is a bit lengthier as we substitute both balance sheets ($F_1 = L_1 - \delta_B Q_1 K_0$, and $F_2 = Q_2 K_2 - N_2$) in the value of the bank in the right-hand side of the ICC for the first intermediation period $J_1 = \kappa L_1$.

After substitutions and some algebra, the ICC becomes:

$$[\tilde{\Omega}_1(R_{k,2} - R_{b,1}) - \kappa]L_1 + [\tilde{\Omega}_1 R_{b,1}]\delta_B Q_1 K_0 + \Lambda_{1,3}\delta[(R_{k,3} - R_{b,2})L_2 + R_{b,2}\delta_B Q_2 K_1] = 0$$

With $\tilde{\Omega}_1 = (1-\theta)\Lambda_{1,2} + \Lambda_{1,3}\theta^2 R_{b,2}$

The leverage is given by:

$$\phi_1 = \frac{L_1}{\delta_B Q_0 K_1} = \frac{-[\tilde{\Omega}_1 R_{b,1}] - \Lambda_{1,3}\theta[(R_{k,3} - R_{b,2})L_2 + R_{b,2}\delta_B Q_2 K_1]/(\delta_B Q_0 K_1)}{[\tilde{\Omega}_1(R_{k,2} - R_{b,1}) - \kappa]}$$

Then,

$$\frac{\partial \phi_1}{\partial \tau_2} = -\frac{\tilde{\Omega}_1 R_{b,1} + \Lambda_{1,3}\theta[(R_{k,3} - R_{b,2})L_2 + R_{b,2}\delta_B Q_2 K_1]/(\delta_B Q_0 K_1)}{[\tilde{\Omega}_1(R_{k,2} - R_{b,1}) - \kappa]^2} \cdot \left(\frac{r_2(\tau_2)}{Q_1}\right) < 0$$

Finally, notice how in the expressions $\frac{\partial \phi_1}{\partial \tau_2}$ and $\frac{\partial \phi_2}{\partial \tau_3}$ the denominator implies that the derivatives grow with the friction parameter κ. ■

E.4 Optimal Taxes in extended model

Individual optimal taxes. The procedure for obtaining the optimal taxes consists of equating the welfare effects $\frac{dW}{d\tau}$ to zero and then solving for the tax. This is done via backward induction. First, we solve the last period case for τ_3, and similarly in the first period for $\tau_2(\tau_3, \cdot)$. Afterward, we replace the solution found in the first step to obtain τ_2.

In the case of the center and for the last period, there are no explicit τ_3^c terms in the welfare effect. Then, to pinpoint the tax we use the fact that banking returns show the tax explicitly

($R_{k,3}(\tau_3)$) to back out the tax after substituting it for one of the rates it equates.

$$\tau_2^a = \overbrace{\frac{\alpha-1}{\alpha} - \frac{1}{\alpha r_2^a}\left\{(I_1+\kappa K_1)\frac{dQ_1^a}{dK_1^a} + \frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a} + \kappa R_1 Q_1^a\right.}^{\text{contemporaneous component}}$$
$$\underbrace{\left. + \left(1-\frac{\Lambda_{1,2}}{\Lambda_{2,3}}\right)\alpha_4(\kappa)\frac{dQ_2^a}{dK_1^a} + (1-\Lambda_{1,2})\frac{B_2^a}{R_2}\frac{dR_2}{dK_1^a} + \kappa\left(1+\theta(\Lambda_{1,2}-\Lambda_{2,3}) - \frac{\Lambda_{1,2}}{\Lambda_{2,3}}\right)Q_2^a\frac{dK_2^a}{dK_1^a}\right\}}_{\text{forward-looking component}}$$

$$\tau_3^a = -\frac{1}{\Lambda_{2,3}\alpha r_3^a}\left\{\alpha_4(\kappa)\frac{dQ_2^a}{dK_2^a} + \Lambda_{2,3}\frac{B_2^a}{R_2}\frac{dR_2}{dK_2^a} + \kappa(1-\theta\Lambda_{2,3})Q_2^a\right\} + 1 - \frac{1}{\alpha}$$

$$\tau_2^c = \overbrace{-\frac{1}{\theta\alpha r_2^c}\left\{(1-\theta)(1-\delta)Q_2^c + \left(\frac{B_1^c}{R_1}-\theta D_1\right)\frac{dR_1}{dK_1^c} + R_1 K_1^c\frac{dQ_1^c}{dK_1^c} + (1-\theta)\left(\frac{dR_{b,1}^{eme}}{dK_1^c}F_1^{ab} + R_{b1}^{eme}\frac{dF_1^{ab}}{dK_1^c}\right)\right.}^{\text{contemporaneous component}}$$
$$\underbrace{\left. + \frac{1}{R_2}\left[\gamma_2\frac{dK_2^c}{dK_1^c} + \frac{B_2^c}{R_2}\frac{dR_2}{dK_1^c} + \gamma_3\frac{dQ_2^c}{dK_1^c} + \left(\frac{dR_{b2}^{eme}}{dK_1^2}F_2^{ab} + R_{b2}^{eme}\frac{dF_2^{ab}}{dK_1^c}\right)\right]\right\}}_{\text{forward looking component}} + \frac{\alpha\theta-1}{\alpha\theta}$$

$$\tau_3^c = \frac{Q_2^c}{r_3^c}\left\{\gamma_2\frac{dK_2^c}{dF_2^{ab}} + \Lambda_{2,3}B_2^c\frac{dR_2}{dF_2^{ab}} + \gamma_3\frac{dQ_2^c}{dF_2^{ab}} + \left(F_2^{ab}\right)\frac{dR_{b2}^{\text{eme}}}{dF_2^{ab}}\right\} + \frac{(1-\delta)Q_3}{r_3^c} + 1,$$

with $\alpha_4(\kappa) = I_2^a + \kappa(1-\theta\Lambda_{2,3})K_2^a$, $\gamma_2 = r_3^c + (1-\delta)Q_3$, $\gamma_3 = R_2(I_2^c + (1-\theta)(1-\delta)K_1^c)$, $F_t^{ab} = F_t^a + F_t^b$, and $\frac{\partial\alpha_4(\kappa)}{\partial\kappa} > 0$.

F Online Appendix

F.1 Solution of the Model

Original System:

$$Q_1 = 1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2 + \zeta\left(\frac{I_1}{\bar{I}} - 1\right)\frac{I_1}{\bar{I}} \tag{(1)-(3)}$$

$$Q_2 = 1 + \frac{\zeta}{2} \tag{(4)-(6)}$$

$$K_1 = I_1 + (1-\delta)\xi_1 K_0 \tag{(7)-(9)}$$

$$Y_1 = A_1(\xi_1 K_0)^\alpha \tag{(10)-(12)}$$

$$Y_2 = A_2(\xi_2 K_1)^\alpha \tag{(13)-(15)}$$

$$r_t = \alpha A_t \xi_t^\alpha K_{t-1}^{\alpha-1}, \quad t = \{1,2\} \tag{(16)-(21)}$$

$$R_{k,2} = \frac{r_2 + (1-\delta)\xi_2 Q_2}{Q_1} \tag{(22)-(24)}$$

$$Q_1 K_1 = F_1 + \delta_b Q_1 K_0 \tag{(25)-(26)}$$

$$\pi_{b,2} \geq k R_{k,2} Q_1 K_1 \tag{(27)-(28)}$$

$$(R_{k,2} - R_{b,1}) = \mu\left(\kappa R_{k,2} - (R_{k,2} - R_{b,1})\right) \tag{(29)-(30)}$$

$$F_1^a + F_1^b + Q_1^c K_1^c = D_1 + \delta_b Q_1^c K_0^c \tag{31}$$

$$R_{b,1}^a - R_{D,1} = 0 \tag{32}$$

$$R_{b,1}^b - R_{D,1} = 0 \tag{33}$$

$$R_{k,2}^c - R_{D,1} = 0 \tag{34}$$

$$C_1^s + \frac{B_1^s}{R_1^s} = r_1^s K_0^s + \pi_{f,1}^s + \pi_{inv,1}^s - \delta_b Q_1^s K_0^s \tag{(35)-(36)}$$

$$C_2^s = \pi_{f,2}^s + \pi_{b,2}^s + B_1^s - T^s, \quad for\ s = \{a,b\} \tag{(37)-(38)}$$

$$C_1^c + \frac{B_1^c}{R_1^c} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_b Q_1^c K_0^c \tag{39}$$

$$C_2^c = \pi_{f,2}^c + \pi_{b,2}^c + B_1^c + R_{D,1} D_1 - T^c \tag{40}$$

$$u'(C_1) = \beta R_1 u'(C_2) \tag{(41)-(43)}$$

$$u'(C_1^c) = \beta R_{D,1} u'(C_2^c) \tag{44}$$

$$n_a B_1^a + n_b B_1^b + n_c B_1^c = 0 \tag{45}$$

$$R_1^a = R_1^b \tag{46}$$

$$R_1^c = R_1^b = R_1 \tag{47}$$

We replace the following profits:

$$\pi_{f,t} = A_t(\xi_t K_{t-1})^\alpha - r_t K_{t-1}, \quad for\ t = \{1,2\}$$

$$\pi_{inv,1} = Q_1 I_1 - I_1 \left(1 + \frac{\zeta}{2}\left(\frac{I_1}{\bar{I}} - 1\right)^2\right)$$

$$\pi^s_{b,2} = R^s_{k,2} Q^s_1 K^s_1 - R^s_{b,1} F^s_1, \quad for\ s = \{i, e\}$$

$$\pi^c_{b,2} = R^a_{b,1} F^a_1 + R^b_{b,1} F^b_1 + R^c_{k,2} Q^c_1 K^c_1 - R_{D,1} D_1$$

Simplifications (reduction of number of equations) are applied in the following order:

- *S1:* Replace all related interest rates (we can drop $R^a_{b,1}, R^b_{b,1}, R^i, R^e, R^c$)

- *S2:* Remove already solved equations (function of parameters or pre-defined variables, hence we drop $Q2, Y_1$). Replace $Y_2,\ r_1,\ r_2$, $F^s_1 = Q^s_1 K^s_1 - \delta_b Q^s_1 K^s_0$. From (41) and (42) obtain $R_1 = R_{D,1}$ and replace.

- *S3:* Substitute $R^c_{k,2} = R_1$, $-T = \tau r_2 K_1$

Then, the final system of equations used for solving the model is:

$$Q^a_1 = 1 + \frac{\zeta}{2}\left(\frac{I^a_1}{\bar{I}^a} - 1\right)^2 + \zeta\left(\frac{I^a_1}{\bar{I}^a} - 1\right)\frac{I^a_1}{\bar{I}^a} \quad (1)$$

$$Q^b_1 = 1 + \frac{\zeta}{2}\left(\frac{I^b_1}{\bar{I}^b} - 1\right)^2 + \zeta\left(\frac{I^b_1}{\bar{I}^b} - 1\right)\frac{I^b_1}{\bar{I}^b} \quad (2)$$

$$Q^c_1 = 1 + \frac{\zeta}{2}\left(\frac{I^c_1}{\bar{I}^c} - 1\right)^2 + \zeta\left(\frac{I^c_1}{\bar{I}^c} - 1\right)\frac{I^c_1}{\bar{I}^c} \quad (3)$$

$$K^a_1 = I^a_1 + (1-\delta)\xi^a_1 K^a_0 \quad (4)$$

$$K^b_1 = I^b_1 + (1-\delta)\xi^b_1 K^b_0 \quad (5)$$

$$K^c_1 = I^c_1 + (1-\delta)\xi^c_1 K^c_0 \quad (6)$$

$$R^a_{k,2} = \frac{(1-\tau^a)\alpha A^a_2 \xi^{a\ \alpha}_2 K^{a\ \alpha-1}_1 + (1-\delta)\xi^a_2 Q_2}{Q^a_1} \quad (7)$$

$$R^b_{k,2} = \frac{(1-\tau^b)\alpha A^b_2 \xi^{b\ \alpha}_2 K^{b\ \alpha-1}_1 + (1-\delta)\xi^b_2 Q_2}{Q^b_1} \quad (8)$$

$$R_1 = \frac{(1-\tau^c)\alpha A^c_2 \xi^{c\ \alpha}_2 K^{c\ \alpha-1}_1 + (1-\delta)\xi^c_2 Q_2}{Q^c_1} \quad (9)$$

$$R^a_{k,2} Q^a_1 K^a_1 - R_1 Q^a_1 K^a_1 + R_1 \delta_B Q^a_1 K^a_0 = \kappa^a R^a_{k,2} Q^a_1 K^a_1 \quad (10)$$

$$R^b_{k,2} Q^b_1 K^b_1 - R_1 Q^b_1 K^b_1 + R_1 \delta_B Q^b_1 K^b_0 = \kappa^b R^b_{k,2} Q^b_1 K^b_1 \quad (11)$$

$$R^a_{k,2} - R_1 = \mu^a\left(\kappa^a R^a_{k,2} - (R^a_{k,2} - R_1)\right) \quad (12)$$

$$R^b_{k,2} - R_1 = \mu^b\left(\kappa^b R^b_{k,2} - (R^b_{k,2} - R_1)\right) \quad (13)$$

$$Q^a_1 K^a_1 - \delta_B Q^a_1 K^a_0 + Q^b_1 K^b_1 - \delta_B Q^b_1 K^b_0 + Q^c_1 K^c_1 = D_1 + \delta_B Q^c_1 K^c_0 \quad (14)$$

$$C^a_1 + \frac{B^a_1}{R_1} = A^a_1(\xi^a_1 K^a_0)^\alpha + Q^a_1 I^a_1 - I^a_1\left(1 + \frac{\zeta}{2}\left(\frac{I^a_1}{\bar{I}^a} - 1\right)^2\right) - \delta_B Q^a_1 K^a_0 \quad (15)$$

$$C^b_1 + \frac{B^b_1}{R_1} = A^b_1(\xi^b_1 K^b_0)^\alpha + Q^b_1 I^b_1 - I^b_1\left(1 + \frac{\zeta}{2}\left(\frac{I^b_1}{\bar{I}^b} - 1\right)^2\right) - \delta_B Q^b_1 K^b_0 \quad (16)$$

$$C_2^a = (1-\alpha)A_2^a(\xi_2^a K_1^a)^\alpha + R_{k,2}^a Q_1^a K_1^a - R_1 Q_1^a K_1^a + R_1 \delta_B Q_1^a K_0^a + B_1^a + \tau^a r_2^a K_1^a \tag{17}$$

$$C_2^b = (1-\alpha)A_2^b(\xi_2^b K_1^b)^\alpha + R_{k,2}^b Q_1^b K_1^b - R_1 Q_1^b K_1^b + R_1 \delta_B Q_1^b K_0^b + B_1^b + \tau^b r_2^b K_1^b \tag{18}$$

$$C_1^c + \frac{B_1^c}{R_1} + D_1 = A_1^c(\xi_1^c K_0^c)^\alpha + Q_1^c I_1^c - I_1^c\left(1 + \frac{\zeta}{2}\left(\frac{I_1^c}{\bar{I}^c} - 1\right)^2\right) - \delta_b Q_1^c K_0^c \tag{19}$$

$$\begin{aligned} C_2^c = (1-\alpha)A_2^c(\xi_2^c K_1^c)^\alpha + R_1 Q_1^a K_1^a - R_1 \delta_B Q_1^a K_0^a + \\ + R_1 Q_1^b K_1^b - R_1 \delta_B Q_1^b K_0^b + R_1 Q_1^c K_1^c + B_1^c + \tau^c r_2^c K_1^c \end{aligned} \tag{20}$$

$$C_1^{a\ -\sigma} = \beta R_1 C_2^{a\ -\sigma} \tag{21}$$

$$C_1^{b\ -\sigma} = \beta R_1 C_2^{b\ -\sigma} \tag{22}$$

$$C_1^{c\ -\sigma} = \beta R_1 C_2^{c\ -\sigma} \tag{23}$$

$$n_a B_1^a + n_b B_1^b + n_c B_1^c = 0 \tag{24}$$

Variables: $Q_1^a, Q_1^b, Q_1^c, I_1^a, I_1^b, I_1^c, K_1^a, K_1^b, K_1^c, D_1, R_{k,2}^a, R_{k,2}^b, C_1^a, C_1^b, C_1^c, C_2^a, C_2^b, C_2^c, B_1^a, B_1^b, B_1^c, R_1, \mu^a, \mu^b$

This final system of 24 equations corresponds to the system in table A1, which in addition also has three equations for the price of investment in $t = 2$ (that is constant since there is no investment in the terminal period), and two equations for the interbank lending to emerging economies F_1^e with $e = \{a, b\}$.[53]

F.2 Steady State of the Baseline Model

In this section, we show deterministic steady-state equations and the solution of the model.

We depart from the system of equations in table A1. Some variables are pinned down directly from a static version of the equations:

$$Q^i = 1$$
$$I^i = \delta K^j$$
$$B^i = 0$$
$$R = \frac{1}{\beta}$$

[53]For the final period, we observe that there are no investment activities ($I_2 = 0$ or capital accumulation). Consequently, we assume that the pricing of capital follows the same condition determined by the optimality in previous periods. With no investment, this results in a price of $Q_2 = 1 + \zeta/2$. Alternatively, we could assume that investment returns to its steady state, or consider a different cost function where adjustment costs are based not on the distance between the investment level and its steady state, but relative to its previous value (another plausible option as documented by Gertler and Karadi, 2011), in that case, the relative price of capital would be $Q_2 = 1$, as in standard models without adjustment costs. Both functional approaches were tested, and the results remained similar. Finally, it should be noted that undepreciated capital does not remain unused in the final period, even if it is no longer used in production. These resources are also valued in terms of the final good and thus are returned as profits to households for consumption in the final period, either by the final goods firm, or the capital producer, regardless of whether one sold the undepreciated stock to another. Lastly, imposing $I_2 = 0$ for the final period is not only the natural choice, since investments flows' decisions determine the capital shock and not the other way around, but also because assuming zero capital for production beyond the terminal period would mistakenly lead to negative investment for the final period, as it would require "decumulating" or destroying the undepreciated capital after the final production cycle.

$$K^c = \left(\frac{R-(1-\delta)}{\alpha(1-\tau^c)}\right)^{\frac{1}{\alpha-1}}$$

The rest of the system, expressed in static terms leads to the following system of equations:

$$\begin{aligned}
R_k^a &= (1-\tau^a)\alpha K^{a\ \alpha-1} + 1 - \delta \\
R_k^b &= (1-\tau^b)\alpha K^{b\ \alpha-1} + 1 - \delta \\
\beta(R_k^a - (1-\delta_b)R) &= \kappa^a \\
\beta(R_k^b - (1-\delta_b)R) &= \kappa^b \\
\beta(R_k^a - R) &= \mu^a(\kappa^a - \beta(R_k^a - R)) \\
\beta(R_k^b - R) &= \mu^b(\kappa^b - \beta(R_k^b - R)) \\
(1-\delta_b)K^a + (1-\delta_b)K^b + (1-\delta_b)K^c &= D \\
C^a\left(1+\frac{1}{R}\right) &= \left(1+\frac{1-\alpha}{R}\right)K^{a\ \alpha} + \frac{R_k^a - R}{R}K^{a\ \alpha} + \frac{\tau^a\alpha}{R}K^{a\ \alpha} \\
C^b\left(1+\frac{1}{R}\right) &= \left(1+\frac{1-\alpha}{R}\right)K^{b\ \alpha} + \frac{R_k^b - R}{R}K^{b\ \alpha} + \frac{\tau^b\alpha}{R}K^{b\ \alpha} \\
C^c\left(1+\frac{1}{R}\right) + D &= \left(1+\frac{1-\alpha}{R}\right)K^{c\ \alpha} + (1-\delta_b)K^a + (1-\delta_b)K^b + (1-\delta_b)K^c + \frac{\tau^c\alpha}{R}K^{c\ \alpha},
\end{aligned}$$

where the last three equations are obtained from the life-time budget constraint of each representative household.

We solve this system of equations for: $C^a,\ C^b,\ C^c,\ K^a,\ K^b,\ D,\ R_k^a,\ R_k^b,\ \mu^a,\ \mu^b$.

F.3 Additional Ramsey Policy Equilibria results

In this section we report the simulation results for alternative versions of the baseline model.

F.3.1 Financial Frictions in the Center

This version of the model includes a financial friction in the center banking sector. In that case, the center bank solves:

$$\begin{aligned}
\max_{F_1,L_1,D_1} J_1 = \mathbb{E}_1\Lambda_{1,2}\pi_{b,2}^c &= \mathbb{E}_1\left[\Lambda_{1,2}(R_{b,1}^a F_1^a + R_{b,1}^b F_1^b + R_{k,2}^c L_1^c - R_{D,1}D_1)\right], \\
s.t. \quad F_1^a + F_1^b + L_1^c &= D_1 + \delta_b Q_1^c K_0^c, \\
J_1 &\geq k^c \mathbb{E}_1\Lambda_{1,2}^c\left[R_{a,1}^a F_1^a + R_{b,1}^b F_1^b + R_{k,2}^c L_1^c\right],
\end{aligned}$$

with associated F.O.C. analogous to the emerging banks' problem but yielding expressions for positive credit spreads between the center's revenue rates ($R_{b,1}^a, R_{b,1}^b, R_{k2}^c$) and the deposit rates.

As a result, we no longer have that most interest rates in the model are equalized to R_1 (the world interest rate of bonds), but that intermediation rates of the center ($R_{k,2}^c,\ R_{b,1}^a,\ R_{b,1}^b$) will also be subject to a premium. In this version of the model we still obtain no gains from coordination (results are shown in appendix F.3). However, now we get lower gains with respect to the no policy case and the peripheries will apply more subsidization.

The intuition for this new finding is that the friction in the center works in the opposite direction on the emerging credit spreads. That is, a premium in the center lending rates will decrease the credit spreads in the EMEs. We could say that the frictions between lenders and borrowers are partially offsetting each other, the aggregate effects of the distortions are weaker and the peripheries would now opt for subsidizing the intermediation rather than undoing the friction.

Table F7: Welfare comparison for the model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$)

	Bechmark: Nash			Bechmark: First Best			
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.00	1.00	1.00	1.03	1.04	1.03	1.03
A	1.00	1.00	1.00	0.97	0.98	0.98	0.97
B	1.00	1.00	1.00	0.97	0.98	0.98	0.98
World	1.00	1.00	1.00	1.00	1.00	1.00	1.00
EME Block	1.00	1.00	1.00	0.97	0.98	0.98	0.98

Units: Proportional steady state consumption increase in the benchmark model

Table F8: Ramsey-Optimal taxes for the model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$)

	Policy Scheme			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	-0.11	-0.68	-0.19	-0.47
τ^b	-0.11	-0.68	-0.19	-0.22
τ^c	0.68	0.34	0.65	0.55

Units: proportional tax on banking rate of return

F.3.2 Other alternative exercises results

Table F9: Welfare comparison for the model with higher financial friction in both emerging economies ($\kappa^a = \kappa^b = \frac{1}{2}$)

	Bechmark: Nash			Bechmark: First Best			
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.00	1.00	1.00	1.01	1.01	1.01	1.01
A	1.00	1.00	1.00	0.99	0.99	0.99	0.99
B	1.00	1.00	1.00	0.99	0.99	0.99	0.99
World	1.00	1.00	1.00	1.00	1.00	1.00	1.00
EME Block	1.00	1.00	1.00	0.99	0.99	0.99	0.99

Units: Proportional steady state consumption increase in the benchmark model

Table F10: Ramsey-Optimal taxes for the model with higher financial friction in both emerging economies ($\kappa^a = \kappa^b = \frac{1}{2}$)

	Policy Scheme			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	0.20	-0.30	-0.04	0.15
τ^b	0.20	-0.30	-0.04	0.16
τ^c	1.29	1.09	1.23	1.25

Units: proportional tax on banking rate of return

Table F11: Welfare comparison for the model with higher financial friction in one emerging economy ($\kappa^a = \frac{1}{2}$, $\kappa^b = 0.399$)

	Bechmark: Nash				Bechmark: First Best				
Country	Coop. (All)	Coop. (EMEs)	Coop. (C + EME-A)	Coop. (C + EME-B)	Nash	Coop. (All)	Coop. (EMEs)	Coop. (C + EME-A)	Coop. (C + EME-B)
C (Center)	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.01
A	1.01	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.99
B	1.01	1.01	1.01	1.01	0.98	0.99	0.99	0.99	0.99
World	1.01	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00
EME Block	1.01	1.01	1.01	1.01	0.98	0.99	0.99	0.99	0.99

Units: Proportional steady state consumption increase in the benchmark model

Table F12: Ramsey-Optimal taxes for the model with higher financial friction in one emerging economy ($\kappa^a = \frac{1}{2}$, $\kappa^b = 0.399$)

	Policy Scheme				
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Cooperation (Center and EME-B)
τ^a	-0.05	-0.28	-0.08	0.08	0.11
τ^b	0.09	-0.12	0.18	0.40	0.37
τ^c	1.19	1.03	1.17	1.20	1.20

Units: proportional tax on banking rate of return

Table F13: Welfare comparison for the model with larger financial center. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{6}, \frac{1}{6}, \frac{2}{3})$.

	Bechmark: Nash			Bechmark: First Best			
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.00	1.00	1.00	0.98	0.98	0.98	0.98
A	1.00	0.99	1.00	0.99	1.00	0.99	1.00
B	1.00	0.99	1.01	0.99	1.00	0.99	1.00
World	1.00	1.00	1.00	0.98	0.99	0.98	0.99
EME Block	1.00	0.99	1.01	0.99	1.00	0.99	1.00

Units: Proportional steady state consumption increase in the benchmark model

Table F14: Ramsey-Optimal taxes for the model larger financial center. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{6}, \frac{1}{6}, \frac{2}{3})$.

	Policy Scheme			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	-0.71	-0.90	-0.44	-1.14
τ^b	-0.71	-0.91	-0.44	-0.92
τ^c	0.09	-0.05	0.30	-0.11

Units: proportional tax on banking rate of return

Table F15: Welfare comparison for the model with a smaller periphery. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{3}, \frac{1}{6}, \frac{1}{2})$.

Country	Bechmark: Nash				Bechmark: First Best				
	Coop. (All)	Coop. (EMEs)	Coop. (C + EME-A)	Coop. (C + EME-B)	Nash	Coop. (All)	Coop. (EMEs)	Coop. (C + EME-A)	Coop. (C + EME-B)
C (Center)	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.01
A	1.00	1.01	1.00	1.00	0.99	0.99	1.00	0.99	0.99
B	1.01	1.01	1.01	1.01	0.97	0.99	0.99	0.99	0.99
World	1.00	1.01	1.00	1.00	0.99	1.00	1.00	1.00	1.00
EME Block	1.01	1.01	1.00	1.00	0.98	0.99	0.99	0.99	0.99

Units: Proportional steady state consumption increase in the benchmark model

Table F16: Ramsey-Optimal taxes for the model with a smaller periphery. $(n_a, n_b, n_c) = (\frac{1}{3}, \frac{1}{6}, \frac{1}{2})$.

Country	Policy Scheme				
	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)	Cooperation (Center and EME-B)
τ^a	0.30	0.25	0.13	0.32	0.35
τ^b	-0.16	0.11	-0.67	0.33	0.27
τ^c	1.12	1.06	0.97	1.14	1.15

Units: proportional tax on banking rate of return

Table F17: Welfare comparison for model with unfeasibly aggressive subsidization

Country	Bechmark: Nash		Bechmark: First Best	
	Cooperation (EMEs)	Cooperation (Center and EME-A)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.03	1.04	1.03	1.05
A	1.00	1.10	0.99	1.08
B	1.00	0.99	0.99	0.98
World	1.01	1.04	1.01	1.04
EME Block	1.00	1.04	0.99	1.03

Units: Proportional steady state consumption increase in the benchmark model

Table F18: Ramsey-Optimal taxes for the model with unfeasibly aggressive subsidization

Country	Policy Scheme	
	Cooperation (EMEs)	Cooperation (Center and EME-A)
τ^a	-0.75	-1.66
τ^b	-8.21	-2.37
τ^c	-8.21	-15.09

Units: proportional tax on banking rate of return

F.4 On Achieving Gains from Coordination

To understand potential welfare equivalence between regimes with different instrument combinations (that internalize international spillovers) we can can refer to Korinek (2016), who develops a first welfare theorem for open economies. In a nutshell, the premise from which a call for policy coordination departs is that the de-centralized equilibrium is inefficient and could be subject to Pareto improvements if coordinated. However, there are a number of sufficient conditions that allow the non-cooperative outcome to become efficient:

1. *Competition:* The policy makers act as price takers by not exerting market power over international asset prices.
2. *Sufficient Instruments:* The policy is flexible and effective enough to achieve the targeted level in the international variables of interest.
3. *Frictionless International Markets:* The international market for assets is free of imperfections or frictions that would impair risk sharing.

Notice that no other conditions are necessary, that is, there can be other domestic frictions in place and the non-cooperative outcome will still be efficient and coordination would be redundant. The lesson from this theorem is that, as long as the flow of resources in the international markets is efficient and we have a flexible and effective toolkit to set allocations at desired levels, any policy can achieve the first best and the international externalities represent only efficient spillovers.

On the other hand, the policy spillovers may not be strong enough in our simplistic setup to deliver important welfare differences between regimes. For example, and to elaborate on this point, the policies in our setup have short-lived effects as the banks intermediate only once. The alternative exercises relative to the baseline (costly policies, dynamic policymaking, altered frictions) that we carry out are motivated by this theorem result and go precisely in the direction of departing from international spillovers efficiency conditions.