Strategic Macroprudential Policymaking: When Does Cooperation Work? *

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Abstract

I study the usefulness of coordinated macroprudential policy frameworks for emerging economies. Specifically, I look for cooperative regimes' long-run welfare gains and whether these setups can shield the emerging economies from external shocks. For this, I set an open economy model of banks with financial frictions in an environment with multiple emerging economies and a center. I compare the policy incentives of cooperative versus national-oriented planners; then, I perform a welfare comparison of several policy regimes that vary by the degree of cooperation and explore their short-run performance. I find that not every type of cooperation is beneficial relative to nationally-oriented policies. Instead, only schemes where the financial center acts cooperatively generate welfare gains. Two mechanisms generate the gains: a cancellation effect of national incentives to manipulate the global interest rate and a new incentive to substitute local with foreign intermediation at the center. Both channels will improve the financial stability, and the second will increase the allocation efficiency of capital flows. Finally, the short-run dynamics show these mechanisms allow for a better performance of the peripheries after external shocks while generating banking leverage dynamics that favor a faster global recovery.

JEL Codes: F38, F42, E44, G18

Key words: Macroprudential Policies, International Policy Coordination, Banking.

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1 Introduction

The emerging economies' fragility to the global financial cycle has become a core concern in international finance in the last decade.[1] As these economies started to attract more capital flows, they have become a new source of (global) financial risk, presenting new challenges to policymakers. On the one hand, the local regulators would like to facilitate the participation of emerging economies in international financial markets while still protecting their economies from adverse external shocks. At the same time, financial centers and multilateral institutions prioritize the mitigation of new sources of risk.

As a result, we have witnessed a general increase in the usage of macroprudential policy regulations in the form of stricter balance sheet requirements at the banking level, for example, leverage caps, loan-to-value ratios, or taxes, among others. Crucially, as the balance sheets' links of these banks extend beyond national borders, these regulations affect both domestic and international agents, raising immediate questions over the potential gains from international cooperation by policymakers

With this in mind, I study whether international macroprudential policy cooperation is beneficial for emerging economies and could be used to improve their economic performance and financial resilience. In particular, I address two specific questions: (i) is macroprudential cooperation beneficial for emerging economies in general?, and (ii) are cooperative policies useful in protecting emerging economies from external shocks?.

To answer these questions, I extend an open economy model with banking frictions to include two smaller economies that depend financially on a Center, but that still have general equilibrium effects. Based on this setup, I will use a simplified model to outline the welfare effects and policy mechanisms under cooperation and relative to nationally-oriented policymakers. Afterward, I set a quantitative model and solve for the optimal macroprudential policies of several regimes that vary by the degree of international cooperation. With this framework, I can perform a comprehensive welfare comparison and study the regulatory arrangements' short-run and cyclical performance.

The macroeconomic framework used for modeling the banking sector follows Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), extended to an open economy environment. Simultaneously, it is similar to Banerjee, Devereux, and Lombardo (2016) with the difference that I consider multiple peripheral economies and focus on the case with flexible prices. These assumptions allow me to focus on the potential interactions between

[1] See Rey (2013, 2016).

emerging economies at the regional level while restricting the analysis to the potential advantages of coordination between macroprudential policymakers only. To the best of my knowledge, this is the first paper that studies the policy coordination of emerging economies that have general equilibrium effects but are still fragile to a financial center.[2]

I find there are substantial direct and cross-border effects of the macroprudential policies. These effects are more potent when using forward-looking instruments that affect the future economic variables through retained banking profits and net worth dynamics of the financial intermediaries. Additionally, the effects grow with the degree of financial friction, suggesting that policy can be more effective when implemented in more distorted economies.

When looking at the policy mechanisms under cooperation and the drivers of the optimal associated taxes, I obtain two new policy action motives. The first is an off-setting effect that mitigates the national incentives to manipulate the interest rates to improve the net foreign assets position. This mechanism will be at work in every economy. The second, applicable to the Center, consists of a new incentive for increasing the financial intermediation and capital inflows in the peripheries, at the expense of local capital accumulation. The first motive arises from the fact that a cooperative planner pools the national incentives of savers and borrowers of foreign assets affected by the same interest rate. In contrast, the second is a byproduct of the centralized planner's new policy aim, namely boosting global welfare rather than the national economic performance.

For assessing the policy regimes' long-run performance, I carry out a conditional welfare comparison and find important gains from cooperation. However, these only exist when the Center acts cooperatively, with global gains maximized in the world-wide cooperation regime. In that spirit, cooperation is not always beneficial. In fact, a cooperative arrangement that only includes peripheries can be detrimental (socially and individually). Simultaneously, implementing the best regime (global cooperation) can be challenging, as the national distribution of gains is more favorable for the coalition participants under the second-best arrangement (cooperation between the Center and only one periphery). In that case, these countries will be better off than in the socially optimal equilibrium at the expense of the remaining periphery, which ends up worse than at any other regime.

The main sources of welfare gains are the two new cooperative policy motives mentioned

[2]For a framework with small open economies interactions with an exogenous center see Jin and Shen (2020).

above. The first cancels out the national incentives to move taxes to generate yield-seeking fluctuations in the interest rates, which translates into smoother policy and capital accumulation dynamics. The second will facilitate a more efficient allocation of the international capital flows towards the most productive destinations. Furthermore, both channels will work more strongly when the peripheric block's welfare weights become more comparable to that of the Center. I use the relative economic population size as the weight, which implies that the social gains are maximized for regimes where more peripheries engage in cooperation with the Center.

These mechanisms also help understand why the emerging economies' regional cooperation regime fails to yield gains. The first channel is not present as all the involved national incentives (in the coalition) to manipulate the interest rate go in the same direction. For the cancellation to take effect, we need both global creditors (Center) and debtors (EMEs) to cooperate. In contrast, there can be a higher incentive to manipulate the interest rates in this semi-cooperative regime as all the debtors' incentives are pooled in a single policy effort. In turn, that explains why this regional cooperation can even be counterproductive. On the other hand, the second policy incentive is absent as it appears only for a cooperative global intermediator (Center).

Additionally, the cyclical component of these policy frameworks will suggest that, unlike in any other regime or economies, an active cooperative effort by the Center leads to a countercyclical implementation of its policy tools. Thus, this model recognizes the general procyclicality of these policies (Fernández, Rebucci, and Uribe (2015) and Uribe and Schmith-Grohe (2017)), but also that among optimal regimes, the best performing policies are adjusted to adopt countercyclical features as the intuition on macroprudential policies dictates (Bianchi (2011) and Jeanne and Korinek (2019)).

Similarly, the short-run performance of the policy regimes incorporates these features and implies that the world cooperation regime is the most effective in protecting the emerging economies from external shocks. This result stems from higher and smoother capital accumulation in the peripheries that grows at the expense of local capital dynamics at the Center. Noticeably, the reliance on capital flows to peripheries results from a cooperative planner that internalizes the center tax's effect in the peripheral output while prioritizing the global economic recovery over the national welfare.

Finally, I find another benefit of cooperation (with the Center) that only visible in the short run exercise: the deleveraging processes that slow down the economic recovery after financial shocks are noticeably mitigated by the centralized policies, thereby making a stronger case for coordinating regulatory efforts.

Related Literature. This paper is related to the literature that studies the business cycles amplification role of financial frictions that started with Bernanke, Gertler, and Gilchrist (1999) and Kiyotaki and Moore (1997). In addition, I model the banking sector explicitely along the lines of Adrian and Shin (2010), Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). In fact, my model can be seen as an open economy version of the last two. Unlike other papers that consider the banking sector in an open economy environment, such as Banerjee, Devereux, and Lombardo (2016) and Aoki, Benigno, and Kiyotaki (2018), I will abstract from the role of monetary policy. With this simplifcation I can focus solely on the interactions of financial regulators and am able to easily extend the economic environment to one of multiperipheral open economies.

My paper also borrows elements from the literature on pecuniary externalities of borrowing decisions (Mendoza (2010), Bianchi (2011), Jeanne and Korinek (2010, 2019)), namely, I compare the deleveraging processes under different policy regimes, and at the same time, I consider the financial instability external effects of the actions of nationally-oriented policy makers.

This paper also overlaps with the literature on the effects of the global financial cycle on emerging economies, on one hand the participation in global markets creates independency policy challenges for smaller economies as in Rey (2013, 2016), and on the other hand, it considers the role of the financial frictions in vanishing the promised benefits from open financial markets for smaller economies as in Gourinchas and Jeanne (2006, 2013). This frictions and the spillovers stemming for advanced economies will create a role for macroprudential policies as explored in Céspedes, Chang, and Velasco (2017) and Cuadra and Nuguer (2018). As these studies, I consider a policy that targets banks, but in contrast I will focus on the potential additional benefits from coordinating these policy instruments internationally.

Finally, this papers relates to the literature on economic policy cooperation in presence of financial frictions. In this group a number of papers revisits the monetary policy case (Sutherland (2004), Fujiwara and Teranishi (2017)) or the interaction between different types of policy makers (De Paoli and Paustian (2017) and Bodenstein, Guerrieri, and LaBriola (2019)[3]), whereas the second group, where my work falls closer, explores the

[3]This paper provides a toolbox for solving two-players policy games and apply their method to an extension of Gertler and Karadi (2011).

potential cooperation between macroprudential regulators only.

In this second group, some papers study the coordination of capital controls, for example, Jin and Shen (2020) study an environment with a large number of symmetric small open economies that benefit from coordination after pooling their atomistic general equilibrium effects, or relatedly, but with a potentially opposite source of welfare gains, Davis and Devereux (2019) study the policy coordination of taxes on capital controls in large open economies and obtain that these will gain from cooperating precisely because their individual incentives to manipulate the terms of trade cancel out. Other papers also explore the coordination of macroprudential instruments that target banks, such as Bengui (2014) for liquidity requirements, or Kara (2016) for capital adequacy requirements, and similarly to this paper, Agénor, Kharroubi, Gambacorta, Lombardo, and da Silva (2017) consider a tax on the banking sector in a center-periphery context.

This paper differs from the these studies in which it simultaneously considers the presence of banking frictions, a large open economy environment with multiple peripheries, and a center whose policymakers take decisions actively. The papers above abstract from one or more of these features, which in turn, allow me to consider a larger set of policy regimes that vary by the extent of policy cooperation.

Lastly, I also consider a multi-country framework as in Granados (2020) where I analyze the one-shot policy problem in a static banking environment. Here, however, I extend the framework to allow for a dynamic banking sector and forward-looking macroprudential policies with persistent effects, thus, developing a setup where I can study the cyclical properties of these coordinated policy regimes.

The rest of this paper is structured as follows. Section 2 describes the recent empirical trend of the capital flows and the associated policy responses. In section 3 I set a simplified model and use it to describe the policy mechanisms at play. Sections 4 and 5 describe the main model and the considered policy regimes. Then, in Section 6 I show the results and address the research questions. Finally, Section 7 concludes.

2 Capital Flows Dynamics After the Crisis and Policy Response

The period before the global financial crisis was characterized by a strong flow of capitals towards advanced economies (see figure 1), such phenomenon, denoted as the global savings glut[4], was partly explained by a financial deregulation process in the largest advanced economies after the termination of the main banking separation Acts put in place as a response to the financial crises of the early 1900s,[5] and contributed to the downward trend of the interest rates of traditional assets in the main economies (Bernanke, Demarco, Bertaut, and Kamin, 2011).

Rather than a change in the direction of the capital flows, the observed response of the markets in the 2000's was a reliance on high leveraged intermediation, together with financial innovation efforts (e.g., securitization of assets) to continue attracting investments with competitive returns but at the expense of a substantial build-up of risk.

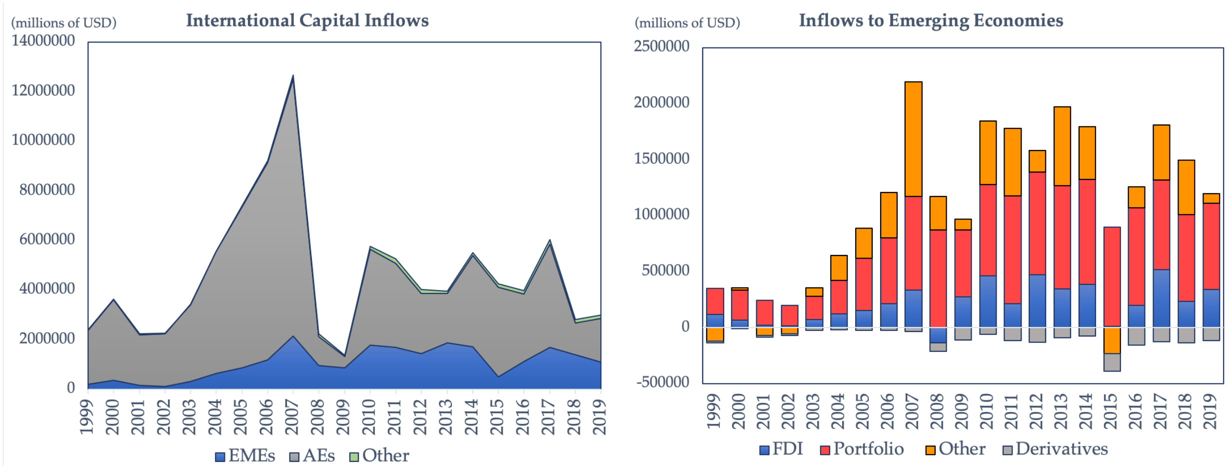
Once the bubble burst and the crisis ensued there was a strong institutional effort towards strengthening the financial regulation, and a higher recognition of the threat posed by the risk of financial contagion prompted an urgent revision of the Basel accords. The G-20 met for the first time in history to deal with an economic matter and as result founded the Financial Stability Board, an institution that has as one of its objectives to promote the coordination of financial regulations.

After that, the financial markets have featured stricter regulations and a decrease in the level of interbank connectedness in advanced economies. Simultaneously, and as a byproduct, the international investment flows have shifted their direction towards the emerging economies. Furthermore, the main type of flows entering these economies were the portfolio and banking flows (Other in the figure 1). These items, that take place within the financial intermediation sector, represent the most volatile types of capital flows. Thus, the banking sector in the emerging economies happens to be at the core of the post-global financial crises potential sources of risk.

[4] See Justiniano et al. (2013) and Bernanke (2005) for a discussion on this topic.

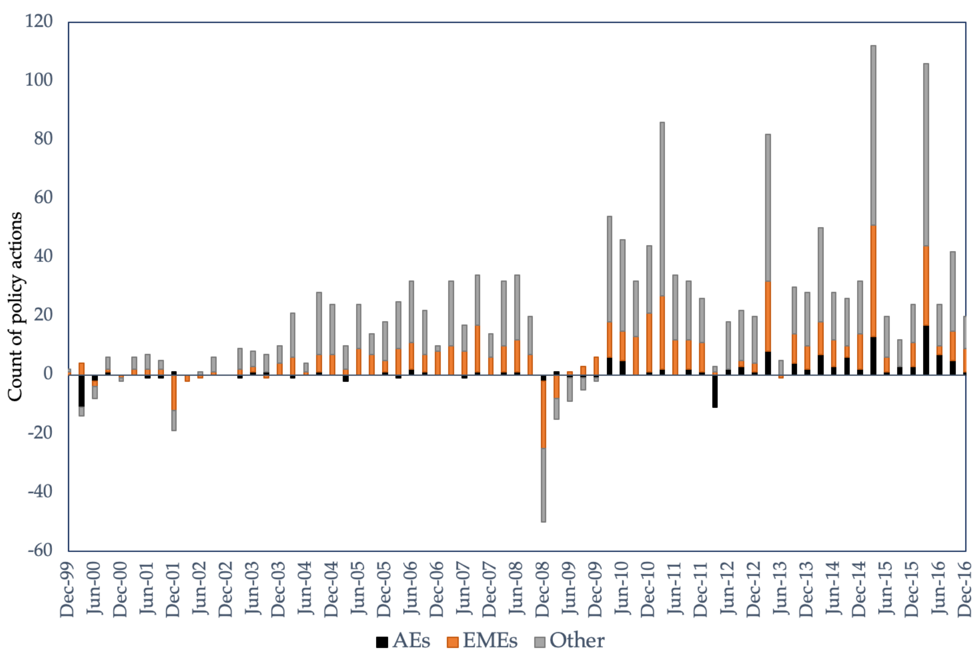
[5] In the USA the Glass-Steagal Act of 1933

Figure 1: Global Capital Inflows: 1999-2019



Source: IMF-IFS and BOP Statistics. Note: the countries in each group follow the IMF definitions. That is, 23 advanced economies, 58 emerging economies and 199 developing countries (other in the graph).

Figure 2: Macroprudential policies stance by type of economy



Source: IMF - Integrated Macroprudential Policy Database (iMaPP) by Alam et al. (2019). Note: the countries in each group follow the IMF definitions. The figure includes information for 23 advanced economies, 52 emerging economies and 135 developing countries (other in the graph).

The observed associated policy response consisted in stricter macroprudential regulations with respect to pre-crisis times, both globally, and specially in the emerging and developing economies. This can be seen in the figure 2 that shows the policy stance by type of economy. There, a tightening of a macroprudential instrument is counted as (+1) and a loosening as (-1), and then the indexes are aggregated for all economies. For example, it can be seen that globally, and in the last quarter of 2015 there were more than 100 tightenings in the instruments (e.g. an increase in the Loan-to-Value requirements or in the banking taxes).

In addition to the observed increase in the usage of these policies in emerging and developing economies, it can also be suggested, from the overall and compositional policy stance dynamics in figure 2, that there may be potential comovement patterns between the instruments, both at the cross-country level and with the business cycles.

In that regard, several papers document the presence of significant external policy effects, for example, Forbes, Reinhardt, and Wieladek (2017) study the UK case and show that these policies can have large spillovers in the international capital flows. Buch and Goldberg (2017) document how the macroprudential policies generate significant cross-border credit effects that spills over through the interbank lending, and Aiyar, Calomiris, and Wieladek (2014) show how stricter capital requirements on the UK made the foreign banks to increase their activities in the UK, in an attempt of substituting the curtailed intermediation that resulted from the macroprudential tightenings. Similarly, but finding international spillovers in a Center-periphery environment, Tripathy (2020) studies the spillover of banking regulations from Spain to Mexico through Mexican subsidiaries of Spanish banks and explains how the borderless nature of the banking business, operated by large global banks can imply significant cross-country spillovers.

Judging from the findings of these studies, and as explained by Forbes (2020), it can be thougth that the presence of these leakages could mitigate the effectiveness of the macroprudential policies or generate new vulnerabilities and risks. In that vein, it is interesting to determine from a theoretical perspective if these spillovers may open some scope for cooperative policy schemes, or if instead, they just represent efficient adjustment effects that still render the cooperation redundant.

To contribute to the understanding of these policy effects, in the next section I show in a modelling framework the direct and cross-border spillovers of a macroprudential instrument, and explore whether the cross-border policy effects have the same mechanisms at work under cooperation.

3 Simple Three-Period Model

Before analyzing the main dynamic model of this paper, I lay out a simplified setup in finite horizon for building intuition about the main mechanisms at work. In that spirit, I consider the simplest possible model that still features a dynamic decision making by banks and macroprudential regulators.[6] This model shares the essential features of the main one, and can be thought of as a small scale version of it, with the advantage of allowing to analytically disentangle the welfare effects of different types of policies, for example, tools that are forward looking, static, nationally-oriented or cooperative. Clearly, there is a trade-off between the improved tractability, and the potential uses of a more quantitatively involved model, e.g., the smaller scale model would not allow for a complete study of the response of the economy to shocks or a comprehensive welfare accounting comparison between models. I leave such additional applications for subsequent sections of the paper that are based on the larger-scale model.

Similarly, when a sector is completely analogous to that of the main model explained in section 4 I review it more briefly here, and instead focus more in the sectors with meaningful differences, the banks and the households.

3.1 Setup

General economic environment. Time is discrete and there are three periods, $t = \{1, 2, 3\}$. The world economy is populated by three countries, two emerging economies or periferies, labeled as a and b, and a financial center c. The relative population size of each economy is given by n_i with $i = \{a, b, c\}$ and these sizes are such that the sum of the periferies is never larger than the population size at the center, that is, $n_c \geq \frac{1}{2}$, with $n_c = 1 - n_a - n_b$. Each economy is populated by five types of agents: households, final goods firms, investors or capital good firms, the government and a representative bank.

The households will own the firms (final good, capital and banks) and there is a production technology that transforms the predetermined capital into a final consumption good with a Cobb-Douglas agregator: $Y_t^i = A_t^i K_{t-1}^i$. This good will be identical across countries.

The economies are endowed with a predetermined level of capital in the first period (K_0),

[6] For reference an even simpler finite time horizon version of this model, with static banks and one-shot policies can be found in Granados (2020).

after that, a bank will intermediate the physical capital acquisition for production. For this, at the end of each period, the firm will take its input and indebtedness decisions, the bank will provide the funds and will be repaid the next period after production takes place.

This implies that there are two periods of financial intermediation, the first at the end of the first period, and one more a period later. Notice something important, the banking decisions will be dynamic, or forward looking, in $t = 1$, while in $t = 2$ the banking problem will be static as there are not further intermediation activities. I will focus on the differences in the decision making of the bankers and policy-makers between these two periods.

The households will have standard preferences over consumption and their welfare is given by: $W^i = u(C_1^i) + \beta u(C_2^i) + \beta^2 u(C_3^i)$, with $u(C) = C^{1-\sigma}/(1-\sigma)$.

Additionally, given the homogeneous good assumption, and the identical preferences at the world level, we have that the law of one price and purchasing power parity will hold. Consequently, we can abstract from the real exchange rate. Finally, for this simple model I work with a perfect foresight assumption.

3.2 Banks

Each economy will have a representative bank that aims to maximize the present value of its franchise. There are two important features that distinguish emerging economies (EME) banks from that of the Center: First, the EME banks will be subject to a financial friction in the form of agency costs, and second, the Center bank will act as creditor of the EME banks in the interbank market. The latter feature will appear due to the limited capacity of local intermediation in the peripheries.

EME-Banks. The banks in the emerging economies will intermediate funds in order to provide resources to local firms for capital acquisition and production. These banks will be financially constrained and depict a lower level of financial development, in the spirit of Chang and Velasco (2001). As a consequence, two features arise that characterize these banks. First, these firms will have a lower capacity of financial intermediation at the local level, and to compensate, they rely on borrowing money from the Center in an international interbank market. Second, their lending relationships are subject to a costly-enforcement agency friction where the banks could divert a portion κ of the assets they intermediate.

The friction creates a distortion in the credit spread of these banks, in the form of a default risk premium. This features are modelled following the structure of Gertler and Karadi (2011) and Gertler and Kiyotaki (2010).

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:

$$
\begin{aligned}
J_1^e &= \max_{F_1^e, L_1^e} \mathbb{E}_1 \left\{ (1-\theta)\Lambda_{1,2}^e (R_{k,2}^e L_1^e - R_{b,1}^e F_1^e) + \Lambda_{1,3}^e \theta (R_{k,3}^e L_2^e - R_{b,2}^e F_2^e) \right\} \\
s.t \quad & L_1^e = F_1^e + \delta_B Q_1^e K_0^e && \text{[Balance sheet in t=1]} \\
& L_2^e = F_2^e + \delta_B Q_2^e K_1^e + \theta [R_{k,2}^e L_1^e - R_{b,1}^e F_1^e] && \text{[Balance sheet in t=2]} \\
& J_1^e \geq \kappa Q_1^e K_1^e && \text{[ICC, t=1]}
\end{aligned}
$$

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 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 that they pay to the Center intermediary, Q_t is the price of capital, $\delta_B Q_t K_{t-1}$ represents the start-up capital that the bankers get from their owner households, and $\Lambda_{t,t+j}$ is the stochastic discount factor between periods t and $t+j$.

Also, notice I highlight the terms that correspond to future periods for a clearer exposision of the dynamic nature of the banking problem.

The present value of the bank, will be given by the expected profits in the next period. For this, I include the posibility of exit from the banking business, with an associated probability of survival θ. [7] In that sense, with probability $(1-\theta)$ the bank will fail and report back its profits to the household, and with probability θ the bank will be able to continue its business and pursue future profits.

The constraints are given by the balance sheets of the bank for each period in which they operate and an incentive compatibility constraint. These balance sheets have, on the asset side, the loans that are intermediated, and on the liabilities side, the interbank foreign borrowing and their net worth. The latter in the initial period is only a bequest or

[7] 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

start-up capital that they receive from their household owners, while later also accounts for previously retained earnings. That is, I assume the bank will retain its earnings as long as it operates.[8]

Finally, the incentive compatibility constraint (ICC) reflects the imposition that the value of the franchise has to be equal or larger than the value the bank could divert after defaulting its creditors, which is given by a fraction κ of the intermediated assets.[9] For simplicity, this divertable fraction will be constant across locations and time.

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

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

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 e country bank 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 for the probability of a bank failure.

With these conditions an initial result can be stated:

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

Proof: See appendix A. ■

Since the friction is embodied in a positive spread, this result implies we can talk about κ and the extent of the distortion as analogous concepts.

[8]This assumption is common in the literature and also particularly reasonable in this model environment as, given the friction, the returns from banking tend to be higher than those of other assets.

[9]I follow Gertler and Karadi (2011) closely in the formulation of the ICC and assume the bank only considers to divert assets as soon as they obtain the funds. Other formulations are also possible, e.g., in Granados (2020) I explore a stricter ICC case where the potential diversion occurs the next period, after the firms repay their debt.

Center-Banks. The Center representative intermeriary will solve a similar problem. But it will not be subject to frictions. This means that the only constraints it faces are given by the balance sheets in each period. These reflect that the Center-Bank acts as the creditor of the EME-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 will be dynamic, as it accounts for the potential profits and balance sheets of every intermediation period.

In contrast, in the next period the bank will solve a simpler problem, consisting of maximizing the profits of a single term.

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

$$s.t$$

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

The resulting first order conditions will 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 our perfect foresight assumption, we can drop the borrowing cross border rates ($R_{b,t}$) as they are all equal to the rate for deposits at the Center ($R_{D,t}$). Furthermore, the Euler equations for the Center households with respect to the bonds and deposits can be used to simplify further and replace the deposits rate with that of the bonds.

3.3 Production Sectors

There will be two types of firms. Here I describe them briefly as the structure is analogous to the main model and the detailed formulation is explained in subsequent sections.

Final Good Firm. There will be a firm that maximizes their profits, given by the value of the production, plus the sales of undepreciated capital after production, minus the payment of their banking loans. The only constraint they face 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 and Q_t is the price of capital in period t.

Capital Producers. There will be a firm that will carry out the investments in each economy. Their job will be to buy any remaining undepreciated capital from the final good firms and to produce the new physical capital. Moreover, the investment will be subject to a cost of adjustment that depends on the investment growth with relation to that of the previous period.

3.4 Households

The households will own the three types of firms (final goods, capital and banks) and will use their profits for consumption, saving, and for supplying the bequests to their banks. They will not pay the banking taxes directly, these are paid by the banks before distributing profits. However, they will receive a lump sum transfer from the government once the latter levies the financial intermediaries.

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 will rent the capital to the firms directly.

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

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

$$s.t.$$

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

$$C_2^e + \frac{B_2^e}{R_2^e} = \pi_{f,2}^e + \pi_{inv,2}^e + \pi_{bank,2}^e - \delta_B Q_2^e K_1^e + B_2^e - T_2^e$$

$$C_3^e = \pi_{f,3}^e + \pi_{bank,3}^e + B_2^e - T_3^e \qquad for\ e = \{a,b\}$$

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 remaining 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.

I also assume that the household does not have access to deposits. This is a simplification that reflects the lower financial development in the periphery and that generates the financial dependency from EME-Banks on Center-Banks. It is important to remember that this assumption does not have consequences in the saving decisions of the households as they can freely access the bonds market for such purposes.

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

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

$$\begin{aligned}
&s.t. \\
&C_1^c + \frac{B_1^c}{R_1^c} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_B Q_1^c K_0^c \\
&C_2^c + \frac{B_2^c}{R_2^c} + D_2 = \pi_{f,2}^c + \pi_{inv}^c + \pi_{bank,2}^c - \delta_B Q_2^c K_1^c + B_2^c + R_{D,1} D_1 - T_2^c \\
&C_3^c = \pi_{f,3}^c + \pi_{bank,3}^c + B_2^c + R_{D,2} D_2 - T_3^c
\end{aligned}$$

3.5 Macroprudential Policy

There will be a role for policy in the model, that is justified by the friction in the banking sector. In that spirit, I consider a macroprudential policy that targets the banks. A government will tax the rate of return of the bankers in each period, and qfterwards, will rebate the tax income back to the households.

As a result, the effective revenue rate perceived by the banks after paying their taxes will be: $R_{k,t} = \frac{(1-\tau_t) r_t + (1-\delta) Q_t}{Q_{t-1}}$, where τ_t is the macroprudential tax.

With such structure, the following proposition holds:

Proposition 2: *An increase in the macroprudential tax decreases the leverage ratio of banks and its effect grows with the friction*

Proof: See appendix A. ■

This result suggests that, in addition to the direct effect in decreasing the credit spread of a distorted economy, the macroprudential tax will also lower the banking leverage of the banking sector. Furthermore, the extent at which it does this increases with the financial friction (κ).

In addition, notice that since τ_2 affects the first banking period, which is forward looking, and τ_3 the terminal period, where the banking decisions are static, it also follows that τ_2 and τ_3 are, respectively, a forward-looking and a static tool.

3.6 Equilibrium

Market Clearing and International Links. The bonds market will depict a zero-net-supply in the first two periods:

$$n_a B_t^a + n_b B_t^a + n_c B_t^c = 0, \quad \text{for } t = \{1, 2\}$$

In addition, I assume the uncovered parity holds which allows us to equate the interest rate of the bonds in each country:

$$R_t^a = R_t^b = R_t^c = R_t$$

Furthermore, I make use of the Euler equation for the deposits and bonds from the first order conditions of the Center, according to which ${C_t^c}^{-\sigma} = \beta R_{D,t} {C_{t+1}^c}^{-\sigma}$ and ${C_t^c}^{-\sigma} = \beta R_t {C_{t+1}^c}^{-\sigma}$, to 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 on 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 franchise value, the government runs a balance budget, and the goods and bonds markets clear.

A summary of the final set of equilibrium conditions used for solving the model can be found in table 6. I solve this system of equations non-linearly and using a perfect foresight approximation.

3.7 Welfare Effects of Policy

Based on the 3-period model we can approximate the welfare effects of policy at the national and cross-border level.

Numerical solution. I solve the model private equilibrium non-linearly, using the parameters shown in table 7. The agents will take the taxes as given, and hence, I have to provide them exogenously when solving for the private equilibrium. I solve the model with zero taxes and compare it with the solution after marginal changes in each of the taxes. The results are shown in table 1.

Table 1: Welfare effects in 3-period model

Effect		Change in tax 1%	3%	5%	8%
Direct effect of τ_2	$\tau_2^a \to W^a$	0.146	0.144	0.142	0.138
	$\tau_2^b \to W^b$	0.146	0.144	0.142	0.138
	$\tau_2^c \to W^c$	-0.242	-0.457	-0.179	-0.027
Cross-border effect	$\tau_2^a \to W^b$	-0.047	-0.047	-0.047	-0.048
	$\tau_2^a \to W^c$	-0.016	-0.017	-0.017	-0.017
	$\tau_2^b \to W^a$	-0.047	-0.047	-0.047	-0.048
	$\tau_2^b \to W^c$	-0.016	-0.017	-0.017	-0.017
	$\tau_2^c \to W^a$	-0.162	-0.226	-0.180	-0.155
	$\tau_2^c \to W^b$	-0.162	-0.226	-0.180	-0.155
Direct effect of τ_3	$\tau_3^a \to W^a$	0.057	0.057	0.056	0.056
	$\tau_3^b \to W^b$	0.057	0.057	0.056	0.056
	$\tau_3^c \to W^c$	-0.087	-0.122	-0.243	-0.134
Cross-border effect	$\tau_3^a \to W^b$	-0.018	-0.018	-0.018	-0.018
	$\tau_3^a \to W^c$	0.006	0.005	0.004	0.003
	$\tau_3^b \to W^a$	-0.018	-0.018	-0.018	-0.018
	$\tau_3^b \to W^c$	0.006	0.005	0.004	0.003
	$\tau_3^c \to W^a$	-0.051	-0.059	-0.087	-0.074
	$\tau_3^c \to W^b$	-0.051	-0.059	-0.087	-0.074

Note: the column denotes the size of the change applied in the taxes. The effect is obtained by the numerical approximation to the derivative of welfare with respect to a change in the tax ($\frac{\Delta W}{\Delta \tau}$). The superindexes refer to the countries with a: EME-A, b: EME-B and c: Center.

The table shows the numerical approximation to the derivative in welfare with respect to a change in a tax. The results indicate that the welfare effect of forward-looking taxes

(τ_2) is stronger than that of the terminal (static) tax (τ_3). This is particularly true for the cross-border effects of the taxes in both the Center and peripheral countries. This is consistent with studies such as Davis and Devereux (2019) and Gertler et al. (2020) where the taxes that are macroprudential in nature are potentially more effective than crisis-management policies.

I also obtain that for most of the changes sizes, the direct effect of the Center tax, i.e., on its own welfare, is weaker than its cross-border effects. This is similar to what I found in the purely static version of this model, however, it is also compensated by the effect of the terminal tax.

In terms of international policy effects, these results indicate that there is a negative policy spillover from the taxes set in the EMEs, i.e., the local and international welfare responses from a change in their taxes have opposite signs. This constrasts with the results of the static policy model in Granados (2020), although the differences may not only be due to the inclusion of dynamics but to the fact that the ICC is formulated differently in this model, in a way that the value of banking reacts less to the banking interest rate and tax. Finally, the spillovers from the Center tax are positive, suggesting the presence of potential policy free-riding incentives by the peripheries that may want to rely on the Center macroprudential taxes.

Analytical Welfare Effects In order to understand the mechanisms that generate these spillovers I set a Social Planner Problem and obtain the analytical welfare effects, following the methodology of Davis and Devereux (2019). For this, I set the welfare equations and simplify them using the private equilibrium conditions. Then, the welfare effects are obtained via implicit differentiation.

A social planner will consider the following simplified welfare expressions.

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

with $\varphi(\tau) = (1 - \alpha\,(1-\tau))$

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

To obtain these expressions, I set the welfare as the sum utilities in present value plus a sum-product of Lagrange multipliers times the budget constraints in each period. Then, I replace the profits and tax rebates in the constraints. Notice that these expresions are correct since the constraints are binding, and hence sum to zero, leaving the usual definition of welfare as result.

Setting the welfare in this fashion is very convenient given the algebra and differentiation is greatly simplified by the fact that we can ignore the effect of the decision variables of the households because their first order conditions (equal to zero) will be a factor of the associated differential terms.

Next, I obtain the welfare effects from changing each type of tax. We should remember that a planner setting the tax in the last period,[10] will take the taxes and variables from the previous period as given, 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, for the first period we must also consider the lagged versions of these variables.

The welfare effects of the taxes are:

For the EMEs:

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

$$\frac{dW_0^a}{d\tau_3^a} = \beta\lambda_2^a\left\{\alpha_5(\kappa)\frac{dK_2^a}{d\tau_3^a} + \alpha_4(\kappa)\frac{dQ_2^a}{d\tau_3^a} + \frac{B_2^a}{(R_2)^2}\frac{dR_2}{d\tau_3^a} + \alpha\frac{Y_3^a}{R_2}\right\}$$

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

[10] 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.

$\{1, 2, 3, 4, 5\}$.

and for the Center:

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

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

With $\gamma_1 = (1 - \alpha\theta\,(1 - \tau_2^c))\, r_2^c + (1-\theta)(1-\delta)Q_2^c$, $\gamma_2 = (r_3^c + (1-\delta)Q_3)$, $\gamma_3 = R_2\,(I_2^c + (1-\theta)(1-\delta)K_1^c)$, 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 effects. This helps to explain why the effects of the former are stronger.

On the other hand, there are four drivers of the static welfare effects of the tax: (i) the effect from hindering the capital accumulation, (ii) the effect from changes in the global interest rate, which will be proportional to the net foreign asset position, (iii) the effect from changes in the prices of capital, and for the center (iv) the effect of changes in the cross-border lending rates and quantities. The welfare effects of (i) and (iv) that capture a halting in local and global intermediation will be negative, while the effect of (ii) and (iii) depends, respectively, on whether an economy is a net creditor or on the investment growth, in that sense we expect (ii) to be positive for an emerging economy and negative for the Center. Finally, assuming that the investment in these economies is growing, (iii) is expected to be negative if the investment after the change in the tax is still larger than that of to the previous period.

The dynamic effects will have similar drivers. However, in all cases it will refer to the effect in future variables, for instance, (i) would refer to the effect on future capital accumulation and (ii) on the future net assets position. The signs for the dynamic effects will not be as straightforward. Then, we may expect similar signs but with potential corrections, for example, when tighter initial taxes imply delaying investment or capital acumulation plans for future periods when the taxes return to their previous level.

It is also important to mention that the negative effects are reflective of the potentially negative growth consequences of setting these taxes as they are akin to putting sand in the wheels of the financial sector. That is what some literature refers to when pointing out the potential immiserizing growth effects of these tools.[11] Of course, the policy trade-off here is that mitigating the friction may be well worth such cost.

A critical feature that can be observed is that the welfare effects from changes in capital accumulation and capital prices are augmented by the degree of financial distortion in the peripheries (κ). This is very important as it indicates that these taxes are potentially more effective for highly distorted economies.

Optimal taxes. I use the welfare effects expressions to derive the optimal taxes. These expressions are left for the appendix A. Here, as an example, I show the expression for the optimal national-oriented tax for the Center:

$$\tau_3^c = \frac{Q_2^c}{r_3^c}\left\{\gamma_2 \frac{dK_2^c}{dF_2^{ab}} + \Lambda_{23} B_2^c \frac{dR_2}{dF_2^{ab}} + \gamma_3 \frac{dQ_2^c}{dF_2^{ab}} + F_2^{ab} \frac{dR_{b2}^{\text{eme}}}{dF_2^{ab}}\right\} + \frac{(1-\delta)Q_3}{r_3^c} + 1 \tag{3}$$

with $\gamma_2 = (r_3^c + (1-\delta)Q_3)$, $\gamma_3 = R_2\left(I_2^c + (1-\theta)(1-\delta)K_1^c\right)$, and $F_2^{ab} = F_2^a + F_2^b$

There are two relevant features I find in both types of taxes (forward-looking and static), first, just as their welfare effects (and because of it), the peripheral taxes will grow in scale with the financial distortion and second, the center depicts a substitution effect motive between local and foreign intermediation that will push the tax upwards to favor local intermediation when the foreign lending grows ($\frac{\partial K^c}{\partial F}$ terms in (3) or the reciprocal in the other taxes expressions in the appendix A). This latter effect helps to understand how the optimal tax setting of the Center differs from the periphery, given its role of international creditor, which will be important when understanding the importance of the Center in generating gains from the international coordination of policies in the main model of the section 4.

Finally, in terms of the dynamic effects and given their forward-looking nature, the optimal initial period taxes will reflect the effects on future variables from a change in the capital accumulation of the economy where the instrument is being set.

[11]See Boar, Gambacorta, Lombardo, and da Silva (2017) and Belkhir, Naceur, Candelon, and Wijnandts (2020) for a discussion on the growth effects of macroprudential policies

On the other hand, when considering the cross-border effects of these policies I obtain similar expressions, with the difference that there will be no direct welfare effects from changing the taxes, i.e., any welfare change will come only from variations in the endogenous economic variables, and simultaneously, the variable driving the changes in the differentials will be that of a foreign country.

Welfare effects and Policy in Cooperative Settings. I have analyzed the spillover effects of these policies and optimal taxes for individual policy makers (non-cooperative) that maximize the national welfare of their economy. In contrast, in cooperative settings the planners will join efforts and act as one with the objective of maximizing the aggregate welfare of their coalition members, the policy cases I consider are shown in detail in table 2. As a result the global welfare effects will be given by weighted averages of the expressions shown previously.

With these new welfare effect expressions we can find the associated optimal cooperative taxes in an analogous fashion. Here I show the resulting optimal tax for the Center in the last period. In the appendix A I show how this expression is obtained from the average of the individual welfare effects after considering the policy effect in the objective of the cooperative planner.

$$\tau_3^{c,coop} = \tau_3^{c,nash} + \overbrace{\frac{Q_2^c}{\Lambda_{23} r_3^c} \frac{\lambda_2^a}{\lambda_2^c} \left\{ \alpha_5(\kappa) \frac{dK_2^a}{dF_2^{ab}} + \alpha_4(\kappa) \frac{dQ_2^a}{dF_2^{ab}} \right\}}^{\substack{\text{New substitution of Center capital accumulation for} \\ \text{foreign intermediation (EMEs) motive under cooperation}}} - \frac{\lambda_2^a}{\lambda_2^c} \overbrace{\frac{Q_2^c}{r_3^c} \frac{B_2^c}{R_2} \frac{dR_2}{dF_2^{ab}}}^{\substack{\text{NFA-led interest rate} \\ \text{manipulation motive} \\ \text{at Center}}} \tag{4}$$

Where $\tau_3^{c,nash}$ is the optimal tax for the non-cooperative planner as in (3).

As previously: $\alpha_4(\kappa) = (I_2^a + \kappa (1 - \theta \Lambda_{23}) K_2^a)$ and $\alpha_5(\kappa) = (\kappa (1 - \theta \Lambda_{23}) Q_2^a + \varphi (\tau_3^a) \Lambda_{23} r_3^a)$, with $\frac{\partial \alpha_s(\kappa)}{\partial \kappa} > 0$ for $s = \{4, 5\}$.

Something crucial happening with a cooperative Center is that the welfare effects associated to changes in the global interest rates, that are proportional to the net foreign assets positions of the economies, will cancel out between creditors and debtors that are engaging in cooperation. Additionally, a new motive for increasing the Center taxes emerges, which in addition, will be proportional to the increase in capital accumulation at the EMEs after a change in global banking intermediation and, very importantly, will increase with the extent of the financial friction κ.

These two features, the first one present in every country, and the second in the Center, will be the main factors explaining welfare differences between cooperative and non-cooperative policy settings as we will see in the results section.

As for the presence of welfare gains from cooperation and, if these exist, their distribution between economies, I set a more comprehensive model that accounts for the entire path of the taxes and the persistency of their effects in a stochastic environment. For that, I will endogeneize the taxes by formulating a Ramsey policy problem. I present the model and policy problems in the following two sections.

4 The Main Model

In this section I set the main model of this study and analyze how the perfect-foresight results hold in a stochastic environment. The model borrows standard elements from the literature for representing each agent. In particular, I take elements from Banerjee, Devereux, and Lombardo (2016), Agénor, Kharroubi, Gambacorta, Lombardo, and da Silva (2017) and Gertler and Karadi (2011) and incorporate them into a three country center-periphery framework with incomplete markets.

Our world economy consists of three countries, one financial center with population size $1 - n_a - n_b$ and two periferies, A and B, with population sizes n_a and n_b, with $n_a + n_b \leq \frac{1}{2}$.

The agents will have access to an international bonds market where they can trade non-contingent bonds. There is a single consumption good in the world which is freely traded. The model is set in real terms. Also, the preferences are identical between agents in each country and the law of one price holds. Thus, the purchasing power parity holds and the real exchange rate is one. In addition, the uncovered interest rate parity holds.

This implies that the only friction present in our model will be the financial agency friction in borrower-lending relationships. In that regard, this is a costly-enforcement model like Gertler and Kiyotaki (2010).

As for the key features I consider, other than introducing the lending friction, I differentiate the banking sector in the financial center and emerging economies. For doing this, I consider a setup of limited financial development in the emerging economies, that makes necessary for the banks of these countries to rely on funding from financial centers in order to fulfill its intermediary role with the firms.

Throughout this section, the superindex i will be used when the expression applies to each country $i = \{a, b, c\}$, otherwise I use the corresponding specific superindex.

4.1 Households

The households in each economy will choose consumption, savings (with bonds or deposits) and leisure to maximize their welfare, given by the present value of their life-stream utility:

$$\max_{\{C_t, H_t, B_t, D_t\}_{t=0}^{\infty}} W_0^i = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{i(1-\sigma)}}{1-\sigma} - \frac{H_t^{i(1+\psi)}}{1+\psi} \right) \tag{1}$$

s.t.,

$$C_t^i + B_t^i + \frac{\eta}{2}(B_t^i)^2 + D_t^i + \frac{\eta}{2}(D_t^i - \bar{D}^i)^2 = R_{t-1}^i B_{t-1}^i + R_{D,t-1}^i D_{t-1}^i + w_t^i H_t^i + \Pi_t^i \tag{2}$$

With $i = \{a, b, c\}$ and where B_t^i: non-contingent international bonds, D_t^i: domestic deposits, $w_t^i H_t^i$: labor income (wages times hours supplied), Π_t^i : profits from banks and other firms net of lump-sum taxes.

In addition, adjustment costs from changes in assets positions are included to prevent non-stationarity of the model in an incomplete markets setup (see Schmitt-Grohe and Uribe (2003)).

The consumption of the final good by the home household in the country i is C^i. Since only one good is produced, that is, there are no country-specific commodities, a retail and intermediate goods sector is not included. That implies there is no home bias in consumption generated by the asymmetric size of the countries. Furthermore, since no departure from the law of one price is assumed, the relative prices across countries and real exchange rates are abstracted from.

Financial Center. The F.O.C. for the households of the Center are:

$$\mathbb{E}_t \left[R_t \Lambda_{t,t+1}^c \right] = 1 + \eta(B_t^c)$$
$$\mathbb{E}_t \left[R_{D,t}^c \Lambda_{t,t+1}^c \right] = 1 + \eta(D_t^c - \bar{D}^c)$$

$$C_t^{c\ -\sigma} = \frac{H_t^{c\ \psi}}{(1-\alpha)A_t^c \xi_t^{c\ \alpha} K_{t-1}^{c\ (\alpha)} H_t^{c\ (-\alpha)}}$$

Where $\Lambda_{t,t+1} = \beta\lambda_{t+1}/\lambda_t$ is the stochastic discount factor and λ_t is the marginal utility of consumption.

Emerging Economy Households. One difference between the households of the advanced economy and the emerging one is that households at the former will be able to freely purchase deposits from the Center country banks while the emerging economy banks will have a limited local intermediation capacity. This implies the banks in these countries will hold less deposits. As a simplification, I drop the deposits for these countries altogether (i.e., D_t^a and D_t^b are zero). Note that this feature is not explicitely reflected in the household budget constraint above.

The F.O.C. of the emerging economy A are:

$$\mathbb{E}_t\left[R_t \Lambda_{t,t+1}^a\right] = 1 + \eta(B_t^a)$$
$$C_t^{a\ -\sigma} = \frac{H_t^{a\ \psi}}{(1-\alpha)A_t^a \xi_t^{a\ \alpha} K_{t-1}^{a\ (\alpha)} H_t^{a\ (-\alpha)}}$$

The F.O.C. of the emerging economy B will be analogous.

4.2 Final Goods Firms

There is one single good produced in the world that is obtained from a CD technology:

$$Y_t^i = A_t^i \left(\xi_t^i K_{t-1}^i\right)^\alpha H_t^{i(1-\alpha)} \tag{3}$$

H^i, K^i are labor and capital, A^i is a labor productivity shock, and ξ^i is a capital-quality shock (both are first-order AR processes).

The capital quality shock implies the depreciation rate is given by $\delta_t^i(\xi_t^i) = 1 - (1-\delta)\xi_t^i$.

Each period, the firms will choose labor and capital inputs to maximize the profits obtained from producing and from the sales of undepreciated physical capital to investors, while paying both wages and the banking loan with which they funded the acquisition of physical capital:

$$\max_{K^i_{t-1},H^i_t} \Pi^{i,prod}_t = Y^i_t + (1-\delta)\xi^i_t Q^i_t K^i_{t-1} - w^i_t H^i_t - \tilde{R}^i_{k,t} Q^i_{t-1}$$
$$\text{s.t.} \quad (3)$$

I define the marginal product of capital as $r^i_t \equiv \alpha A^i_t \xi^{i\ \alpha}_t K^{i\ \alpha-1}_{t-1} H^{i\ 1-\alpha}_t$, and obtain the wages and gross rate of returns paid to the banking sector from the FOCs with respect to labor and capital:

$$w^i_t = (1-\alpha) A^i_t H^{i(-\alpha)}_t \xi^{i\ \alpha}_t K^{i(\alpha)}_{t-1}$$
$$\tilde{R}^i_{k,t} = \frac{r^i_t + (1-\delta)\xi^i_t Q^i_{t-1}}{Q^i_{t-1}}$$

As we will see when describing the banking sector, the capital is funded by selling company securities to domestic banks in a one to one relationship, i.e., $Z^i_t = K^i_t$, where Z^i_t is the stock of securities from the representative final goods firm in the country i. In that spirit, the marginal product of capital r^i_t can also be interpreted as the return from the firm securities.[12]

4.3 Capital Goods Firms

Physical capital is produced in a competitive market by using old capital and investment. The depreciation rate of capital is $1-(1-\delta)\xi^i_t$. The investment will be subject to convex adjustment costs, i.e., the total cost of investing I^i_t is:

$$C(I^i_t) = I^i_t \left(1 + \frac{\zeta}{2}\left(\frac{I^i_t}{I^i_{t-1}} - 1\right)^2\right)$$

The capital dynamics will be given by:[13]

$$K^i_t = I^i_t + (1-\delta)\xi^i_t K^i_{t-1} \tag{4}$$

[12]For simplicity, when solving the model, I replace $\tilde{R}_{k,t}$ back in the profit function so that I can drop $\tilde{R}$ as a variable and work only with the effective (after tax) revenue rate perceived by banks. When I do such substitution a standard expression for the profits is obtained: $\Pi^{i,prod}_t = Y^i_t - r^i_t K^i_t + W^i_t H^i_t$.

[13]In this notation, the time index of capital denotes the period in which it was determined, rather than the period when it is used for production.

With these dynamics into account, the firms will buy back the old capital stock from the final goods firms at price Q_t^i and produce new capital subject to the adjustment cost.

Finally, the problem of the capital goods firm choosing the investment level is given by:

$$\max_{\{I_t^i\}_{t=0}^{\infty}} E_0 \sum_{s=0}^{\infty} \Lambda_{t,t+s}^i \left\{ Q_{t+s}^i I_{t+s}^i - I_{t+s}^i \left(1 + \frac{\zeta}{2} \left(\frac{I_{t+s}^i}{I_{t+s-1}^i - 1} \right)^2 \right) \right\}$$

From the first order condition we can derive the dynamics for the price of capital:

$$Q_t^i = 1 + \frac{\zeta}{2} \left(\frac{I_t^i}{I_{t-1}^i} - 1 \right)^2 + \zeta \left(\frac{I_t^i}{I_{t-1}^i} - 1 \right) \frac{I_t^i}{I_{t-1}^i} - \mathbb{E}_t \left[\Lambda_{t,t+1}^i \zeta \left(\frac{I_{t+1}^i}{I_t^i} \right)^2 \left(\frac{I_{t+1}^i}{I_t^i} - 1 \right) \right] \tag{5}$$

4.4 Banking Sector

The set-up for this sector is based on Gertler and Karadi (2011). Each economy will have a financial firm that intermediates funds for capital accumulation between savers and firms. It will borrow funds from either the depositors or the interbank market and it will lend it to the local firms. The spread in the interest rates of lending and borrowing will generate the profits of the sector.

I consider a setup with entry and exit for banks with a survival rate given by θ. This prevents the banks from engaging in self-funding schemes that would prevent the constraints arising from the agency frictions to bind. In this scheme, the banks entering each period will receive a start-up capital from their household owners that will be proportional to the scale of the banking assets in the preceding period. Simultaneously, each period the bank will re-invest its proceeds back in its business. However, when the bank fails and exit the market, it will give back its net worth in the form of profits to the owners.

In each case, I consider an incentive compatibility constraint (ICC) that reflects the agency problem in the lending relationships of the bank. I assume these constraints are binding.

The structure of the sector in each country and the decisions they face are explained in detail in the following subsections. However, it can be said that in general, the problem of the bank in t consists in maximizing a financial intermediation value function $J(N_{j,t}) = \mathbb{E}_t \max \Lambda_{t,t+1}[(1-\theta)N_{j,t+1} + \theta J(N_{j,t+1})]$ subject to the dynamics of the net worth of the bank (N), the balance sheet and the ICC.

The emerging market banks will also have the additional constraint of having a limited intermediation capacity. This eventually implies funding flows from the Center economy to the peripheries that results in balance sheet effects at the cross country level.

EME Banks. The banks start with a bequest from the households and continue their activities with probability θ. The index e refers to either emerging market with $e = \{a, b\}$.

Let N^e_{jt} be the net worth and F^e_{jt} the amount borrowed from center banks at a real rate $R^e_{b,t}$. The balance sheet of the bank j is given by:

$$Q^e_t Z^e_{jt} = N^e_{jt} + F^e_{jt} \tag{6}$$

We also have that there is a one to one relationship between the securities of the bank and the physical capital units, i.e., $Z^e = K^e$.

The aggregate net worth of the banking system is:

$$N^e_t = \overbrace{\theta N^e_{j,t}}^{\text{surviving banks}} + \overbrace{\delta_T Q^e_t K^e_t}^{\substack{\text{new banks} \\ \text{start-up K}}}$$

We can see that the bequests provided by the households to the banks are proportional to the pre-existing level of intermediation (capital) times the current price of capital.

At the same time, $N^e_{j,t}$ is the net-worth of surviving banks which displays the following dynamics:

$$N^e_{j,t} = R^e_{k,t} Q^e_{t-1} K^e_{j,t-1} - R^e_{b,t-1} F^e_{j,t-1} \tag{7}$$

The gross return on capital, $R^e_{k,t}$, will account for the payment of the macroprudential tax:

$$R^e_{k,t} = \frac{(1 - \tau^e_t) r^e_t + (1 - \delta) \xi^e_t Q^e_t}{Q^e_{t-1}}$$

with $\tau^e_t \gtrless 0$ representing a tax/subsidy.

The contracts between savers and banks will be subject to limited enforceability, i.e., a bank can default, in which case, the savers will take it to court but will only be able to recover a portion of the promised payment. In practice, this implies the bank can run away with a portion κ^e of the assets.

The problem of the j banker is to maximize the franchise value of the bank:[14]

$$J^e_{j,t}(N^e_{j,t}) = \mathbb{E}_t \max_{N^e_{j,t}, Z^e_{j,t}, F^e_{j,t}} \Lambda^e_{t,t+1}\left[(1-\theta)N^e_{j,t+1+s} + \theta J^e_{j,t+1}(N^e_{j,t+1})\right]$$

subject to the net worth dynamics (7), the balance sheet constraint (6) and the associated ICC:

$$J^e_{j,t} \geq \kappa^e Q^e_t K^e_{j,t} \tag{8}$$

This Incentive Compatibility Constraint condition states that the continuation value of the bank is larger than the potential profit of defaulting.[15]

The bank problem yields the following optimality conditions:

F.O.C. with respect to intermediated capital:

$$[K^e_{j,t}]: \qquad \mathbb{E}_t \Omega^e_{t+1|t}\left(R^e_{k,t+1} - R^e_{b,t}\right) = \mu^e_t \kappa^e \tag{9}$$

and envelope condition:

$$[N^e_{j,t}]: \qquad J^{e'}(N^e_{j,t})(1-\mu^e_t) = \mathbb{E}_t \Omega^e_{t+1|t} R^e_{b,t} \tag{10}$$

where μ^e_t is the lagrange multiplier associated with the ICC and $\Omega^e_{t+1|t} = \Lambda^e_{t,t+1}\Big(1-\theta+\theta J^{e'}_{t+1}\Big)$ is the effective stochastic discount factor of the bank.

Center Economy Banks. The structure of the center economy banks is similar. We only need to be careful when setting the balance sheet and net worth dynamics. Both need to reflect the foreign claims intermediated and the proceeds from being a global creditor.

The balance sheet of the global country bank j is:

$$F^a_{j,t} + F^b_{j,t} + Q^c_t Z^c_{j,t} = N^c_{jt} + D^c_t \tag{11}$$

where D^c are the deposits from the households, $F^e_{j,t}$ are the claims on the $e = \{a, b\}$ representative periphery banks (EMEs), and $Q^c_t Z^c_{j,t}$ are claims on the core country capital

[14] An analogous sequential problem is given by maximizing: $J^e(N^e_{j,t}) = E_t \max_{\{N_t, Z^e_t, F^e_{j,t}\}_{t=0}^{\infty}} (1-\theta)\sum_{s=0}^{\infty} \Lambda^e_{t,t+1+s}[\theta^s N^e_{j,t+1+s}]$

[15] There are several feasible choices for the right hand side term depending on the timing of the assets absconding. Here I assume they compare the value of the bank to diverting assets as soon as they obtain them, i.e., before these yield returns.

stock with $Z^c_{j,t} = K^c_{j,t}$.

Their net (after taxes) return on intermediated capital is:

$$R^c_{k,t} = \frac{(1-\tau^c_t)r^c_t + (1-\delta)\xi^c_t Q^c_t}{Q^c_{t-1}}$$

The bank j value function is:

$$J^c_{j,t}(N^c_{j,t}) = \mathbb{E}_t \max_{N^c_{j,t},\, Z^c_t,\, F^e_{j,t},\, D^c_t} \Lambda^c_{t,t+1}\Big[(1-\theta)(\overbrace{R^c_{k,t+1}Q^c_t Z^c_{j,t} + R^a_{b,t}F^a_{j,t} + R^b_{b,t}F^b_{j,t}}^{\text{gross return on assets}} - \overbrace{R^c_{D,t}D^c_t}^{\substack{\text{repayment}\\ \text{of deposits}}}) \\ + \theta J^c_{j,t+1}(N^c_{j,t+1})\Big]$$

The bank maximizes such value while being subject to the balance sheet constraint (11) and to an incentive compatibility constraint given by:

$$J^c_{j,t} \geq \kappa^c_{F_1} F^a_{jt} + \kappa^c_{F_2} F^b_{jt} + \kappa^c Q^c_t Z^c_{j,t} \tag{12}$$

with $\kappa^c_{F_i}, \kappa^c > 0$.

The optimality Conditions are:

$$[Z^c_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}(R^c_{k,t+1} - R^c_{D,t}) = \kappa^c \mu^c_t \tag{13}$$

$$[F^a_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}\left(R^a_{b,t} - R^c_{D,t}\right) = \kappa^c_{F_1}\mu^c_t \tag{14}$$

$$[F^b_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}\left(R^b_{b,t} - R^c_{D,t}\right) = \kappa^c_{F_2}\mu^c_t \tag{15}$$

and the envelope condition,

$$[N^c_{j,t}]: \quad J^{c'}(N^c_{j,t})(1-\mu^c_t) = \mathbb{E}_t \Omega^c_{t+1|t} R^c_{D,t} \tag{16}$$

4.5 Macroprudential Policy

The policy tool considered is a tax on the return to capital. This is a general enough tool that encompasses several variaties of macroprudential instrumets. For example, and as I showed in the proposition 2, it can have leverage implications.

Furthermore, setting the tool as a tax on the revenue rate of banking has the advantage of affecting the wedge between return on capital and deposit rate (credit spread) in a direct fashion. Therefore, policy actions can be applied right at the source of inefficiencies.

$$\tau_t^i r_t^i K_{t-1}^i + T_t^i = 0 \qquad i = \{a, b, c\}$$

Effect of the macroprudential tool in the model. In the finite horizon version of this model with simple dynamics, I obtained that leverage is a function of the macroprudential instrument and that their relation is negative. That is, an increase in the tax will decrease the leverage ratio of banks. As a result, by implementing a given tax, the planner would also enforce a leverage ratio in the banking sector, a commonly used macroprudential policy.

In the infinite horizon setup of this section, proving such result is less straightforward because the future effects of the policies show up only implicitly in the continuation values of the recursive expressions for the value of the bank.

Nevertheless, it is still possible to describe the way leverage responds to an increase in the tax. I do it by following Gertler and Karadi (2011) and setting the value of the bank in terms of current lending, net worth, and dynamic coefficients. Here I present the expressions for the emerging economies, but the same results hold for the advanced one that intermediates more types of assets. The value of the bank can be expressed as:

$$J_{jt}^e = \nu_t Q_t^e K_{jt}^e + \eta_t N_{jt}^e$$

with,

$$\nu_t = \mathbb{E}_t\{(1-\theta)\beta\Lambda_{t,t+1}^e(R_{k,t+1}^e - R_{b,t}^e) + \beta\Lambda_{t,t+1}^e\theta x_{t,t+1}\nu_{t+1}\}$$
$$\eta_t = \mathbb{E}_t\{(1-\theta) + \beta\Lambda_{t,t+1}^e\theta z_{t,t+1}\eta_{t+1}\}$$

Where $x_{t,t+i} = Q_{t+i}^e K_{j,t+i}^e / Q_t^e K_{j,t}^e$ and $z_{t,t+i} = N_{j,t+i}^e / N_{j,t}^e$

I now substitue J_{jt}^e from (8) when it binds and obtain the leverage as ϕ_t^e:

$$\frac{Q_t^e K_t^e}{N_t^e} = \phi_t^e = \frac{\eta_t}{\kappa^e - \nu_t} \tag{17}$$

Where I removed the j sub-index as the components of the leverage will not depend on firm-specific factors. It also follows that $z_{t,t+1} = [(R_{k,t+1}^e - R_{b,t})\phi_t^e + R_{b,t}^e]$ and $x_{t,t+1} =$

$(\phi^e_{t+1}/\phi^e_t)z_{t,t+1}$.

With this, we can see that as the tax increases and the spread goes down, η_t and ν_t will decrease. The overall effect on leverage would be negative. However, even if we can indicate the direction of the changes in the leverage expression, i.e., in the equation (17), it is difficult to pinpoint the actual change in leverage as the tax increases as in the simpler setup becuause the terms in the right hand side of the equations will depend on current and future values of the leverage themselves.

4.6 Market Clearing Conditions

The corresponding market clearing conditions of the model, for the final goods market and bonds, are:

$$\text{Goods market:} \qquad \sum_i n_i Y_t^i = \sum_i n_i \left(C_t^i + I_t^i \left(1 + \frac{\zeta}{2} \left(\frac{I_t^i}{I_{t-1}^i} - 1 \right)^2 \right) + \frac{\eta}{2}(B_t^i)^2 + \frac{\eta}{2}\left(D_t^i - \bar{D}^i \right)^2 \right)$$

$$\text{Bonds market:} \qquad \sum_i n_i B_t^i = 0, \qquad \forall t$$

where i denotes a country index, i.e., $i = \{a, b, c\}$.

Notice that the market clearing condition for the final goods reflects, first, the adjustment cost of executing investment projects, and second, the fact that the final good is fully tradable and produced in each economy (no home bias).

Due to Walras law, when solving the model we can use either the budget constraints of each type of household, or two of them and the goods market clearing condition.

Equilibrium. For a given path of macroprudential policies $\boldsymbol{\tau_t} = \{\tau_t^a, \tau_t^b, \tau_t^c\}$ a tax-distorted competitive equilibrium is given by the prices $\{w_t^i, Q_t^i\}$, rates $\{R_t, R_{D,t}, R_{k,t}^i, R_{b,t}^e\}$ and quantities $\{C_t^i, H_t^i, B_t^i, D_t^c, K_t^i, I_t^i, N_t^i, F_t^e, Y_t^i\}$ with $i = \{a, b, c\}$ and $e = \{a, b\}$ such that,

Given $\{w_t^i, R_t, R_{D,t}\}$, the sequences $\{C_t^i, B_t^i, D_t^c, H_t^i\}$ solve the households utility maximization problem for each t.

Given $\{Q_t^i, w_t^i, R_{k,t}^i\}$ and the technological constraint $\{Y_t^i\}$, $\{K_t^i, H_t^i\}$ solve the final goods firms profit maximization problem for each t.

Given $\{Q_t^i\}$ and the expected path of prices $\{\mathbb{E}_t Q_{t+s}\}_{t=0}^{\infty}$, $\{I_t^i\}$ solves the capital producer profit maximization problem.

Given $\{Q_t^i, R_{k,t}^i, R_{b,t}^e, R_{D,t}\}$, $\{N_t^i, Z_t^i, F_t^e\}$, with $Z_t^i = K_t^i$ solves the franchise value maximization problem of the banks.

In addition, capital dynamics are given by (4), and the goods and bonds market clearing conditions hold for each t.

In the table 11 in the appendix B, I show the final system of equations that characterizes the equilibrium. These structural equations will be used as the set of constraints for the policy makers that decide the optimal level of the tools in each of the considered regimes.

5 Ramsey Policy Problem

So far I have characterized the private equilibrium for this economy. In that context, the policy tools are exogenous to the agents, i.e., they take them as given when taking their optimal decisions. However, I am interested in the optimal endogenous determination of these tools for a set of policy arrangements that vary by the degree of international regulatory cooperation. For that, I use the Ramsey Planner Problem, consisting on choosing the optimal level of the policy tools, and the rest of variables, subject to the conditions that characterize the private equilibrium.

The idea is to respect the private equilibrium structure while still shaping the final resulting allocation by setting the policy instruments optimally. I consider four policy schemes that range from no-cooperation (Nash) to world cooperation while allowing for semi-cooperative cases where subsets of countries form regulatory coalitions:

Table 2: Policy Cases Considered

	Planners/Players	Obj. Function	Decision variables
Cooperation (all countries)	World	$W_0^{Coop} = n_a W_0^a + n_b W_0^b + n_c W_0^c$	$\mathbf{x_t}, \boldsymbol{\tau}_t$
Semi-Cooperation (EMEs vs. Center)	Periphery block A+B	$W_0^{ab} = n_a W_0^a + n_b W_0^b$	$\mathbf{x_t}, \tau_t^a, \tau_t^b$
	Center	W_0^c	$\mathbf{x_t}, \tau_t^c$
Semi-Cooperation (EME-A + C vs. EME-B)	Cooperative A+C	$W_0^{ac} = n_a W_0^a + n_c W_0^c$	$\mathbf{x_t}, \tau_t^a, \tau_t^c$
	EME-B	W_0^b	$\mathbf{x_t}, \tau_t^b$
Nash (non-cooperative) One planner per country	EME-A	W_0^a	$\mathbf{x_t}, \tau_t^a$
	EME-B	W_0^b	$\mathbf{x_t}, \tau_t^b$
	Center	W_0^c	$\mathbf{x_t}, \tau_t^c$

Note: $\boldsymbol{\tau}_t = (\tau_t^a, \tau_t^b, \tau_t^c)'$

As shown in table 2, two features are critical for differentiating the cases: first, the objective funtion of the planner will be the weighted welfare of the countries that belong to a coalition (in the non-cooperative case each economy will have an individual planner whose objetive function will be the local welfare), and secondly, the cooperative planners, by joining efforts and acting as one, will have a larger menu of policy tools available.

The detailed policy problems they solve will be described in the following subsection.

5.1 Planning Problems

In every case I consider the planning problem under commitment with a timeless perspective. [16] As explained by King and Wolman (1999) this implies I am assuming the policy makers were making optimal decisions in the past in a time consistent manner. This formulation is the standard in the literature given its property of avoiding indeterminacy issues in the model solution.

In addition, I solve for the *open-loop Nash* equilibrium for the cases where there are two or more players interacting simultaneously.

[16] See Woodford (2003) and Benigno and Woodford (2004) for a detailed discussion on the timeless perspective and time consistency in the policy problem.

Definition 1. *Open-loop Nash equilibrium*

An open-loop Nash equilibrium is a sequence of tools $\{\tau_t^{i\,*}\}_{t=0}^{\infty}$ *such that for all* t^**,* $\tau_{t^*}^{i\,*}$ *maximizes the player* i*'s objective function subject ot the structural equations of the economy that characterize the private equilibrium for given sequences* $\{\tau_{-t^*}^{i\,*}\}_{t=0}^{\infty}$ *and* $\{\tau_t^{-i\,*}\}_{t=0}^{\infty}$*, where* $\{\tau_{-t^*}^{i\,*}\}_{t=0}^{\infty}$ *denotes the policy instruments of player* i *in other periods than* t^* *and* $\{\tau_t^{-i\,*}\}_{t=0}^{\infty}$ *is the sequence of policy moves by all other players. In this sense, each player's action is the best response to the other players' best responses.*

Given that the policymakers specify a contingent plan at time 0 for the complete path of their instruments $\{\tau_t^i\}_{t=0}^{\infty}$ for $i = \{a, b, c\}$, the problem they solve can be interpreted as a static game, which allows me to recast their maximization problems as an optimal control problem where the instruments of the other planners are taken as given.

In that vein and as in the static Nash equilibrium concept, the player i focuses on his own objective function and the maximization problems for the policymakers will be given as follow:

World Cooperation. Under commitment, a single planner, whose objective function is the worldwide welfare, chooses the vector of endogenous variables and the policy instruments to solve:

$$W_0^{coop} = \max_{\mathbf{x}_t, \boldsymbol{\tau}_t} [n_a W_0^a + n_b W_0^b + (1 - n_a - n_b) W_0^c] \tag{18}$$

subject to the system of equations that characterize the private equilibrium (private FOCs, budget constraints and market clearing conditions):

$$\mathbb{E}_t F(\mathbf{x}_{t-1}, \mathbf{x}_t, \mathbf{x}_{t+1}, \boldsymbol{\tau}_{t-1}, \boldsymbol{\tau}_t, \boldsymbol{\tau}_{t+1}; \boldsymbol{\varphi}_t) = 0$$

where W_0^i denotes the welfare of the country i as in (1), $\mathbf{x}_t$ is the vector of endogenous variables, $\boldsymbol{\tau}_t = (\tau_t^a, \tau_t^b, \tau_t^c)'$ is the vector of instruments and $\boldsymbol{\varphi}_t$ is a vector of exogenous variables and shocks.

Semi-cooperative case 1 - cooperation between the Center and the EME-A. The planners of the C and A economies will form a coalition, acting as one and solving:

$$W_0^{coop(C+A)} = \max_{\mathbf{x}_t, \tau_t^a, \tau_t^c} [n_a W_0^a + n_c W_0^c] \tag{19}$$

$$\text{s.t.,} \qquad \mathbb{E}_t F(\mathbf{x}_{t-1}, \mathbf{x}_t, \mathbf{x}_{t+1}, \boldsymbol{\tau}_{t-1}, \boldsymbol{\tau}_t, \boldsymbol{\tau}_{t+1}; \boldsymbol{\varphi}_t) = 0$$

where $F(\cdot)$ denotes the private equilibrium conditions. Notice that these system of constraints will be the same for every planner across all the policy frameworks.

The remaining country (B) will solve the same problem as in the Nash case.

Semi-cooperative case 2 - cooperation between the emerging countries. The planners of the A and B economies will form a coalition and solve:

$$W_0^{coopEME} = \max_{\mathbf{x}_t, \tau_t^a, \tau_t^b} [n_a W_0^a + n_b W_0^b] \tag{20}$$

$$\text{s.t.,} \qquad \mathbb{E}_t F(\mathbf{x}_{t-1}, \mathbf{x}_t, \mathbf{x}_{t+1}, \boldsymbol{\tau}_{t-1}, \boldsymbol{\tau}_t, \boldsymbol{\tau}_{t+1}; \boldsymbol{\varphi}_t) = 0$$

The remaining country (C) will solve the same problem as in the Nash case.

Nash (no cooperation). Finally, a non-cooperative policy-maker of the country $i = \{a, b, c\}$, with the domestic welfare as objective function, will solve:

$$W_0^{i,nash} = \max_{\mathbf{x}_t, \tau_t^i} W_0^i \tag{21}$$

$$\text{s.t.,} \qquad \mathbb{E}_t F(\mathbf{x}_{t-1}, \mathbf{x}_t, \mathbf{x}_{t+1}, \boldsymbol{\tau}_{t-1}, \boldsymbol{\tau}_t, \boldsymbol{\tau}_{t+1}; \boldsymbol{\varphi}_t) = 0$$

5.2 Gains From Cooperation

To compare the performance of the models, I compute the global expected conditional welfare and compute the welfare gains with respect to a benchmark. For example, the welfare gain of world cooperation relative to the non-cooperative (Nash) model will be:

$$Gain_{Coop/Nash} \equiv W_0^{coop} - (n_a W_0^{a,nash} + n_b W_0^{b,nash} + (1 - n_a - n_b) W_0^{c,nash})$$

The gain will be approximated at the second order around the non-stochastic steady state. Moreover, as it is, this welfare gain is given in utility units which makes difficult to assess the magnitude of the relative performance of each model. Then, for a better comparison, we can look for the consumption equivalent variation that would make the private agents indifferent between the models. For this case, that quantity is given by λ, the proportional increase in the steady-state consumption of the world cooperation model that would deliver the same welfare as the Nash case:

$$W_0^{i,coop}(\lambda) = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{((1+\lambda)C_t^{i,coop})^{1-\sigma}}{1-\sigma} - \frac{(H_t^{i,coop})^{(1+\psi)}}{1+\psi} \right) = W_0^{i,nash}$$

For each economy $i = \{a, b, c\}$. Similarly, the global consumption equivalent gain (cost) will be the weighted average of the national ones.

Clearly, an overperforming model, or in this example a model with gains from cooperation, would depict a negative λ. I approximate λ by normalizing the welfare gain (in utility units) by the increase in steady-state welfare that would be obtained from a 1% increment in consumption.

6 Results

In this section, I discuss the solution of the main model under different policy schemes and how it helps us answer our two research questions, namely, (i.) is the international cooperation of macroprudential policies convenient for emerging economies in general?, and (ii.) are cooperative policies useful in shielding the peripheric economies from external shocks and the global financial cycle?.

For (i.) I compare the expected long run welfare that the policy frameworks in table 2 deliver. By construction, this will be a comparison of the long-run performance of the models. On the other hand, for (ii.) I analyze how each policy setup fares when facing negative shocks that originate at the Center.

I use the parametrization shown in table 8 in the appendix B. In most cases I borrow standard parameters from the literature that have the usual targets (e.g., discount factor and depreciation rate). However, there are other parameters that are chosen with the macroprudential litetarure on emerging markets in mind. This is particularly true for the divertable fraction of capital which I adopt from Aoki et al. (2018). At the same time, given the focus on the large open economy dimension of these policies, I set the population sizes of each emerging economy at 0.25 each ($n_a = n_b = 0.25$).

Steady State of the Policy Instruments. The table 3 shows the steady states of the policy taxes for each policy regime considered. The solution algorithm used implies computing an instrument conditional steady state and follows the steps outlined in Christiano, Rotto and Rostago (2007) and Bodenstein et al. (2019). A detailed explanation can be found in the appendix A. I obtain that the Center always applies subsidies to its banking sector in the long run, while planners of the EMEs subsidize its banking sector only when cooperating with the Center, and instead, set a tax to the financial intermediaries in the non-cooperative case or under the regional emerging coalition. Therefore, it follows, at least in the long-run, that cooperation with the center consists on setting higher subsidies (lower taxes).

Table 3: Steady State values for the policy tools

	Nash	Cooperation (Center+EME-A)	Cooperation (EMEs)	Cooperation (All)
τ^c	-0.850	-0.530	-0.806	-0.864
τ^a	0.319	-0.164	0.348	-0.697
τ^b	0.319	0.328	0.348	-0.697

6.1 Welfare Accounting Comparison

A comprehensive comparison of the models can be done in terms of the welfare they deliver. For this, its crucial to compute the conditional welfare in all cases, otherwise the welfare quantities are potentially affected by different predetermined state variables and are not comparable between models as explained in Bilbiie, Fujiwara, and Ghironi (2014). I condition all the models on the same initial state given by the average of the steady state values of a number of the policy regimes. As a result, the outcome allows us to compare and rank the policy frameworks in terms of their long run outcomes.

Table 4: Welfare cost in consumption equivalent compensation relative to the First Best

	Consumption Equivalent Compensation			
	Nash	Cooperation (Center+EME-A)	Cooperation (EMEs)	Cooperation (All)
C	-11.7	2.9	-13.2	-3.9
A	-19.5	0.4	-27.4	-2.4
B	-19.5	-28.3	-27.4	-2.4
World	**-15.6**	**-5.5**	**-20.4**	**-3.2**
EMEs	-19.5	-13.9	-27.4	-2.4

Notes: Compensation using the First Best as benchmark. The numbers in bold denote the departure from the FB model, in terms of steady state consumption. In Cooperation symmetry between instruments rules is assumed for EMEs

The table 4 shows the expected conditional welfare obtained by simulating the models solution at a second order of approximation. The associated welfare levels are shown in the table 10 in the appendix B. I compute the consumption equivalent compensation by normalizing the welfare wedge between each policy model and a reference model (the First Best) by the increase in welfare that would be obtained if consumption were to increase by 1%.[17] These numbers can be interpreted as the equivalent consumption cost derived from transitioning from the first best model to each of the models in the table columns. For example, the world Cooperation model implies a welfare cost equivalent to a decrease of 3.2% in the consumption of every period.

Using the global welfare in the fifth row as the criterion for ranking the expected welfare performance of the models, I find that the best policy framework is the worldwide cooperation, followed by the cooperation between the Center and one periphery (A in Coop(Center+EME-A)), the third best policy would be the non-cooperative one (Nash) and, finally, the worst performing one is the regional cooperation between peripheries (CoopEMEs).

[17]The increase in consumption is applied to the consumption and utility levels used as the initial state for all models. As an alternative, the consumption equivalent cost is computed using a log-utility in consumption approximation, in Lucas (1987). The approximation is relatively valid as our CRRA parameter is close to one and the results are qualitatively the same. The table is reported in the table 9 in the appendix B.

These results suggest that not every type of cooperation will be welfare improving relative to the nationally-oriented regime (Nash case). On the contrary, the cooperation arrangements that are beneficial, globally and to the EMEs, are those that involve a cooperative Center. This helps us answer the first question prompted at the beginning of the section: The emerging economies will not be better off from any type of cooperation, they will only benefit when they can cooperate with a financial center.

At the same time, when looking at the national distribution of the welfare gains, we can see that sustaining the global cooperation would be challenging as the coalition participants will be better-off in the semi-cooperative arrangement (Coop(Center+EME-A) in the table or Coop(A+C) in the model notation). In that case, the gains for the EME-A and the Center are such that they can even overcome the first best allocation at the expense of the periphery that is left out of the coalition (EME-B).

Sources of Welfare Gains From Cooperation For identifying the origins and mechanishms that generate the welfare gains, we can resort to the analytical expression for the optimal tax in the Center under cooperation. Even if more complex, the structure of the taxes in the stochastic and infinite horizon model used to compute the table 4 would be similar.

I find that the optimal tax in the financial center has the following form:

$$\tau_3^{c,coop} = \tau_3^{c,nash} - \overbrace{\varphi_3^{c,NFA}}^{\substack{\text{NFA-led Interest rate} \\ \text{manipulation motive} \\ \text{under Nash}}} + \overbrace{\psi_3^{eme}(\kappa)}^{\substack{\text{local capital for foreign (EME)} \\ \text{intermediation substitution motive}}} \qquad (22)$$

This equation is obtained in the appendix A, NFA stands for net foreign assets and $\tau_3^{c,nash}$ corresponds exactly to the optimal tax for a nationally-oriented (non-cooperative) Center in the equation (3).

The equation (22), with $\varphi_3^{NFA} < 0$ and $\psi_3^{eme}(\kappa) > 0$ will imply that the taxes in the Center that are implemented under cooperation will tend to be larger and favor the capital accumulation in the emerging economies.

Furthermore, by differentiating we have that $\psi_3^{eme\,\prime}(\kappa) > 0$, which implies that the strength of this effect increases with the extent of the peripheral financial distortion.

The welfare enhancing mechanisms, explained by each of the last two terms in the right hand side of (22) work as follows:

Higher Smoothness of Cooperative Taxes: A Cooperative planner that can set the policy tools of the Center and of some or all peripheries (Coop and Coop(A+C)) will find that the incentives to manipulate the global interest rate, in order to improve the net foreign assets position, will dissapear ($-\varphi_3^{NFA}$ cancels out with the same positive term in $\tau_3^{c,nash}$). This happens because in the cooperative welfare expressions, the net foreign assets terms of debtor (EMEs) and creditor (Center) countries go in opposite directions and cancel out, partially or completely, with each other. As a result, there is one fewer source of fluctuations in the cooperative taxes which will make these instruments more stable.

The cancellation effect works better with more peripheries in the policy coalition, and if it is the case, as in our model, when the sum of the welfare weights of the participating EMEs equals that one of the Center.

This mechanism is also present in the literature on cooperative capital controls, such as Davis and Devereux (2019) who describe this effect as the absence of terms of trade manipulation motives by cooperative planners. However, something interesting in this case is that I obtain such result when regulating the banks, rather than taxing the NFA flows directly.

Substitution Motive of Local Capital for Foreign Intermediation: The cooperative planner will have an additional motive for increasing the taxes at the Center. By doing so, it will discourage the local capital accumulation, which in turn protects the capital inflows at the EMEs.

This incentive, represented by φ_3^{NFA} in the equation (22), increases with the financial friction (κ), and is proportional to the scale of the increase in the EMEs capital accumulation after a change in global intermediation, as well as to the capital prices in the peripheries.

In summary, there are two main mechanisms at work: first, a cancellation motive that lowers the volatility of the taxes under cooperation, something that is generally welfare increasing and favors a more efficient pursuit of financial stability goals, as other policy incentives that could be potentially conflicting become absent, and second, a new policy motive towards encouraging the retention of capital flows in the peripheries, even if it comes at the expense of the local capital accumulation of the Center.

Both motives add to the overall financial stability of the world economy. The first one will prevent unnecessary fluctuations in the taxes and even in the global interest rate, hence would lead to less volatility in the international capital fluctuations as the yield-seeking reaction of non-cooperative regimes are muted. The second one, on the other hand, will be a specific motive towards encouraging capital flows to the peripheries, which in presense of external shocks at the Center can be useful in preventing capital retrenchements episodes.

Simultaneously, the second motive also encourages a more efficient use of the capital flows as these are allocated in the more productive destinations. In that spirit, the gains will be boosted as the welfare improving regimes will feature both a higher financial stability and efficiency in the use of capital.

Furthermore, it is important to remark that both motives are present only under cooperative frameworks that include the Center. The first is a cancellation effect between global debtors and creditors incentives, and will be absent if all the countries in the cooperative coalition are debtors as in the peripheric regional cooperation (CoopEMEs).

The second one, on the other hand, is an effect that is unique to the Center given its role as global interbank creditor and recognizes the fact that the cooperative planner acting on behalf of the Center will now internalize the unique capacity she has for boosting the global welfare. This means the tax is not set with the aim to boost the domestic welfare, something that would tentatively imply increasing the local accumulation of capital, but to boost the global output through investment at the peripheries where capital is more productive.

Finally, an additional factor in favor of emerging capital accumulation that is reflected in this model (and is absent in the one of the previous section) is the fact that, unlike in every other regime and type of country, a cooperative planner will tend to set the macroprudential taxes at the Center in a countercyclical fashion.

Table 5: Correlations between output and macroprudential tools in each policy regime

$Corr(\tau^i, Y^i)$	Nash	Cooperation (EMEs)	Cooperation (Center+EME-A)	Cooperation (All)
EME-A	-0.164	-0.265	-0.611	-0.861
EME-B	-0.164	-0.265	-0.221	-0.861
Center	-0.419	-0.425	**0.085**	**0.138**

Cyclicality of the Optimal Policies. In table 5 I report the correlations of the output with the macroprudential tax. Given this tax limits intermediation (capital accumulation), we would have a countercyclical tax when the covariance between the output and the policy tool is positive ($Cov(Y_t, \tau_t) > 0$), i.e., a higher tax is implemented during booms in a way that cools down the banking activities.

The outcome that the Center deviates towards a countercyclical behavior under cooperative frameworks is very important. First, it will implicate the Center planner wants to encourage the capital flows towards the EMEs, so as to prevent retrenchements, and second, it potentially reconciles opposing results of the literature in regards to the cyclicality dimension of these policies by exploiting the varying degree of cooperation across policy regimes.

In terms of the first point, we have that during a boom at the Center, the planner will discourage the inflow (towards the Center) of capital flows at the expense of outflows from the EMEs. It will do so by increasing its taxes and curbing the local financial intermediation.

For the second point, we have on one side, seminal studies as Bianchi (2011) and Jeanne and Korinek (2019) that find the optimal macroprudential policies to be counter-cyclical, as intuition would dictate, since these policies are supposed to cool down the economy rather than to amplify its cycles. On the other hand, Fernández, Rebucci, and Uribe (2015) finds that actual macroprudential policies tend to be procyclical, while Uribe and Schmith-Grohe (2017) supports the procycicallity of these policies in a theoretical context.

On this point, I exploit another dimension of these policies, the degree of cooperation, to find a result that is consistent with both sides of this dicussion.

The results indicate that these policies are procyclical for most of the countries and policy frameworks, as part of the mentioned literature states. However, it turns out that the models that deliver gains from cooperation, originated from a cooperative Center, imply that the tax of that economy will be set countercyclically.

Role of the Welfare Weights. Both of the mechanisms that generate the welfare gains will work better for higher welfare weights of the peripheric welfare in the objective of the cooperative planner. In this paper, I use the relative economic sizes n_i for $i = \{a, b, c\}$ as the actual welfare weights for cooperative regimes. Furthermore, we are assuming that the sum of the peripheral economies sizes amount to that of the Center ($n_a + n_b = n_c$).

With this assumption, first, the cooperative planner will cancel out more evenly the net foreign assets - interest rate manipulation motive of the individual countries, and second, it will have a stronger motive for facilitating the intermediation in the peripheries as these will have a stronger positive effect in its objective, the global welfare.

In that vein, as the economy converges to a small open economy case ($n_a, n_b \to 0$) the cancellation of policy incentives to manipulate the interest rate will no longer work as the cooperative planner would be biased to favor the Center. Also the planner would not find worthwhile to sacrifice local capital accumulation at the Center to encourage peripheric intermediation as the latter, even if more efficient, will not contribute substantially to the global GDP.

Finally, it is relevant to remark that the difference in the welfare gains in favor of the Center is the reason explaining why the semi-cooperative model Coop(A+C) does not perform as well as the global cooperation regime. The fact that the cooperative planner is more biased to increase the welfare of the Center will not allow for a strong enough offsetting of the national interest rate manipulation motives.

On Time Consistency. As part of the auxiliary exercises I also solved a time variant version of this model to explore whether time consistency is relevant in this environment from a welfare perspective. I obtained potentially interesting results. On one hand, it is more difficult to solve the models, something relatively expected as a well known property of time inconsistent models is the presence of underterminacy and sunspots equilibria (Evans and Honkapohja (2003), Evans and Honkapohja (2006)). In fact, it is not possible to obtain a solution for every policy framework. However, the world Cooperation and one of the semicooperative models does yield a solution. This can point to another advantage of cooperation, namely, overriding undeterminacy and non fundamental driven solutions. This may be relevant as the non-fundamental equilibria tend to be welfare decreasing.

Finally, even in the cooperative models that yield a solution, there is a substantial welfare loss with respect to every model I compute under the time consistent framework (timeless perspective). With this, I confirm the conveniency of working with the timeless perspective approximation for the main simulations of this study. The welfare results for a time variant version of the Cooperative model are shown in the table 10 in the appendix B.

6.2 Short Run and Cyclical Performance of the Policy Setups

It is also possible to verify the short-run dynamics and optimal policy paths after financial and real shocks that originate at the Center. By doing this, we can answer the second question of this study: Are cooperative policies useful in protecting the emerging economies from external shocks?.

The type of situation I have in mind when formulating this question is one like the crisis of 2008, where a recessionary shock with origins in the advanced economies ended up having international consequenses as part of the global financial cycle.

Financial shock. The figure 3 shows the dynamic response in the real variables of these economies after a negative financial shock at the Center. The results suggest that, indeed, the global cooperation model protects better the output dynamics of the emerging economies with the semi-cooperative model where the Center cooperates with a periphery (Coop(A+C)) coming in second place. Although in the latter case, as expected, the expansionary effect is concentrated in the periphery that forms a policy coalition with the Center. On the other hand, the dynamics of the regional cooperation case (CoopEMEs) and the Nash are virtually the same, meaning they will not get any extra resilience from engaging in a peripheral cooperation.

With this, we can answer to our second research question: the policy frameworks where the financial Center cooperates are helpful in protecting the emerging economies from external shocks. At the same time, other types of cooperation, such as that between emerging economies only, will not have this feature.

For this protection to happen, we see that the cooperative planners will increase the capital acumulation by EMEs in a much greater scale than non-cooperative planners (fourth row in figure 3). This will come at the expense of the acumulation in the Center, however, it will be deemed appropriate by the planners as their priority now becomes the global output recovery and not only that of the Center. Clearly, such effect will depend on the fact that the relative sizes of the peripheries in our setup are sizable (each amounts to a quarter of the world).

Noticeably, even with a better output response, the emerging economies consumption is hit the most under cooperation (second row panel in the figure). This occurs because the cooperative planners prioritize boosting the investment and intermediation to support the economic activity in these economies. This is reflective of the stronger institutional effort towards aiding the global welfare recovery, even if the shock is not domestic. Finally, the labor supply dynamics will be a by-product of the consumption and capital fluctuations. The former decreases at first, increasing the marginal utility of consumption, while the latter increases, pushing upwards the salaries. As a result, the hours supply increases significantly under cooperation. [18]

The financial variables tell a similar story. I show these in the figure 4. Consistently with the evolution of capital, I obtain that the lending is boosted more strongly under cooperation, although in this case, for every economy. The latter point is crucial, the Center is not accumulating more capital locally for production, however, increases its lending to expand its international financial intermediation activities. Additionally, we see a more persistent build-up of net-worth in the peripheries under cooperative schemes.

On the other hand, the credit spread dynamics reflect a substantial effort by cooperative planners to push up the interest rates in the hit country (Center, third column panel, third row), whereas for the emerging ones we see the opposite. This indicates that the optimal stance under cooperation consists in a fast and active compensation of the effect of the shock (that would push the spread upwards in the peripheries).

Finally, the leverage will go up in the EMEs by construction. However, it is salient that the increase is smoothed over time by the cooperative policymarkers. As for the Center, the non-cooperative planners will try to boost the local leverage, while those that cooperate (Coop and Coop(A+C)) would prefer to focus the intermediation and leverage stimulus on EMEs only. Again, this outlines the critical difference between cooperative and non-cooperative planners, the former internalize its global welfare effects and as a result will know better where to focus (on EMEs) to facilitate a speedier global economic recovery.

Optimal taxes dynamics. The policy response of the planners will be countercyclical on impact for all policy regimes (see fourth row panel in figure 4). That is, the peripheric planners will increase the taxes while the planner at the Center will subsidize the banking sector. However, there are meaningful differences across regimes that explain the discrepancies between the cooperative and non-cooperative outcomes. First, the taxes will be smoother under cooperation and in particular during the first five to ten quarters after the shock. This reflects the comparative advantage of a coordinated policy scheme

[18] This interpretation takes into account that this model displays a wealth effect in the labor supply optimal decisions.

in avoiding unnecessary instrument fluctuations.

Secondly, the non-cooperative Center planner (Nash and Coop(EMEs) regimes) will exert a substantial effort towards increasing the local intermediation by implementing a stronger financial subsidization. The latter does not occur for the other regimes (Coop and Coop(A+C)) as the cooperative planner knows that it could affect negatively the credit spread and, more importantly, the intermediation at the emerging economies.

Figure 3: Response to a negative financial shock at the Center economy

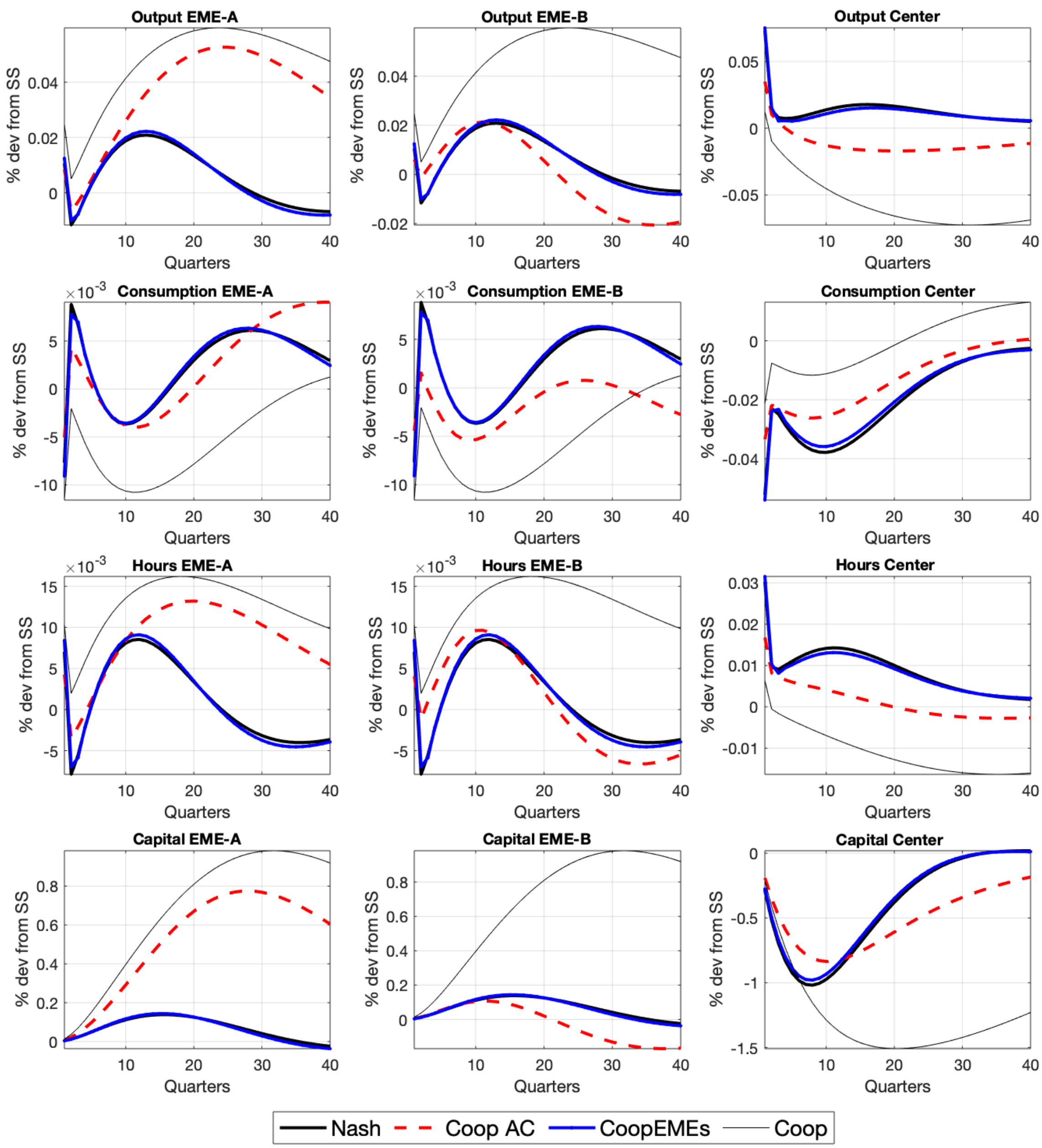
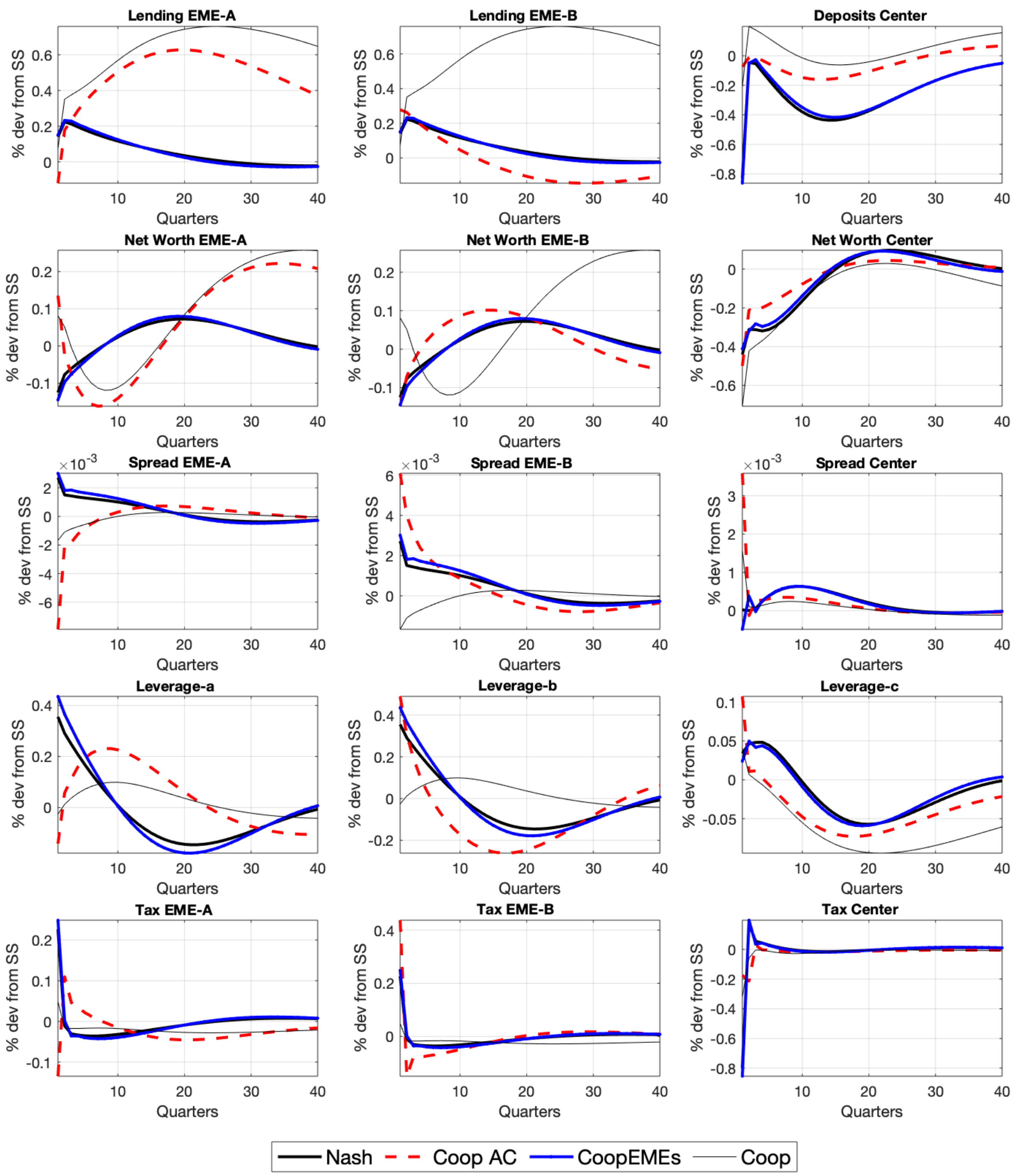
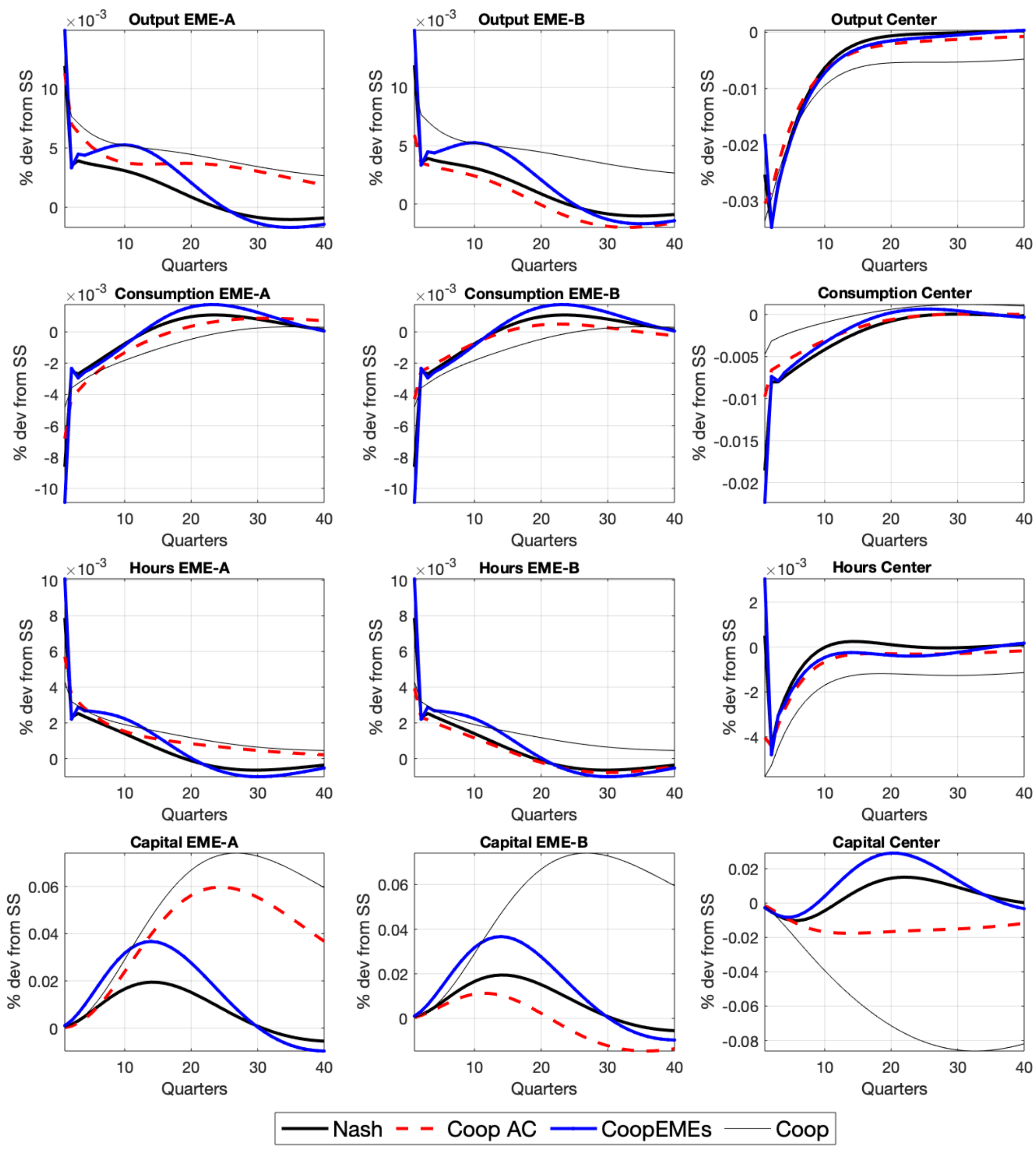


Figure 4: Response to a negative financial shock at the Center economy - Financial Variables and tools



Real Shock. I also report the dynamic response to a negative technological shock in the Center in figure 5. Similarly, I obtain a better output response in the emerging economies with a lengthier Center output recovery under cooperation. Likewise, the capital accumulation in the emerging countries will be larger in the centralized regimes. One difference, nevertheless, is that the increase in capital flows toward the EMEs will be delayed in comparison.

Figure 5: Response to a negative productivity shock at the Center economy

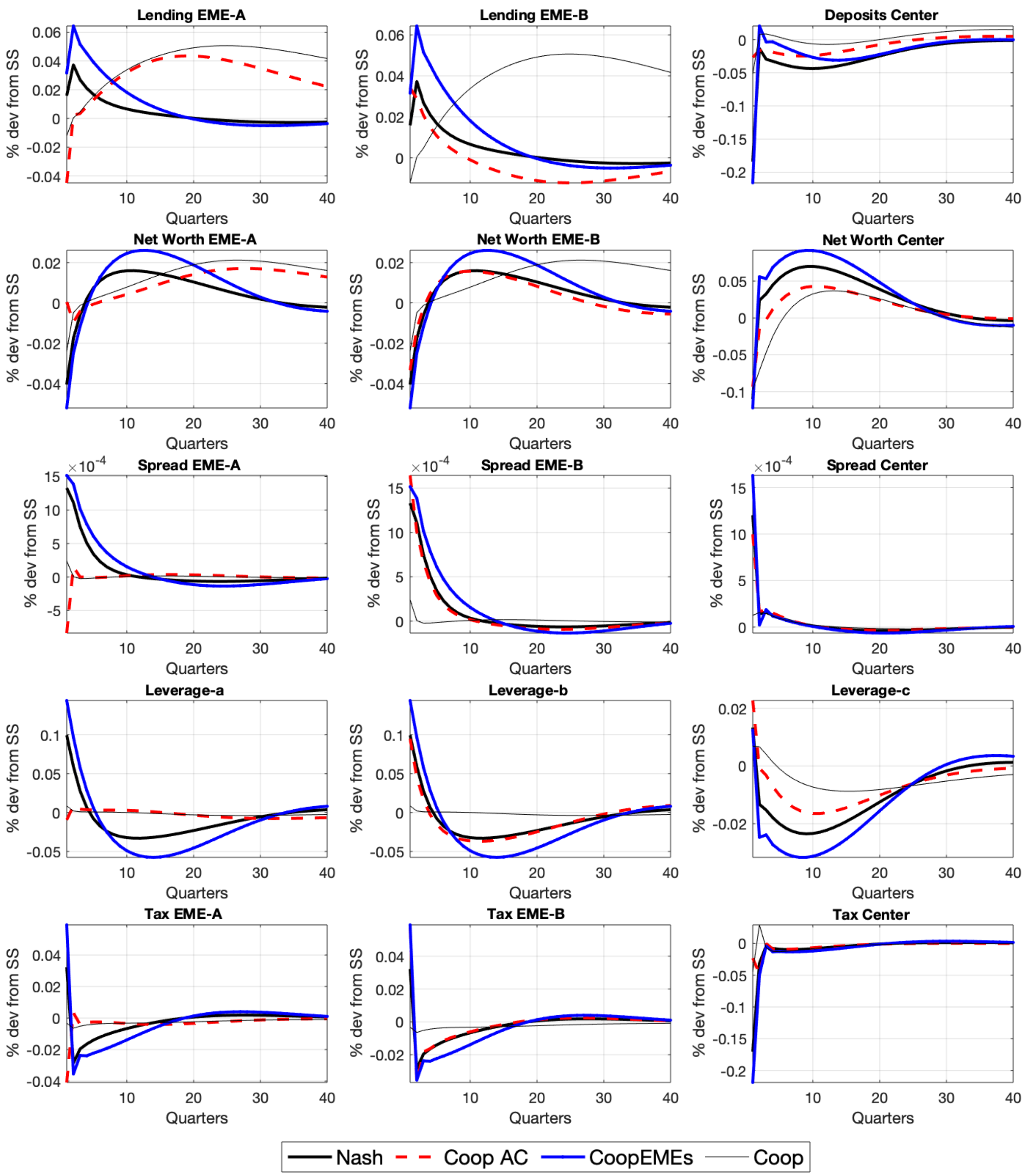


The same occurs with the financial variables as these comove with the level of intermediation. This delayed response feature, characterized by hump shaped responses, for example in the consumption, is documented in Fujiwara, Hirose, and Shintani (2011) and

Steinsson (2008) and reflects the presence of financial frictions in the model.

Simultaneously, the financial variables and the policy instruments vary within a narrower range in the regimes where the center cooperates (Coop and Coop(A+C)), reflective of the financial stability gains from smoother taxes.

Figure 6: Response to a negative productivity shock at the Center economy - Financial Variables and tools



7 Conclusions

In this paper I study whether the international macroprudential policy cooperation is beneficial for emerging economies and can be used to improve their macroeconomic performance and financial resilience. I formulate two specific questions: (i) is macroprudential cooperation beneficial for these economies in general?, and (ii) are cooperative policies useful in protecting these economies from external shocks?.

In a simplified framework, I characterize the structure of the cross-border policy effects and optimal macroprudential policies. As a result, I obtain that two new policy motives appear for a cooperative policymaker that sets the instrument of a financial center. These features will be translated in improved financial stability and an enhanced interbank intermediation towards the emerging economies, which in turn, will generate welfare gains in policy coordination frameworks. Noticeably, this features will be absent in frameworks where only emerging economies engage in cooperation.

I perform a welfare evaluation in an stochastic environment and confirm the existence of welfare gains for frameworks where peripheries collaborate with a Center, answering my first question: cooperation is indeed useful, however, not every type of cooperation will be fruitful, and the presence of a financial center in the arrangement will be crucial.

Nevertheless, I also obtain that the socially optimal policy regime will be the worldwide cooperation, followed by the cooperation between the Center and a subset of the peripheries. This is explained by the fact that the two mechanisms outlined above work better when more emerging economies join their planning efforts. Therefore, the policy recommendation for the peripheries would be that conditional on a participating Center, it is beneficial and advised that more emerging economies join the cooperative initiative.

However, I also obtain that there can be distributional challenges to the implementation of the best social outcome as the second best regime will be more beneficial for its participants and at the expense of the peripheries outside the cooperative coalition.

On the other hand, the short run dynamics and cyclical features of the policies show that the worldwide cooperation and the cooperation between the Center and one emerging periphery will display better output dynamics after a recessionary episode at the Center. This answers the second question: Cooperation, with a Center, allows for an improved protection and output dynamics in the peripheries. This does not occur with the regional cooperation between peripheries. Simultaneously, the best performing regime will be the global cooperation which will display higher and smoother capital accumulation in the peripheries. In addition, the usual deleveraging process after a financial shock will be ameliorated under cooperation.

It should also be noted that an advantage of this study with respect to the rest of the literature is that it provides a clear identification of the two main sources of the welfare gains while also accounting for different types of cooperative and semi-cooperative policies. This allowed me to determine when cooperation works and when it does not, and to generate a clear and innovative policy recomendation.

Finally, while I think this framework represents a contribution in understanding the international role of the macroprudential policies, I acknowledge it still corresponds to a simplified framework that abstracts from other relevant features, such as additional sources of risk (e.g., currency fluctuations) or the presence of regulatory arbitrage and shadowbanking, a core concern for financial regulators. I leave the inclusion of these elements for future work.

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A Results from the Simple Three Periods Model

Proof of proposition 1.

Proof. W.L.O.G. I 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.

Proof: W.L.O.G. I 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 I obtain the leverage, defined as the total assets over net worth. Then I differentiate the resulting expression with respect to the tax.

For the last period:

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

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, I 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 I 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. ■

Table 6: 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]
$C_3 = \pi_{f3} + T_3 + B_2 - T_3$	[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. 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: $\pi^e_{b,2} = (1-\theta)\left(R_{k,2} Q^e_1 K^e_1 - R_1 F^e_1\right)$

Profits of bankers in EMEs, t=3: $\pi^e_{b,3} = R^e_{k,3} Q^e_2 K^e_2 - R_2 F^e_2,$ e = {a,b}

Profits of bankers in Center, t=2: $\pi^c_{b,2} = (1-\theta)\left(R^c_{k,2} Q^c_1 K^c_1 + R^a_1 F^a_1 + R^b_1 F^b_1 - R_1 D_1\right)$

Profits of bankers in Center, t=3: $\pi^c_{b,3} = R^c_{k,3} Q^c_2 K^c_2 + R^a_{b2} F^a_2 + R^b_2 F^b_2 - R_2 D_2$

Table 7: Parameters in the 3-period model

Parameter		**Value**	**Comment/Source**
Adjustment costs of investment	ζ	4.65	Cespedes, Chang and Velasco (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	Captures large open economy effects in all countries
Depreciation rate	δ	0.6	Targets a longer period duration than quarterly
Capital share	α	0.333	Standard

A.1 Optimal Taxes

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

In the case of the Center and for the last period, there is no explicit τ^c_3 terms in the welfare effect. Then, to pintpoint the tax I use the fact that banking returns show the tax explicitely ($R_{k,3}(\tau_3)$) to back out the tax after substituting it for one of the rates it equates.

$$\tau_2^a = \overbrace{\frac{\alpha-1}{\alpha} - \frac{1}{\alpha r_2^a}\left\{(I_1+\kappa K_1)\frac{dQ_1^a}{dK_1^a} + \frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a} + \kappa R_1 Q_1^a\right.}^{\text{contemporaneous component}}$$

$$\underbrace{\left. + \left(1-\frac{\Lambda_{1,2}}{\Lambda_{2,3}}\right)\alpha_4(\kappa)\frac{dQ_2^a}{dK_1^a} + (1-\Lambda_{1,2})\frac{B_2^a}{R_2}\frac{dR_2}{dK_1^a} + \kappa\left(1+\theta\left(\Lambda_{1,2}-\Lambda_{2,3}\right) - \frac{\Lambda_{1,2}}{\Lambda_{2,3}}\right)Q_2^a\frac{dK_2^a}{dK_1^a}\right\}}_{\text{forward-looking component}}$$

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

$$\tau_2^c = \overbrace{-\frac{1}{\theta\alpha r_2^c}\left\{(1-\theta)(1-\delta)Q_2^c + \left(\tfrac{B_1^c}{R_1} - \theta D_1\right)\frac{dR_1}{dK_1^c} + R_1 K_1^c\frac{dQ_1^c}{dK_1^c} + (1-\theta)\left(\frac{dR_{b,1}^{eme}}{dK_1^c}F_1^{ab} + R_{b1}^{eme}\frac{dF_1^{ab}}{dK_1^c}\right)\right.}^{\text{contemporaneous component}}$$

$$\underbrace{\left. + \frac{1}{R_2}\left[\gamma_2\frac{dK_2^c}{dK_1^c} + \frac{B_2^c}{R_2}\frac{dR_2}{dK_1^c} + \gamma_3\frac{dQ_2^c}{dK_1^c} + \left(\frac{dR_{b2}^{eme}}{dK_1^2}F_2^{ab} + R_{b2}^{eme}\frac{dF_2^{ab}}{dK_1^c}\right)\right]\right\}}_{\text{forward looking component}} + \frac{\alpha\theta-1}{\alpha\theta}$$

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

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

Optimal Taxes Under Cooperation. This section shows how to get the optimal Center tax under cooperation and the equation (22).

The procedure is analogous to the individual welfare case (non-cooperative), I will find the welfare effect of setting τ_3^c for the cooperative planner, i.e. $\frac{dW^{coop}}{d\tau_3^c}$, set it equal to zero and solve for the optimal policy $\tau_3^{c,coop}$.

$$\frac{dW_0^{coop}}{d\tau_3^c} = n_a\frac{dW_0^a}{d\tau_3^c} + n_b\frac{dW_0^b}{d\tau_3^c} + (1-n_a-n_c)\frac{dW_0^c}{d\tau_3^c}$$

Now, given the perfect foresight assumption, the equilibrium allocation and welfare is symmetric between peripheries:

$$\frac{dW_0^{coop}}{d\tau_3^c} = (n_a + n_b)\frac{dW_0^a}{d\tau_3^c} + (1 - n_a - n_c)\,\frac{dW_0^c}{d\tau_3^c}$$

Furthermore, I simplify further by using the parameter values $n_a = n_b = \frac{1}{4}$. That is, the summation of the sizes of the peripheral economies equals that of the Center,

$$\frac{dW_0^{coop}}{d\tau_3^c} = \frac{dW_0^a}{d\tau_3^c} + \frac{dW_0^c}{d\tau_3^c}$$

By substituting each of the individual welfare effects in the right hand side:

$$\begin{aligned}\frac{dW_0^{coop}}{d\tau_3^c} = &\Bigg[\beta\lambda_2^a\left(\kappa\left(1-\theta\Lambda_{2,3}\right)Q_2^a + \varphi\left(\tau_3^c\right)\Lambda_{2,3}r_3^a\right)\frac{dK_2^a}{d\tau_3^c} + \beta\lambda_2^a\left(I_2^a + \kappa\left(1-\theta\Lambda_{2,3}\right)K_2^a\right)\frac{dQ_2^a}{d\tau_3^c} \\ &+\beta^2\lambda_3^a\frac{B_2^a}{R_2}\frac{dR_2}{d\tau_3^c}\Bigg] + \Bigg[\beta^2\lambda_3^c\left(r_3^c + (1-\delta)Q_3\right)\frac{dK_2^c}{d\tau_3^c} + \beta^2\lambda_3^c\frac{B_2^c}{R_2}\frac{dR_2}{d\tau_3^c} + \beta\lambda_2^c\left(I_2^c + (1-\theta)(1-\delta)K_1^c\right)\frac{dQ_2^c}{d\tau_3^c} \\ &+\beta^2\lambda_3^c\left(\frac{dR_{b2}^{eme}}{d\tau_3^c}\left(F_2^a + F_2^b\right) + R_{b_2}^{eme}\left(\frac{dF_2^a}{d\tau_3^c} + \frac{dF_2^b}{d\tau_3^c}\right)\right)\Bigg]\end{aligned}$$

Or in simpler terms and with $F_2^{ab} = F_3^a + F_3^b$:

$$\begin{aligned}\frac{dW_0^{coop}}{d\tau_3^c} = &\left[\alpha_1\frac{dK_2^a}{d\tau_3^c} + \alpha_2\frac{dQ_2^a}{d\tau_3^c} + \beta^2\lambda_3^a\frac{B_2^a}{R_2}\frac{dR_2}{d\tau_3^c}\right] + \Bigg[\beta^2\lambda_3^c\alpha_3\frac{dK_2^c}{d\tau_3^c} + \beta^2\lambda_3^c\frac{B_2^c}{R_2}\frac{dR_2}{d\tau_3^c} + \alpha_4\frac{dQ_2^c}{d\tau_3^c} \\ &+\beta^2\lambda_3^c\frac{dR_{b2}^{eme}}{d\tau_3^c}F_2^{ab} + \beta^2\lambda_3^c R_{b_2}^{eme}\frac{dF_2^{ab}}{d\tau_3^c}\Bigg]\end{aligned}$$

The first term in square brackets corresponds to the welfare effects for the peripheric block and the second to that of the Center. Now I use the UIP assumption and absence of a spread in the center to replace: $R_{b,2}^{eme} = R_{k,3}^c = \frac{(1-\tau_3^c)r_3^c + (1-\delta)Q_3}{Q_2^c}$ and equate $\frac{dW^a}{d\tau_3^c}$ to zero, meaning that τ_3^c in the expression becomes the optimal one $\tau_3^{c,coop}$:

$$\begin{aligned}\frac{dW_0^{coop}}{d\tau_3^c} = &\left[\alpha_1\frac{dK_2^a}{d\tau_3^c} + \alpha_2\frac{dQ_2^a}{d\tau_3^c} + \beta^2\lambda_3^a\frac{B_2^a}{R_2}\frac{dR_2}{d\tau_3^c}\right] + \Bigg[\beta^2\lambda_3^c\alpha_3\frac{dK_2^c}{d\tau_3^c} + \beta^2\lambda_3^c\frac{B_2^c}{R_2}\frac{dR_2}{d\tau_3^c} + \alpha_4\frac{dQ_2^c}{d\tau_3^c} \\ &+\beta^2\lambda_3^c\frac{dR_{b2}^{eme}}{d\tau_3^c}F_2^{ab} + \beta^2\lambda_3^c\frac{(1-\tau_3^{c,coop})r_3^c + (1-\delta)Q_3}{Q_2^c}\frac{dF_2^{ab}}{d\tau_3^c}\Bigg] = 0\end{aligned}$$

Solving for $\tau_3^{c,coop}$, and replacing $\alpha_1, \alpha_2, \alpha_3, \alpha_4$, yields:

$$\tau_3^{c,coop} = \frac{Q_2^c}{\Lambda_{2,3} r_3^c} \frac{\lambda_2^a}{\lambda_2^c} \left\{ (\kappa(1-\theta\Lambda_{2,3})Q_2 + \varphi(\tau_3^a)\Lambda_{2,3} r_3^a) \frac{dK_2^a}{dF_2^{ab}} + (I_2^a + \kappa(1-\theta\Lambda_{2,3}K_2^a)) \frac{dQ_2^a}{dF_2^{ab}} \right\}$$
$$+ \frac{Q_2^c}{\Lambda_{2,3} r_3^c} \left(\Lambda_{2,3} \left(r_3^c + (1-\delta)Q_3 \right) \frac{dK_2^c}{\partial F_2^{ab}} + \left(I_2^c + (1-\theta)(1-\delta)K_1^c \right) \frac{dQ_2^c}{dF_2^{ab}} + \Lambda_{2,3} F_2^{ab} \frac{dR_{b2}^{eme}}{dF_2^{ab}} \right)$$
$$+ \frac{(1-\delta)Q_3^c}{r_3^c} + 1 + \frac{Q_2^c}{r_3^c} \left(\frac{B_2^c}{R_2} \frac{dR_2}{dF_2^{ab}} - \frac{\lambda_2^a}{\lambda_2^c} \frac{B_2^c}{R_2} \frac{dR_2}{dF_2^{ab}} \right)$$

In this expression I substituted $B_2^a = -B_2^c$ for the last term.

We can notice the last two lines in the expression are equal to $\tau_3^{c,nash} - \frac{Q_2^c}{r_3^c} \frac{\lambda_2^a}{\lambda_2^c} \frac{B_2^c}{R_2} \frac{dR_2}{dF_2^{ab}}$ where $\tau_3^{c,nash}$ is the optimal individual planner tax given by the equation 3. Thus the optimal cooperative tax can be expressed as:

$$\tau_3^{c,coop} = \overbrace{\frac{Q_2^c}{\Lambda_{2,3} r_3^c} \frac{\lambda_2^a}{\lambda_2^c} \left\{ (\kappa(1-\theta\Lambda_{2,3})Q_2 + \varphi(\tau_3^a)\Lambda_{2,3} r_3^a) \frac{dK_2^a}{dF_2^{ab}} + (I_2^a + \kappa(1-\theta\Lambda_{2,3}K_2^a)) \frac{dQ_2^a}{dF_2^{ab}} \right\}}^{\text{New substitution of Center capital accumulation for foreign intermediation (EMEs) motive under cooperation}}$$
$$+ \tau_3^{c,nash} - \frac{\lambda_2^a}{\lambda_2^c} \underbrace{\frac{Q_2^c}{r_3^c} \frac{B_2^c}{R_2} \frac{dR_2}{dF_2^{ab}}}_{\substack{\text{NFA-led interest rate} \\ \text{manipulation motive} \\ \text{at Center}}}$$

The first right hand side term will represent a new motive for pushing up the taxes in order to lower local Center capital accumulation in favor of emerging economies capital accumulation and intermediation. This term is unambiguously positive for the considered parameter values (as long as the taxes at the periphery is larger than -2).

On the other hand, the last term represents a cancelation term that offsets the policy incentives of the Center for manipulating the global interest rate to take benefit of their net foreign assets (bonds) position. This manipulation incentive is canceled out because the welfare effects of movements in the net foreign assets of the countries engaging in the cooperative arrangement will go in opposite directions between debtors and creditors.

We can make a further simplification[19], for a clearer argument and assume the $\lambda_2^a = \lambda_2^c$ which leads to the equation (22).

An analogous procedure can be carried out with the welfare effects of the peripheral

[19] Otherwise, and in general with $\lambda_2^a \neq \lambda_2^c$, the compensation effect acts even stronger and in favor of the peripheries as $\lambda_2^a > \lambda_2^c$.

taxes under cooperation which would generate the following optimal tax:

$$\tau_3^{a,coop} = \overbrace{\frac{\alpha-1}{\alpha} - \frac{1}{\alpha\Lambda_{2,3}r_3^a}\left\{\left(\alpha_4(\kappa)\frac{dQ_2^a}{dK_2^a} + \kappa\left(1-\theta\Lambda_{2,3}\right)Q_2^a\right) + \left(\frac{B_2^a}{(R_2)^2}\right.}^{\tau_3^{a,nash}} \left. - \frac{\lambda_2^c}{\lambda_2^a}\frac{B_2^a}{(R_2)^2}\right)\frac{dR_2}{dK_2^a}$$
$$\left(\gamma_2\Lambda_{2,3}\frac{dK_2^c}{dK_2^a} + \gamma_3\frac{dQ_2^c}{dK_2^a} + \Lambda_{2,3}F_2^{ab}\frac{dR_{b,2}^{\text{eme}}}{dK_2^a} + R_{b,2}^{\text{eme}}\frac{dF_2^{ab}}{dK_2^a}\right)\right\}$$

with $\alpha_4 = I_2^a + \kappa(1-\theta\Lambda_{2,3})K_2$, $\gamma_2 = r_3^c + (1-\delta)Q_3$, and $\gamma_3 = I_2^c + (1-\theta)(1-\delta)K_1^c$

In terms of the interpretation in section 6 we can express the tax in terms of a wedge with respect to the non-cooperative one as:

$$\tau_3^{a,coop} = \tau_3^{a,nash} - \varphi_3^{a,NFA} - \omega_3$$

Although not refered to explicitely in the main sections, it can be noticed ω_3 is consistent the fact a cooperative planner sets higher subsidies with the EMEs instruments.

B Results from the Main Model

B.1 Steady State of the Policy Models

In the Ramsey model works with a instrument conditional steady state, i.e., a value for the policy tools $\bar{\tau}$ is set and the associated steady state for the rest of the variables is obtained. A related question of utmost importance would be, how to determine the instrument level ($\bar{\tau}$) for conditioning?.

For that, I follow an algorithm outlined in Christiano, Motto and Rostagno (2007):

1. set any value for $\bar{\tau}$ and solve, using the static private FOCs, for the steady state of private variables: $\mathbf{x_t}$

2. replace $\mathbf{x_t}$ in remaining $N+k$ equations, the policy FOC w.r.t. the N endogenous variables and k tools: get a linear system of $N+k$ equations for N unknowns (policy multipliers)

3. With more equations than unknowns the solution is subject to an approximation

error $\mathbf{u}$:

(i) set the $N+k$ static equations in vector form as: $U_1 + \bar{\lambda}[1/\beta F_3 + F_2 + \beta F_1] = 0$

(ii) let $Y = U_1'$, $X = [1/\beta F_3 + F_2 + \beta F_1]$ and $\beta = \bar{\lambda}'$

(iii) get the tools as: $\beta = (X'X)^{-1}X'Y$ with error $\mathbf{u} = Y - X\beta$

(iv) repeat for several values of the tools and choose $\bar{\boldsymbol{\tau}}$ such that: $\bar{\boldsymbol{\tau}} = \arg\min_{\tau} \mathbf{u}$

B.2 Parameters of the Model

The table contains the parameter used in the baseline model.

Table 8: Parameters in the model

Parameter		**Value**	**Comment/Source**
Adjustment costs of investment	ζ	3.456	Banerjee et al. (2016)
Adjustment costs of assets	η	0.0025	Ghironi and Ozhan (2020)
Start-up transfer rate to banks	δ_b	0.003	Gertler and Karadi (2011), Gertler and Kiyotaki (2010)
Survival rate of banking sector	θ	0.95	Gertler and Karadi (2011), Gertler and Kiyotaki (2010)
Divertable fraction of capital	$\kappa^a, \kappa^b, \kappa^c, \kappa^c_{F_1}, \kappa^c_{F_2}$	0.38	Banerjee et al. (2016) Aoki, Benigno and Kiyotaki (2018)
Discount factor	β	0.99	Standard
Risk Aversion parameter	σ	1.02	Standard
Inverse Frisch elasticity of labor supply	ψ	0.276	Standard
Country size	$n_a = n_b$	0.25	
Depreciation rate	δ	0.025	Standard
Capital share	α	0.333	Standard
Persistency of productivity shocks	ρ_A	0.85	Standard
Persistency of capital shock	ρ_{xi}	0.85	Standard
Std. Dev. of productivity shocks	σ_A	0.007	Standard
Std. Dev. of capital shock	σ_{xi}	0.005	Standard

B.3 Welfare Accounting Supplementary Exercises

Table 9: Welfare in consumption equivalent compensation units (alternative method)

	Consumption Equivalent % Compensation				
	Nash	Cooperation (Center+EME-A)	Cooperation (EMEs)	Cooperation (All)	Cooperation (Time Variant)
C	-10.8	2.9	-12.1	-3.8	-93.9
A	-17.5	-0.4	-23.7	-2.3	-97.6
B	-17.5	-24.3	-23.7	-2.3	-97.6
World	**-14.2**	**-5.3**	**-18.1**	**-3.0**	**-96.1**
EMEs	-17.5	-12.8	-23.7	-2.3	-97.6

Notes: Compensation using the First Best as benchmark.

In Cooperation symmetry between instruments rules is assumed for EMEs

Table 10: Welfare levels and consumption equivalent compensation (includes Time Variant Model)

	Nash	Cooperation (Center+EME-A)	Cooperation (EMEs)	Cooperation (All)	Cooperation (Time Variant)
Welfare levels					
W^c	-4975.8	-4961.6	-4977.4	-4968.3	-5243.6
W^a	-5036.2	-5016.6	-5044.0	-5019.4	-5388.6
W^b	-5036.2	-5044.9	-5044.0	-5019.4	-5388.6
W	-5006.0	-4996.2	-5010.7	-4993.8	-5316.1
W^{ab}	-5036.2	-5030.7	-5044.0	-5019.4	-5388.6
Consumption Equivalent Compensation					
C	-11.7	2.9	-13.2	3.9	-286.1
A	-19.5	0.4	-27.4	-2.4	-377.5
B	-19.5	-28.3	-27.4	-2.4	-377.5
World	**-15.6**	**-5.5**	**-20.4**	**-3.2**	**-332.2**
EMEs	-19.5	-13.9	-27.4	-2.4	-377.1

Notes: Compensation using the First Best as benchmark.

In Cooperation symmetry between instruments rules is assumed for EMEs

Summary of final model equations. To obtain a summarized version of the model equations I substitute the marginal product of capital, wages, tax rebates and the interest rates that are equalized due to the uncovered interest rate parity. The result is:

Table 11: Summary of private equilibrium equations of the baseline model

Common to all countries:	
$Q_t^i = 1 + \frac{\zeta}{2}\left(\frac{I_t^i}{I_{t-1}^i} - 1\right)^2 + \zeta\left(\frac{I_t^i}{I_{t-1}^i} - 1\right)\frac{I_t^i}{I_{t-1}^i} - \Lambda_{t,t+1}^i \zeta \left(\frac{I_{t+1}^i}{I_t^i}\right)^2 \left(\frac{I_{t+1}^i}{I_t^i} - 1\right)$	[Price of Capital]
$K_t^i = I_t^i + (1-\delta)\xi_t^i K_{t-1}^i$	[Capital Dynamics]
$R_{k,t}^i = \frac{(1-\tau_t^i)\alpha A_t^i H_t^{i\ (1-\alpha)} \xi_t^{i\alpha} K_{t-1}^{i\ (\alpha-1)} + (1-\delta)\xi_t^i Q_t^i}{Q_{t-1}^i}$	[Banks rate of return]
$R_t \Lambda_{t,t+1}^i = 1 + \eta\left(B_t^i\right)$	[Euler Equation, bonds]
$C_t^{i\ -\sigma} = \frac{H_t^{i\ \psi}}{(1-\alpha)A_t^i(\xi_t^i K_{t-1}^i)^\alpha H_t^{i\ (-\alpha)}}$	[Intra-temporal Euler Equation, labor]
$Y_t^i = A_t^i\left(\xi_t^i K_{t-1}^i\right)^\alpha H_t^{i\ 1-\alpha}$	[Output]
$\Lambda_{t,t+1}^i = \beta\left(\frac{C_{t+1}^i}{C_t^i}\right)^{-\sigma}$	[Stochastic Discount Factor]
$A_t^i = \rho_A A_{t-1}^i + \sigma_A \epsilon_{A,t}^i$	[Aggregate Productivity]
$\xi_t^i = \rho_\xi \xi_{t-1}^i + \sigma_\xi \epsilon_{k,t}^i$	[Capital Quality]
for EMEs:	
$Q_t^e K_t^e = N_t^e + F_t^e$	[Bal. sheet of banks]
$\mathbb{E}_t \Omega_{t+1\mid t}^i \left(R_{k,t+1}^i - R_{b,t}^i\right) = \mu_t^i \kappa^i$	[Credit Spread]
$j_t^e N_t^e = \kappa^e Q_t^e K_t^e$	[ICC]
$N_t^a = \theta\left[R_{k,t}^a Q_{t-1}^a K_{t-1}^a - R_{b,t-1}^a F_{t-1}^a\right] + \delta_B Q_t^a K_{t-1}^a \kappa$	[Net Worth Dynamics]
$j_t^e(1-\mu_t^e) = \mathbb{E}_t\left[\Omega_{t+1\mid t}^e R_{b,t}^e\right]$	[Envelope Condition for Net Worth]
$C_t^e + B_t^e + \frac{\eta}{2}(B_t^e)^2 = R_{t-1}B_{t-1}^e + (1-\alpha)A_t^e(\xi_t^e K_{t-1}^e)^\alpha H_t^{e\ (1-\alpha)} + \Pi_t^a$	[Budget Constraint, households]
for the Center:	
$Q_t^c K_t^c + F_t^a + F_t^b = N_t^c + D_t^c$	[Bal. sheet of banks]
$\mathbb{E}_t \Omega_{t+1\mid t}^c \left(R_{k,t+1}^c - R_{D,t}^c\right) = \mu_t^c \kappa^c$	[Credit Spread for Local Intermediation]
$\mathbb{E}_t \Omega_{t+1\mid t}^c \left(R_{b,t}^a - R_{D,t}^c\right) = \mu_t^c \kappa_{F_a}^c$	[Spread for Foreign Lending to EME-A]
$\mathbb{E}_t \Omega_{t+1\mid t}^c \left(R_{b,t}^b - R_{D,t}^c\right) = \mu_t^c \kappa_{F_b}^c$	[Spread for Foreign Lending to EME-B]
$j_t^c N_t^c = \kappa^c Q_t^c K_t^c + \kappa_{F_a}^c F_t^a + \kappa_{F_b}^c F_t^b$	[ICC]
$N_t^c = \theta\left[R_{k,t}^c Q_{t-1}^c K_{t-1}^c + R_{b,t-1}^a F_{t-1}^a + R_{b,t-1}^b F_{t-1}^b - R_{D,t-1}^c D_{t-1}^c\right] + \delta_B Q_t^c K_{t-1}^c$	[Net Worth Dynamics]
$j_t^c(1-\mu_t^c) = \mathbb{E}_t\left[\Omega_{t+1\mid t}^c R_{D,t}^c\right]$	[Envelope Condition for Net Worth]
$C_t^c + B_t^c + \frac{\eta}{2}(B_t^c)^2 + D_t^c + \frac{\eta}{2}\left(D_t^c - \bar{D}^c\right)^2 = R_{t-1}^c B_{t-1}^c + R_{D,t-1}^c D_{t-1}^c + w_t^c H_t^c + \Pi_t^c$	[Budget Constraint, households]
$R_{D,t}^c \Lambda_{t+1}^c = 1$	[Euler Equation, deposits]
International Links:	
$n_a B_t^a + n_b B_t^b + n_c B_t^c = 0$	[Net Supply of Bonds]

Note: $i = \{a, b, c\}$, $e = \{a, b\}$ and $w_t^c = (1-\alpha)Y_t^c/H_t^c$ corresponds to the wages.

In this system of equations I use the following auxiliary definitions:

$$\begin{aligned}
\Pi_t^c = (1-\theta)\left[Q_{t-1}^c R_{k,t}^c K_{t-1}^c + R_{b,t-1}^a F_{t-1}^a + R_{b,t-1}^b F_{t-1}^b - R_{D,t-1}^c D_{t-1}^c\right] - \delta_B Q_t^c K_{t-1}^c + Q_t^c I_t^c \\
-I_t^c \left(1 + \frac{\zeta}{2}\left(\frac{I_t^c}{I_{t-1}^c} - 1\right)^2\right) + \tau_t^c \alpha A_t^c H_t^{c\ (1-\alpha)} \xi_t^{c\ \alpha} K_{t-1}^{c\ (\alpha)} \\
\Pi_t^a = (1-\theta)\left[Q_{t-1}^a R_{k,t}^a K_{t-1}^a - R_{b,t-1}^a F_{t-1}^a\right] - \delta_B Q_t^a K_{t-1}^a + Q_t^a I_t^a - I_t^a \left(1 + \frac{\zeta}{2}\left(\frac{I_t^a}{I_{t-1}^a} - 1\right)^2\right) \\
+\tau_t^a \alpha A_t^a H_t^{a\ (1-\alpha)} \xi_t^{a\ \alpha} K_{t-1}^{a\ (\alpha)} \\
\Pi_t^b = (1-\theta)\left[Q_{t-1}^b R_{k,t}^b K_{t-1}^b - R_{b,t-1}^b F_{t-1}^b\right] - \delta_B Q_t^b K_{t-1}^b + Q_t^b I_t^b - I_t^b \left(1 + \frac{\zeta}{2}\left(\frac{I_t^b}{I_{t-1}^b} - 1\right)^2\right) \\
+\tau_t^b \alpha A_t^b H_t^{b\ (1-\alpha)} \xi_t^{b\ \alpha} K_{t-1}^{b\ (\alpha)}
\end{aligned}$$