Essays on International Macroprudential Policy Interactions

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Abstract

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In this dissertation, I study the international interactions of financial regulations and the macroeconomic implications of accounting for the borderless dimension of these policies when designing macroprudential coordinated policy frameworks. In the first chapter, I revise empirically if there is evidence supporting the existence of strategic policy interactions between regulators based in different economies. I find that for some types of economies and instruments, the foreign prudential policies may be relevant benchmarks that they consider for adjusting their policies, and point that these additional adjustments, or interactions, could potentially generate the scope for policy coordination improvements. In chapter two, I set a theoretical framework for thinking about the international policy macroeconomic spillovers that could justify such interactions. I specify the relevant factors these may depend on, the relevance of these policies for mitigating financial market frictions, and the importance of considering interactions both at the global level, between centers and peripheries, as well as regionally between peripheries alone. In the third chapter, I argue a dynamic setup is necessary for a complete welfare evaluation of potential cooperative setups given the persistence of the effect of policy on the regulated banks. Then I set a dynamic, stochastic, general equilibrium model with multi-peripheral features to study when coordination can be fruitful and when it becomes counterproductive. I obtain the mechanisms driving the potential welfare and financial stability gains of coordination, and generate policy recommendations on when to engage in a cooperative effort and why. I conclude the dissertation mentioning potential extensions of these studies for future work.

More specifically, in chapter one, I obtain that the dynamics of the prudential instruments set by policymakers are consistent with the application of regulatory adjustments that would

depend on the domestic perception about the nature of the financial stability spillover effect of the actions exerted by foreign regulators, which itself tends to be an instrument-specific feature. When the effect is positive the regulators engage in policy substitution efforts and relax their policy stance, choosing to rely on the stricter regulations of other countries. On the contrary, when the potential effect is negative the regulators engage in policy competition efforts and match the foreign policy tightenings with local stricter policies. The former is found on interactions between peer, or similar economies, such as advanced reacting to advanced, or emerging countries reacting to other emerging, while the latter effect is found on interactions of non-similar economies (emerging-to-advanced, and advanced-to-emerging).

In chapter two, I set up a three-country center-multiperpheral model, where I model a regulated banking sector in each economy that is subject to financial agency frictions. In that setup the financial center will act as a global creditor which I found will be a key feature in simultaneously dampening the local effects, and increasing the cross-border effects of the macroprudential policies at the center, which jointly will imply important international spillovers towards the emerging economies. I explain how coordinated policies imply a mitigation in the level of interventionism required for the treatmeant of the financial frictions which implies that coordinated policies can be worth pursuing in presence of important implementation costs of the regulations.

Finally, in the last chapter, I make a comprehensive welfare comparison of coordinated, semi-coordinated, and decentralized policy frameworks in a multilateral environment, and explain that a necessary condition for policy coordination to be welfare improving is that the financial center acts cooperatively, otherwise policy cooperation becomes counterproductive. I identify two mechanisms that generate these welfare gains, namely the cancelation of the incentives to manipulate the global interest rates with policy within a cooperative coalition, and a policy motive for substituting local capital accumulation at the financial center for global intermediation towards the peripheries. I show these mechanisms work better with coalitions where more emerging economies interact cooperatively with the center and provide policy recommendations on when cooperation is worth pursuing.

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I am also grateful to my family, my parents, and my grandmother. They raised me well, with good values, and with love and support for my urge to pursue my dreams, no matter where they took me or for how long. My dad, in particular, has been a referent to me. He has taught me the satisfaction of quenching my academic curiosity, as well as to enjoy the learning processes, journeys, and detours in life, as much or more than the achievements themselves.

Last but never least, I am infinitely grateful to my wife, Daniela. She supported me immensely during every moment of this experience, and I can say, with confidence, that with all of her efforts, patience, and devotion, she made it possible for me to have the freedom to immerse into my dissertation and enjoy my Ph.D. to the fullest. She even brought home in the middle of the program our little pet Taro to relax me and to walk (me or I to him?) around frequently. It was during those walks that many of the ideas imprinted in this document were born.

DEDICATION

to my parents, siblings, my grandmother Alba Lilia, my dear wife, Daniela, and to Willy, Maya and Taro.

Chapter 1

MACROPRUDENTIAL POLICY INTERACTIONS: WHAT HAS CHANGED SINCE THE GLOBAL FINANCIAL CRISIS?

1.1 Introduction

Do countries adjust their macroprudential policies in presence of foreign regulatory changes for strategic purposes? We investigate whether this could be the case for advanced and emerging economies, focusing on the change of these potential policy interactions after the Global Financial Crisis.

The macroeconomic effects of prudential regulations have been studied actively since the onset of the Global Financial Crisis. In that effort, a consensus has been reached suggesting these policies are effective on their targets (Cerutti, Claessens, and Laeven (2017), Akinci and Olmstead-Rumsey (2018), Claessens, Ghosh, and Mihet (2013), Aikman et al. (2019)), but also imply unintended policy leakages and external effects that can be detrimental for agents outside the financial system (Richter, Schularick, and Shim (2019b), Boar et al. (2017), Aikman, Bush, and Davis (2016)). This property of the prudential tools generates a trade-off for regulators between financial stability and other desired features for policymakers (e.g., macroeconomic growth), and because of that, a key emphasis of macroprudential regulation relates the application of the appropriate but least necessary level of interventions.

Simultaneously, these external effects can extend to other economies (Buch and Goldberg (2017), Forbes, Reinhardt, and Wieladek (2017)), and as suggested by Forbes (2020), these leakages can mitigate the effectiveness of these policies or even generate new vulnerabilities. In light of that, it can be natural for a domestic regulator to adjust its own policies, not only in response to local and global fundamentals, but also stratetically as a function of foreign policy dynamics. In this study, we refer to such cross-border reaction, that is not based on the observed state of fundamentals, as international policy interactions.

Verifying the presence of these policy-to-policy interactions can be relevant as these may constitute a critical feature for the design and evaluation of regulation. Such effects may imply important departures between the inteded and actual outcomes of policy and may become a

source of economic inefficiency, for example, in the case that countries engage in international regulatory feedback loops with their instruments that lead to excessive interventionism.

With this in mind, we use a local projection approach to estimate the empirical domestic macroprudential dynamic response to changes in the prudential policies implemented in the rest of the world, and after accounting for the regulatory response to economic and financial fundamentals. In doing this, we exploit information about multiple macroprudential instruments at the cross-country level for a panel of 65 economies that include 23 advanced economies, 31 emerging economies, and 11 low income economies.

This methodology provides a flexible framework for separating the effects of a foreign policy that are intermediated by fluctuations in observed fundamentals (policy-to-fundamentals effect) from the direct effects of changes in foreign regulations (policy-to-policy effects), and can be easily applied for a large number of specifications that vary by type of policies, of domestic economy, or origin of foreign policy innovations and sample period.

Our main results suggest that countries tend to adjust their policies in response to foreign regulatory changes beyond what could be explained by the direct spillover of these regulations in observed local and global fundamentals, i.e. a policy-to-policy interaction takes place in the sense that domestic regulations are adjusted strategically and in anticipation to potential foreign policy leakages. The average reaction is positive, implying that a foreign policy tightening is followed by a local tightening adjustment. This effect can vary by the type of local economy reacting (advanced or emerging), the type of foreign country implementing the policy, the type of instrument changing abroad, and the period of reference for estimating the effect.

On the type of country dimension, there are strong reactions to foreign policies implemented in advanced economies while the reactions to emerging economies' regulations is usually weaker. However, we also obtain that it is important to disentangle the policy interaction effect by the type of instrument changing abroad, as the results based on specificic categories of policy tools that are considered separately may differ from the aggregate substantially.

In effect, when splitting the aggregate policy indicator into instruments' classifications we find more interesting results. We obtain that similar economies seem to engage in positive policy interactions resembling regulatory competitions. That will be the case of advanced-to-advanced or emerging-to-emerging policy reactions. In that case, the domestic planner would perceive that the foreign policy change is detrimental their financial stability and would be prompted to implement more stringent policies as a response. In constrast, for non-similar economies, that is, for advanded-to-emerging, or emerging-to-advanced, we see that the reaction is negative and could resemble a policy substitution, meaning that these economies might not perceive that the foreign policy is instead beneficial, thus providing them with the scope to relax local regulations.

We also find that emerging economies seem to engage in policy competitions almost exclusively in regards to foreign policies related with the global financial cycle, which represents their most immediate macroprudential concern as pointed out by Rey (2013) and Alam et al. (2019). In contrast, their competitive reaction to other instruments is less prevalent across classifications. For advanced economies, on the other hand, the reaction will be competitive across most instruments categories, although as mentioned, mostly in response to policy changes in other advanced economies.

Our results suggest that there are some cases in which countries do react strategically to a selection of foreign prudential policies. For such selection, the regulations implemented in advanced economies will be of particular interest. However, the tightening-to-tightenign adjustments are generally be given in cases where regulatory arbitrage by financial intermediaries is more likely to occurr, which would be the case between peer economies (advanded-to-advanced or emerging-to-emerging). For other cases, where the response of local regulators consists on relaxing their toolkit, there could be potential free-riding incentives of these regulators on the policy actions of their foreign counterparts.

These policy interactions are not elicited by observable changes in fundamentals and can imply an additional degree of macroprudential interventionism, usually in the direction of implementing more policy tightenings, which may not be desirable from the prudential policy perspective and could imply a scope (or implied only by prudential foreign spillovers on local fundamentals) for improvements in the outcomes of regulations from the implementation of internationally coordinated policies.

These results are novel and help clarify the empirical policy considerations made by regulators that internalize the effect of global banking activities and foreign macroprudential policies in their domestic financial sector. Until now, the literature had documented the intended effects of these policies or the presence of regulation leakages, which in itself might justify domestic policy adjustments based on the state of economic fundamentals, but it wasn't clear about whether there exists strategic mechanisms at work implying further policy adjustments by policymakers.

Related Literature. This paper is related to the empirical studies of the effects of macroprudential policies. [1] More specifically, it relates closely to articles concerned about the external effects of the macroprudential toolkit.

[1] Another group of contributions touch these same topics from a theoretical standpoint, both in terms of the direct effects of these policies (Gertler and Kiyotaki (2010), Aoki et al. (2018), Farhi and Werning (2016)), the interactions with other types of policies (Coimbra and Rey (2017), De Paoli and Paustian (2017)), and the potential cross-border policy effects and international coordination of these instruments (Granados (2021), Davis and Devereux (2019), Korinek (2020))

These external effects can involve the real and financial sector, and more importantly for this paper, can have an international dimension. For example, Buch and Goldberg (2017) obtain that there are significant cross-border credit effects that spill over through the interbank lending, while Forbes et al. (2017) find that the volume of foreign lending itself is affected by these prudential policies. As mentioned before, this can affect the intended outcome and effectiveness of these policy tools substantially.

Related studies also suggest that the cross-border impact on the financial stability could go in different directions, i.e., after a foreign policy change, a domestic country can import the financial instability of foreign economies or it can also import part of the intended, and stabilizing effects of the regulations. An example of the latter is found in Aiyar et al. (2014) who study the UK case and explain how foreign banks with activities in this economy can mitigate the effect of local prudential policies by increasing their level of intermediation, which is indicative of regulatory circumvention effects (e.g., foreign countries affected by regulation attempting to compensate the policy effect by increasing activities in UK). On the other hand, an example of a positive effect is given by Tripathy (2020) for Mexico and Spain in 2012, where Mexico absorbed the financial stabilizing effects of policies targeting the Spanish real state sector through the activities of subsidiaries of BBVA in Mexico.

The evidence on the cross-border spillovers of these policies, as well as the potential policy interactions involving these instruments is what motivates this study, e.g., it may be reasonable to think the regulators internalize the external effects of foreign prudential policy changes in their economies and react in response by adjusting the domestic toolkit, both in response to changes in observed fundamentals, but also preemptively, in anticipation of potential policy leakages stemming from abroad. Simultaneously, the former policy incentive may lead to strategic interactions between policy makers at the cross-country level.

Despite this, and in contrast with the study of external policy-to-fundamental effects, the literature on the empirical strategic response between financial regulators (or lack thereof) in scarce, which is where our article represents a contribution.

On this front, Agénor et al. (2017) study the static policy response to foreign policies based on data on the usage of macroprudential tools, i.e., they study whether a country would increase their extensive utilization of prudential tools in presence of an increased use abroad and obtain a negative relationship. We complement that study, by investigating the dynamic international policy interaction effects in terms of the policy stances (and not only the usage), i.e., we account for the type of policy change (tightening, loosening), while also considering an ample number of additional specifications by type of local and foreign country, sample period, and type of policy change abroad.

1.2 The Macroprudential policies in the last decades

The first half of the last two decades was characterized by a deregulation of the banking sector in the advanced economies (e.g. the termination of Glass-Steagal Act of 1933 in the US) and an increase in the scale of activities of these firms in the global financial markets. The latter was reflected in a steady increase of capital flows, initially to advanced, and after the Global Financial Crisis to the emerging economies. This increase has been largely explained by portfolio investments, the most volatile type of international capital flow.

These partial change in the potential sources of risk, from advanced to emerging[2], was in part caused by a tightening in the financial regulation stance in the US, implemented in response to the global financial crisis experience (Frank Dodd Act of 2010) that prompted a subsequent flight of international investment flows to less regulated economies.

In this context, there have been regulatory responses in the form of updates the Basel Accords, and the establishment of several institutional bodies specifically aimed to strenghten the oversight of the international financial system (e.g. the Financial Stability Board). The revisions of the Basel accords in particular, have tried to address the shortcomings of previous versions that proved in some way or another to be unable to prevent or mitigate the effects of financial crises.

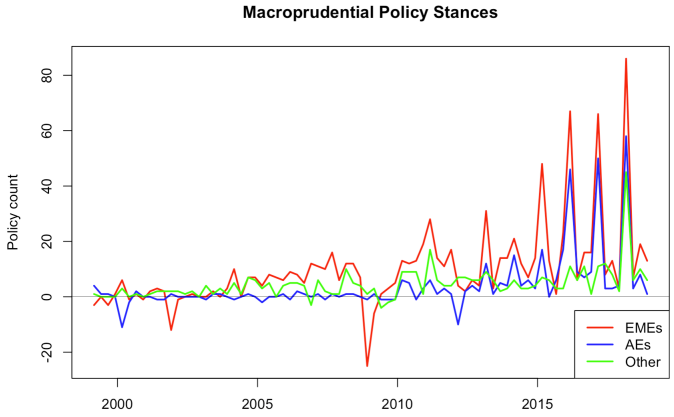
The specific drawbacks of the Basel II accord that motivated the latest update are particularly important for this study, as it relates to the failure to account for the sources of systemic risk that extend beyond the individual sustainability of a regulated bank, and whose effects are driven by the interlinks between financial firms at the national and cross-country level as well as by the global nature of the banking business. In fact, intuition could dictate that this interdependence may justify for a national regulator to look closely at the foreign regulations before setting the level of their own policy toolkit.

We can see in figure 1.1 the macroprudential policy responses during this period. In the left panel we show the interventions by country groups in each quarter, where a positive policy count denotes a net macroprudential tightening (i.e. a stricter stance) and negative a net loosening or a more accomodative stance.[3] Before the crisis the level of regulatory activity reflected in these policy interventions was relatively small, however, after 2008 there was a steep increase in regulatory activity as well as a generalized tendency to implement less accommodative policy stances (apply more tightenigns).

[2]For a detailed description of the change in the direction of capital flows and towards emerging see McQuade and Schmitz (2017)

[3]For example, at the start of 2015 the indicator for emerging economies takes a value of 64, meaning that these countries applied that many more tightenigns across policy instruments in relation to loosenings.

Figure 1.1: Macroprudential Policy Stance by Country Type



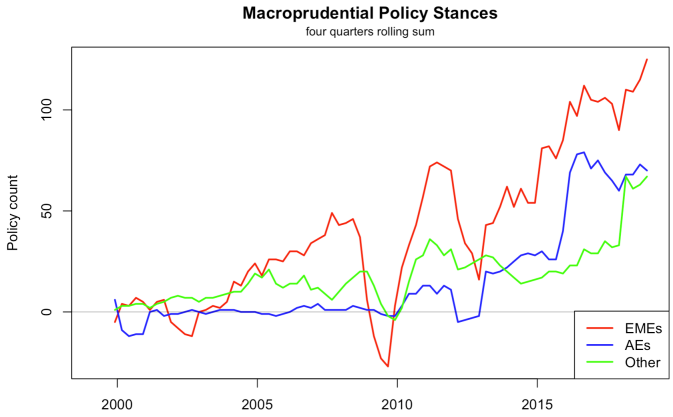
Note: Policy Indicator level. The indicator denotes the policy stance calculated by the indicators of net tightenings across policy tools, increasing by 1 for each tightening and decreasing by -1 for a loosening. At each point the policy indicators at the country level are summed by type of country.

Source: Integrated Macroprudential Policy Database (iMAPP), IMF.

The policy indicator shown above only accounts by the date of a tightening, or policy change, but afterwards may not reflect the policy stance of regulators (unless there are further changes). Because of this, to provide a better account of the policy stance over time, the literature usually focuses on the cummulative policy stance at longer horizons (e.g. Richter et al. (2019b), or Coman and Lloyd (2019)). We also report such type of indicator in figure 1.2, where we show the annual policy stance defined as the four quarter rolling sum (current and previous three quarters) at each period. In the case of the annual policy stance we can see even more clearly the tightening pattern in the last decade.

In addition to the tightening and higher interventionism patterns we could also expect these policies to co-move over time between economies and particularly so after the crisis episode, if we account for the potential regulatory arbitrage efforts that could be made by banks operating in several economies. In the appendix 1.A we confirm that is the case. Before the crisis of 2008 these policies are virtually uncorrelated across countries, however, after that they become highly correlated. This pattern holds for both quarterly and annual indicators, and even for the average policy stances, i.e. after filtering out the effect of the increase in the number of countries using these tools which has risen steadily over time.

Figure 1.2: Macroprudential Annual Policy Stance by Country Type



Note: Four quarter rolling sum of the quarterly indicator. The indicator measure net tightenigns across policy tools by group of countries. A higher value denotes a tighter (or less accommodative) policy stance.

Source: Integrated Macroprudential Policy Database (iMAPP), IMF.

In addition to the tightening and higher interventionism patterns we could also expect these policies to co-move over time between economies and particularly so after the crisis episode, if we account for the potential regulatory arbitrage efforts that could be made by banks operating in several economies. In the appendix 1.A we confirm that is the case. Before the crisis of 2008 these policies are virtually uncorrelated across countries, however, after that they become highly correlated. This pattern holds for both quarterly and annual indicators, and even for the average policy stances, i.e. after filtering out the effect of the increase in the number of countries using these tools which has risen steadily over time.

Now, as our aim is to analyze the cross-border policy co-movement it is more appropriate to depart from the analysis of country group aggregates, and instead exploit the cross-sectional variation at the country level of this data. However, for carrying out a country-level analysis we must construct a policy indicator for the rest of the world, from each country's perspective. This constitutes the foreign policy stance they each economy deems relevant when setting their own policy toolkit. We generate such variable based on the financial links between economies approximated by the portfolio investment position data reported by the economies in our sample, we describe the construction and data sources in more detail in the section 1.3.

With the policy indicator of the rest of the world we can perform a basic descriptive analysis at the country cross-section level before our main estimation. We report the coefficients of simple country regressions between the macroprudential policy stance and the policy in the rest of the world in the figure 1.17 in the appendix 1.A. In absence of other controls these figures account for the covariance between the policy stance and that of the rest of the world for each country. We

find that the distribution of covariances is bimodal, with some countries reporting a covariance close to zero, and the majority of economies depicting a positive coefficient around the unity. Additionally, the economies displaying no relationship are mostly in the "Other" category which are the Low Income Countries, although some emerging are also included in this group. In constrast, the majority of advanced and emerging countries show a positive relationship with foreign policies.

A similar analysis by sub-periods confirms the lack of a co-movement before the crisis, as the modal correlation is zero in every country group, while in the post-crisis sample the positive relationship between domestic and foreign policies for advanced and domestic economies is clearer.

In the sections that follow we will perform a more comprehensive empirical analysis of the cross-country relationship between these policies, both on average, but also by type of policy instruments, domestic and foreign economies, and time period.

1.3 Methodology and Empirical Strategy

Our objective consists in approximating the empirical policy-to-policy effects, that we also denote as "policy interactions" at the cross-border level. These refer to adittional domestic policy adjustments made in response to foreign policies developments that cannot be explained by observable fundamentals. The existence of these effects could imply that prudential regulators also act strategically when setting their policies.

Conversely, the effect intermediated by fundamentals may also obey to international policy spillovers but can either be consistent with strictly nationally oriented policies, for example, a local regulator may react to changes in fundamentals after these are affected by foreign regulations, or it may even reflect endogeneous policy responses, for example to the same cofounding fundamentals. In any case, such change in domestic policies would be just an adjustment given some observed spillovers, but does not imply that local regulators are interacting strategically to exogenous policy innovations.

We show these types of domestic policy adjustments in figure 1.3. Methodologically, we will filter out the Intermediated Effect with estimation controls. Then, we capture the remaining policy adjustments with a local projection approach.

In this section we describe the data sources, the policy indicators, the construction of the rest-of-the-world policies, and the baseline setup used to obtain this interaction.

Figure 1.3: Types of Foreign-to-Local Policy Effects

$$\text{①: Policy}^{*} \longrightarrow \overbrace{\text{Fundamentals (local, global)}}^{\text{Intermediated Effect}} \longrightarrow \text{Policy}$$

$$\text{②: Policy}^{*} \longrightarrow \text{Policy: Direct Effect}$$

Note: the star denotes a foreign variable

1.3.1 Data

We carry out our analysis based on quarterly data for 65 economies for the period 1999Q1 to 2018Q4. Our sample includes 23 advanced economies, 31 emerging economies and 11 low income economies, the list of countries can be seen in the table 1.5. Our database includes macroprudential policy variables, as well as economic and financial variables we use as controls in the estimations.

The macroprudential policies are obtained from the Integrated Macroprudential Policy Database (iMAPP) from the IMF and Alam et al. (2019). From this source we obtain the policy stance indicators for 17 policy tools and the level of the average Loan-to-Value for a subsample of 52 economies. We discuss the structure of the policy indicators and the specific instruments considered in the next subsection.

On the other hand, we construct a measure of the Macroprudential policy of the rest of the world from the perspective of each economy. This variable will be calculated as the weighted average of the policy instruments of the countries, with weights given by the financial links between economies that we approximate using the investment portfolio flows in the Coordinated Portfolio Investment Survey from the IMF.

The economic and financial data used as controls is obtained from several sources, the GDP, CPI, capital flows, exchange rate, and monetary policy rate is obtained from the International Finance Statistics (IFS) from the IMF. The IFS is relatively imbalanced, then as a second step, missing data on credit and policy rates was obtained from the BIS statistics warehouse. Other missing data was obtained from Monnet and Puy (2019) that provide IFS consistent series for a large number of economies. Finally, at last and in some remaining cases we replaced additional available missing data from national sources, such as central banks and statistics departments.

Other variables considered were the Financial Development Index from the IMF Financial Development Database, and other global controls such as the CBOE VIX and TED spread were obtained from the St. Louis FRED.

We also adjust some monetary policy rates with zero lower bound issues by replacing them for their associated shadow rates, that can take on negative values and are constructed to reflect changes in the monetary policy stance even at times where the official rate is fixed at zero. For the US, EU, and UK, we obtained the shadow rates from Wu and Xia (2016), and for Japan we obtain the rate from Krippner (2013).

Macroprudential Policy Variables

We obtain a measure of the macroprudential policy stance from the iMAPP-IMF database based on Alam et al. (2019). The data consists on policy indicators for 17 instruments (shown in table 1.1). For each tool and period an indicator is calculated according the policy change observed:

$$MaPP_t^{\text{instrument } j} = \begin{cases} 1 & \text{if tightened} \\ 0 & \text{if unchanged} \\ -1 & \text{if loosened} \end{cases}$$

Then, we aggregate through the available instruments and obtain the indicator of the average policy stance of the economy i at time t: $MaPP_{i,t} = \sum_{j=1}^{17} MaPP_{i,t}^{\text{instrument } j}$

This indicator will take values between -17 and 17 at each date depending on the invididual changes in each instrument. In that sense, the indicator can be interpreted as a measure of the net macroprudential tightenings of an economy.

It should also be noticed that although this measure accounts for the stance, it is given in terms of policy changes. Which implies that a less accomodative policy stance (a tightening) may be reflected only once in the indicator. Because of that, a common practice in this literature consist on using a rolling sum of this indicator. We do that as well and focus in the 4 quarter rolling sum, meaning that in each period our policy index accounts for the annual macroprudential policy stance (current and previous three quarters).

This database is recent and improves on previously available panel data on macroprudential policies at the coutry level. Before, the data available consisted on an indicator on the number of instruments being used each period in an economy. In that sense, it was not possible to distinguish the policy stance, and instead policy indicator only accounted by the level of policy activity (see for example, Cerutti, Claessens, and Laeven (2017))

At the same time, this dataset also provides the level for one of the tools for a smaller set of countries (52 out of our 65 countries sample), that is the average Loan-to-Value. Data on the actual policy tool is even more meaningful than the policy stance indicator, as it not only

accounts for the policy stance (tightening or loosening) but also for its intensity. However, the availability is limited as it abstracts from the dynamics of many tools and relates to a tool that only targets borrowers rather than financial institutions. Because of this limitation we still mainly focus on the aggregate policy indicator (and some associated instruments classifications). However, we also estimate the model for the LTV requirement as an additional exercise.

Table 1.1: Macroprudential policy instruments considered

Countercyclical Capital Buffer	Conservation Cap. Buffer	Capital Requirements
Limits to Leverage	Loan Loss Provision	Limits to Credit Growth
Loan Restrictions	Limits on Foreign Currency Lending	Debt Service to Income Ratio
Loan-to-Value Ratio (LTV)	Taxes	Liquidity Requirements
Loan-to-Deposit Ratio	Limits on FX positions	Reserve Requirements
SIFI (Too-big-to-fail institutions)	Other (e.g. stress testing, structural measures)	

Policy Indicator for the Rest of the World

As mentioned before, we want to exploit the cross-country variation of these policies rather than only analyzing the co-movement policy aggregates by type of economy. To do that, we must construct a policy indicator for the rest of the world that we can relate vis-a-vis with the policy indicator of each economy, i.e. we should have a rest-of-the-world (ROW) indicator from the perspective of each economy and at each period of time.

Then, from the perspective of each economy i, we compute the policy of the ROW "$-i$" as a weighted average of the policies of the remaining countries:

$$MaPP_{-i,t} = \sum_{s \setminus i} \omega_{s,t} MaPP_{s,t}$$

Ideally the weights should reflect the financial links between economies, which we approximate based on data from the Coordinated Portfolio Investment Survey from the IMF as follows:

$$\omega_{s,t} = \frac{\text{Portfolio Investments of country } s \text{ on country } i \text{ at } t}{\text{Total foreign portfolio investments on country } i \text{ at period } t}$$

The survey provides the investment positions at an annual frequency meaning we can update the financial weights every year in our sample.

1.3.2 Baseline estimation

We will use a Local Projection approach following Jordà (2005) to model the co-movement between the macroprudential policies in a panel estimation. Our baseline estimation follows also the structure of Richter, Schularick, and Shim (2019b) although our variable of interest is the macroprudential policy stance of a country i and the explanatory variable is the policy stance of the rest of the world:

$$\Delta_h MaPP_{i,t} = \alpha_i^{(h)} + \beta^{(h)} \Delta MaPP_{-i,t} + \overbrace{\sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k}}^{\text{domestic controls}} + \overbrace{\sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k}}^{\text{global controls}} + \varepsilon_{i,t+h}$$

for $h = 0, 1, \cdots, H$ and with $\Delta_h MaPP_{i,t} = MaPP_{i,t+h} - MaPP_{i,t-1}$

As a very initial exploration, we use a basic fixed effects panel framework (i.e. $h = 0$) to test several set ups and choose our baseline. The results of these regressions can be seen in table 1.2.

Table 1.2: Baseline model of Macroprudential Interactions

Model for $\Delta MaPP_i$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta MaPP_{-i}$	0.235 ***	0.297 ***	0.273 ***	0.256 ***	0.242 ***	0.252 ***	0.235 ***
	(0.05)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Domestic Economic Controls		Yes	Yes	Yes	Yes	Yes	Yes
Global Economic Controls			Yes	Yes	Yes	Yes	Yes
Domestic Financial Controls					Yes		Yes
Global Financial Controls				Yes	Yes	Yes	Yes
Extra Domestic Financial Controls						Yes	Yes
n	5135	4135	4135	4135	4135	3917	3858
R^2	0.01	0.02	0.03	0.03	0.04	0.04	0.04
F	16.91	3.71	8.55	7.65	16.22	27.72	733.21
P-value (F)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of countries	65	65	65	65	65	65	65

Clearly, this estimation can be subject to improvements, however for now we are just arriving to the combination of controls we will use. We would like to include as many meaningful controls as possible without compromising our sample size too much. For that, we start with a estimation without controls and add controls by type until we arrive to our baseline (model (5)).

This baseline includes the following set of controls:

- *Domestic Economic Controls*: Real GDP growth, yoy CPI inflation, change in monetary policy rate (or shadow rate for zero lower bound cases)

- *Domestic Financial Controls*: Financial Development Index, annual depreciation of the nominal exchange rate.
- *Global Economic Controls*: Global growth (first principal component of growth of US, UK and Japan), global interest rate (first principal component of US, EU, UK).
- *Global Financial Controls*: VIX, TED spread

All the variables are included in changes (first difference) unless a particular variation (e.g. annual) is mentioned above.

We base the selection of controls on other empirical papers in the international finance literature such as Aizenman et al. (2017a), Aizenman et al. (2020) and Richter et al. (2019b). The approximation of global controls based on principal components is based on Aizenman et al. (2017b).

Additionally, we consider other potential controls (Extra Domestic Financial Controls in table 1.2) such as Credit-to-GDP, Capital inflows to GDP, as well as an additional estimation with the capital openness index of Aizenman et al. (2017b). However, we decided against including additional controls beyond the listed above because of the cost in terms of sample size due to missing data (particularly in credit) while the results were virtually the same as in our baseline regression.

Identification Strategy and Baseline Formulation

Ideally, we would count with a series of orthogonal foreign policy shocks that we could include in the right hand side instead of the foreign policies themselves as these could be affected by the policy of country i too. However, at the moment there is not any available series of shocks that accounts for all of these instruments.

Because of this limitation most of the literature instrumentalize the macroprudential policy indicator, by using the first lag directly (or in an analogous IV regression). The main idea behind this choice is that the policy of the rest of the world of previous periods is unlikely to be affected by future policy decisions in our dependent variable. Clearly, this is a less than ideal strategy, since it could also be argued that the (lag) instrument may not work completely as intended given the forward-looking nature of financial markets (and ROW regulators).

Other papers in the literature such as Richter, Schularick, and Shim (2019b) have created measures of prudential policy shocks based on filtering the data on the LTV requirement. However, we cannot use a similar measure since we are interested in the changes of the rest of

instruments, whose levels are not available, but that more closely resemble the regulation of the banking sector in these economies.

Finally, it should be mentioned that even after findind a series of identified policy shocks, we likely would have to trade-off the possibility of analyzing different types of instruments as we do here. Because of that, even as it becomes available, we think of this exercise as complementary (particularly sections for disaggregated policy instruments).

Then, our actual specification for the generation of the impulse responses is:

$$\Delta_h MaPP_{i,t} = \alpha_i^{(h)} + \beta^{(h)} \Delta MaPP_{-i,t-1} + \overbrace{\sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k}}^{\text{domestic controls}} + \overbrace{\sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k}}^{\text{global controls}} + \varepsilon_{i,t+h} \tag{1.1}$$

For $h = 0, 1, \cdots, H$. We pick $H = 15$ when generating the estimation results.

Here $MaPP_{-i,t-1}$ is the policy indicator one period before. The controls will be defined as mentioned (economic and financial, domestic and global). Additionally α_i represents a country specific fixed effect. The estimation also adjusts the errors using robust clustered errors at the country level. This level of clustering acknowledges that the country is the level at which the policies are implemented.

1.4 Results

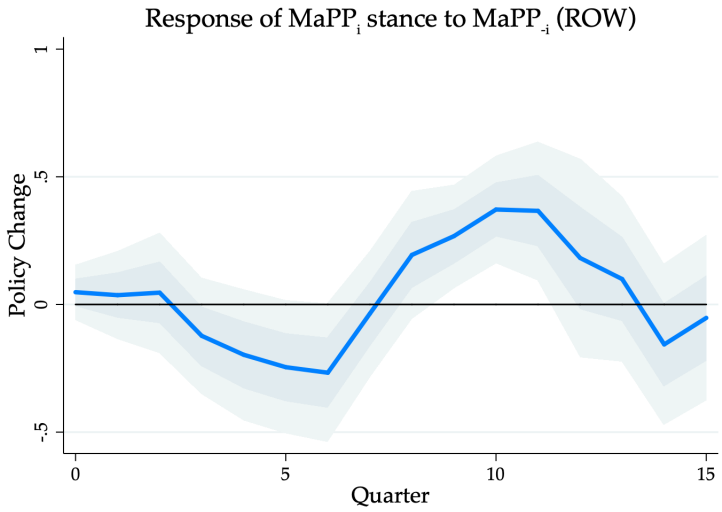
We start by generating the Impulse Response Function results for our baseline estimation in figure 1.4. We also show a table summary for some horizons in the table 1.6. The response displayed indicates the policy reaction in the average economy to a positive policy change made (or tightening) by the rest of the world (ROW), where the foreign ROW country comprises every type of economy (emerging and advanced). Additionally, the policy indicator considered aggregates the policy stance reflected in every instrument (17 in total).

The result indicates that there is a delayed positive response, approximately equivalent to one half of a tightening. In other words, domestically, we would see a full macroprudential tightening in the presence of a two tightenigns abroad (e.g., a simultaneous tightening in two policy instruments).

The positive response persists for several quarters which is expected given the nature of the policy indicator (annual accumulated macroprudential stance) that reflects any policy change

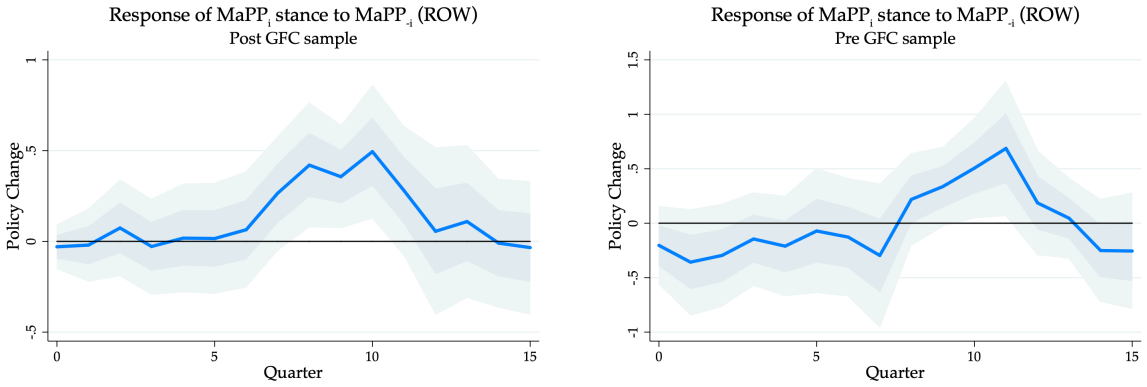
during four quarters.[4]

Figure 1.4: Response of Local MaP policies to policy changes in the rest of the world



Note: Impulse Response Function from a local projection based on equation 1.1. The MaPP indicator comprises the information for all the 17 instruments. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q1-2018Q4

Figure 1.5: Response of Local MaP policies to policy changes in the rest of the world, after the global financial crisis (left panel) and before (right panel).



Note: the figure displays Impulse Response Function from a local projection based on equation 1.1. Where the MaPP indicator comprises the information for all the 17 instruments. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 2008Q4-2018Q4 (left panel), 1999Q1-2008Q3 (right panel) .

At the same time, we calculate this result on different estimations that consider the sub-periods

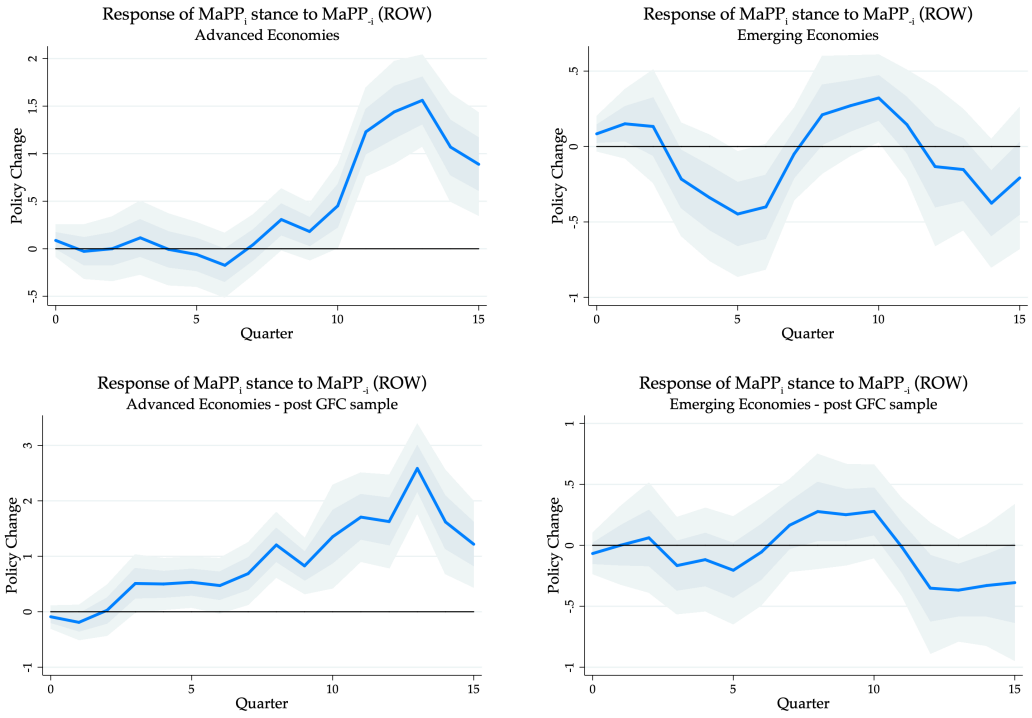
[4]See figure 1.19 in appendix 1.B for an conceptual plot explaining how to read the Linear Projection IRF results in the case of the annual accumulated policy.

after and before the Global Financial Crisis and show the result in figure 1.5. We see that the positive response is more representative of the post crisis period.

Similarly, it is plausible that the policy response implemented by advanced and emerging economies differ. To verify this, we compute the baseline estimation for subsamples considering only countries in each category (one model for 23 advanced economies and another for 32 emerging). The results are shown in figure 1.6. In this case, we see that the positive policy reaction is more resembling of the behavior of regulators in the advanced economies. At the same time when estimating models by type of economy we also find a stroger response (and even subject to less uncertainty) in the post-crisis period. [5]

The interpretation is similar, a policy tightening abroad is following by delayed tightening adjustments domestically. This effect takes place mainly in advanced economies and has strengthened after the Global Financial Crisis.

Figure 1.6: Response of MaP policies to policy changes in the rest of the world. Model for Advanced Economies (left panel) and for Emerging Economies (right panel).



Note: the figure displays Impulse Response Function from a local projection based on equation 1.1. Where the MaPP indicator comprises the information for all the 17 instruments. Left panel: estimation for Advanced Economies (complete sample and post-GFC sample), Right panel: estimation for Emerging Economies (all sample and post-GFC sample). Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: complete sample: 1999Q4-2018Q4, post-GFC sample: 2008Q4-2018Q4.

[5] For additional local projection results not shown here see the appendix 1.B.

Notice, we are making conservative statements about these effects. That is the case because this result corresponds only to the average effect across all instruments and in presence of a policy action taken by an aggregation all types of countries in the ROW. It is worthy to examine if this average result describes the general nature of the policy interactions between countries, or if instead, it corresponds to the net policy effect, after off-setting responses across types of instruments and countries take place.

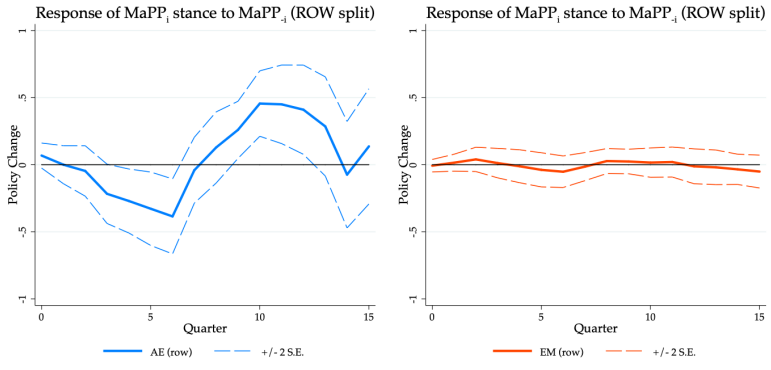
1.4.1 Splitting the Effects by Type of Foreign Country

To understand the origin of the relevant policy actions abroad for the domestic policy stance we perform an estimation where we split the foreign or ROW policies as follow,

$$MaPP_{i,t+h} - MaPP_{i,t-1} = \alpha_i^{(h)} + \beta_1^{(h)} \Delta MaPP^{AE}_{-i,t-1} + \beta_2^{(h)} \Delta MaPP^{EM}_{-i,t-1} + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h} \tag{1.2}$$

The coefficients $\beta_1^{(h)}$ and $\beta_2^{(h)}$ represent the IRF for periods $h = 1, \cdots, 15$, to the policy changes implemente in the ROW by advanced economies and emerging, respectively. As with the foreign policy indicator for the totality of the ROW, we construct each policy indicator by taking a weighted average of the policy actions of each group of economies, and analogously, the weights are based on the bilateral portfolio investment positions (as a total of the investments of each group of economies). The estimation procedure and controls are identical to the baseline above.

Figure 1.7: Response of MaP policies to policy changes in the rest of the world. Model for Advanced Economies (left panel) and for Emerging Economies (right panel).

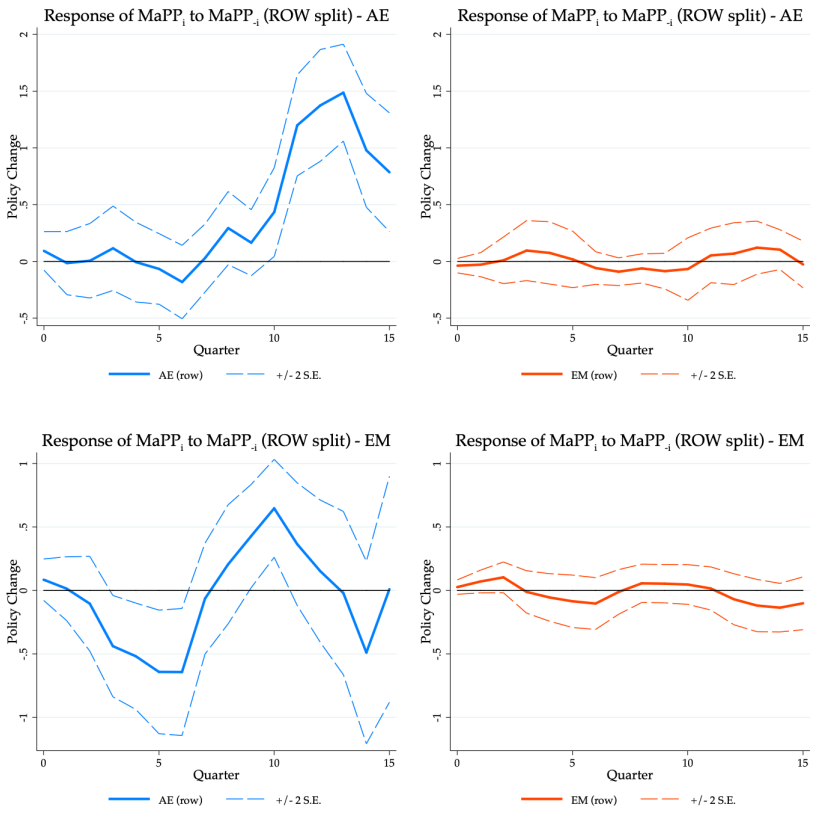


Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Left panel: Domestic Response to Change in Foreign policy in Advanced Economies, Right panel: Domestic Response to Change in Foreign policy in Emerging Economies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4

The associated responses can be seen in 1.7. We can see that the foreign policy actions that countries are responding to on average are those of the advanced economies (AE). In contrast, the average domestic country is not reacting to the policies enacted in emerging economies at any horizon.

The result of models for each type of economy point to the same conclusion. Both advanced, and emerging are reacting mostly to the policies implemented in the advanced economies. In particular, the delayed positive reaction is better capture by the response of AE policies to that of other advanced economies, although it is also partly reflected in the responses of emerging regulators.

Figure 1.8: Response of MaP policies to policy changes in the rest of the world. Model for Advanced Economies (top panels) and for Emerging Economies (bottom panels).



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4

In summary, the lesson we get for the analysis of a policy indicator that comprises the dynamics of all instruments is that, there is a delayed positive policy reaction to the policy

tightenigns implemented abroad. At the same time, the foreign tightenings that the regulators are reacting to are those of advanced economies. This result holds for both the responses made by advanded and emerging economies. Finally, the positive policy response has strengthened after the Global Financial Crisis episode.

As for the intuition behind this response, there are several hypotheses we can formulate. On one hand, a tightening abroad, i.e. stricter foreign banking regulations will likely elicit an regulation arbitrage effort by banks with cross-border activities (or balance sheet links) looking to circunvent the new (and more constraining) policy stipulations. That intuition aligns with the findings of Aiyar et al. (2014), and is consistent with the global nature of the banking business and the difficulties it implies for policymakers attempting to enforce a regulation at the local economy level.

As a result, the policy abroad may have destabilizing domestic effects in the financial sector, i.e., more financial institutions trying to increase the scale of their activities to compensate for the hindered activities in foreign locations. The local regulators will aknowledge this and tighten their own policies to prevent it.

Another complementary interpretation to this story relates to the dynamics of the international portfolio flows. These investment flows can be destabilizing and sometimes an economy is interested in repelling them (and prioritize more stable flows such as FDI). It is also plausible, that a country repelling these flows abroad may imply a higher threat for the domestic economy that may try to implement a tightening to in order to shield itself from a potential intake of these flows and the waves of the global financial cycle.

1.4.2 Effects by Type of Instrument

So far we have analyzed the average policy reaction of an economy in the presence of foreign macroprudential policy changes. By average, we refer to the overall policy stance accounting for an aggregation across all 17 policy instruments.

However, it is plausible that different cross-country policy considerations apply to different types of policy instruments. Here we explore if that is the case. We do it by splitting the policy indicator according to two typical macroprudential policy tools classifications used in the literature:

1. Borrower and Lending (fin. institutions) tools (Cerutti, Claessens, and Laeven, 2017)

   Borrower: Loan-to-value (LTV), Debt-Service-to-Income (DSTI)

Financial Institutions (Lender): The rest of instruments.

2. Capital, Asset-side, Liquidity and Foreign Currency tools (ECB, BIS)

   Capital: Counter-Cyclical Capital Buffer, Capital Conservation Buffer, Capital Requirements, Leverage Limits, Loan Loss Provisions, SIFI (large banks).

   Asset-side: limits on Credit Growth, Loan Restrictions, LTV, DSTI, Tax.

   Liquidity and Foreign Currency: Liquidity Requirements, Limits on Loan-to-Deposit ratio, Limits on Foreign Exchange Positions, Limits on Foreign Currency Lending, Reserve Requirements.

In principle, by making these separations we are able to either indicate what type of instrument is more relevant for driving the positive strategic policy interaction we find on aggregate. Or we can even check whether there are certain types of instruments for which the opposite relationship holds.

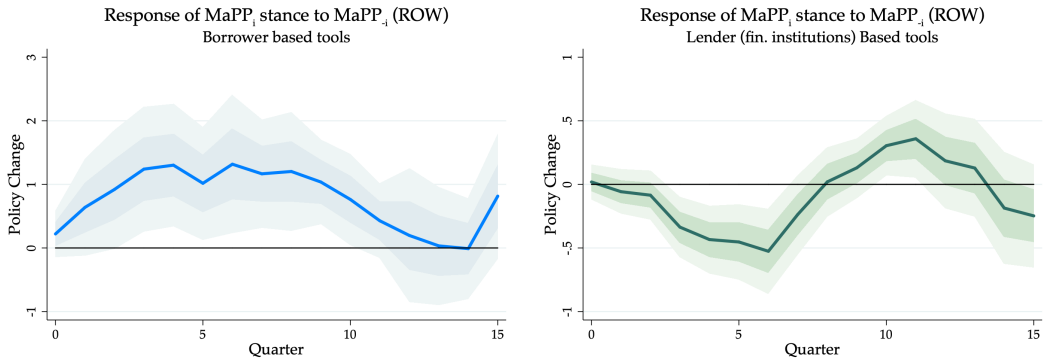
First Classification: Borrower and Lender Related Instruments

We divide the policy stance variable into two separate variables, according to the instrument types in the first classification. The first index $MaPP^{Borrow}_{-i,t}$ is an aggregate of the policy stance indicator of borrower targeted tools (LTV, DSTI), and $MaPP^{Lender}_{-i,t}$ is an aggregate of the stance captured by the rest of instruments that target the (lenders) financial institutions. We estimate the following equation:

$$\begin{aligned}\Delta MaPP_{i,t+h} = \alpha_i^{(h)} + \beta_1^{(h)} \Delta MaPP^{Borrow}_{-i,t-1} + \beta_2^{(h)} \Delta MaPP^{Lender}_{-i,t-1} \\ + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h}\end{aligned} \tag{1.3}$$

The policy response to each type of policy action is shown in the figure 1.9. In the left panel we see the domestic policy reaction to a tightening in the foreign borrower targeted tools. This reaction is positive and is implemented with a small delay (about 2-3 quarters), and amounts to approximately a full tightening. In that sense, the response is analogous to what we found on average for the aggregate prudential stance indicator.

Figure 1.9: Response of MaP policies to policy changes in the Rest Of the World. Response to Borrower instruments (left panel) and to Lender based policies (right panel).



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.3). The foreign MaPP indicator includes Borrower tools (response shown in left panel) and Lender tools (right panel) separately as explanatory variables. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4.

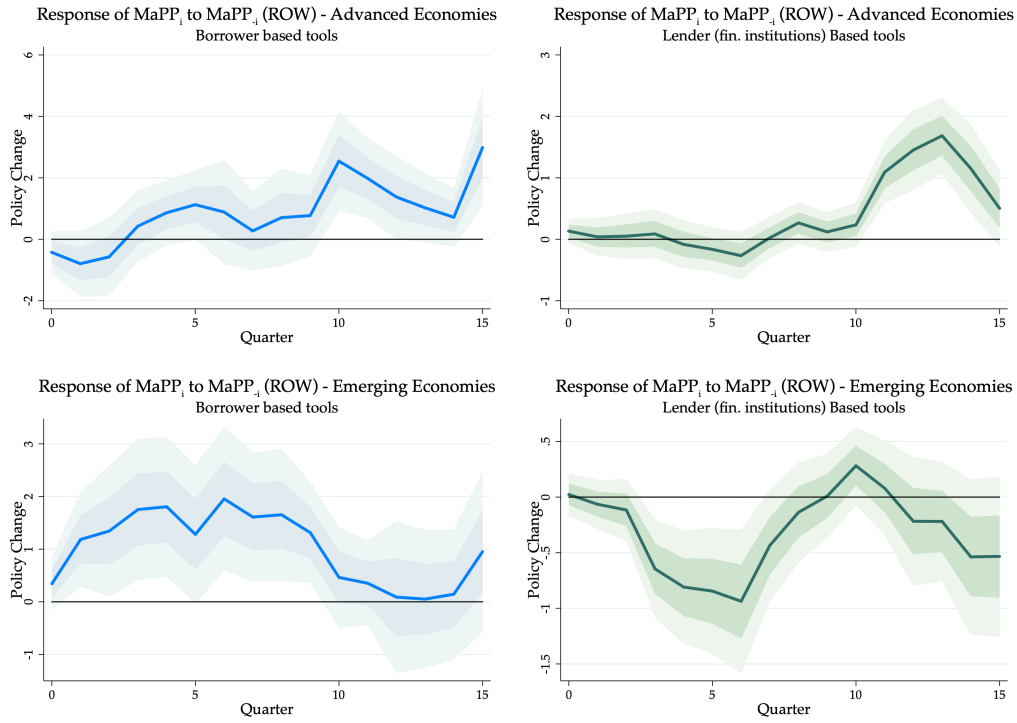
On the other hand, the right panel depicts the policy response to a tightening in the foreign lender tools. In this case, we see a negative response, although with a weaker magnitude. This contrasts with the rest of our findings until now, which in itself can be interesting as it may denote potential free-riding incentives by the national regulators. Still, we disentangle these before making additional interpretations.

We obtained these effects in separate models for advanced economies (AE) and emerging economies (EM) respectively and plot the results in the figure 1.10. To begin, we see that the policy responses in advanced economies goes along the same line as our baseline results: there is a positive reaction (tightenings) made in response to policy tightenigns abroad. This holds for any type of instrument.

Conversely, for the emerging economies we see that there is a positive policy reaction to foreign policy tightenings only for borrower instruments. Thus, we can track down the negative policy reaction to these countries, and in response to changes in foreign policy tools targeting the banking sector.

Here, similar to the baseline result for the aggregation of instruments, the response to policy changes in each type of foreign tool is explained only by the post crisis (GFC) data (figure 1.23 in the appendix 1.B). The same pattern holds for estimations by type of country.

Figure 1.10: Response of MaP policies to policy changes in the Rest Of the World. Response to Borrower instruments (left panel) and to Lender instruments (right panel). Model for Advanced Economies (top), and for Emerging Economies (bottom)



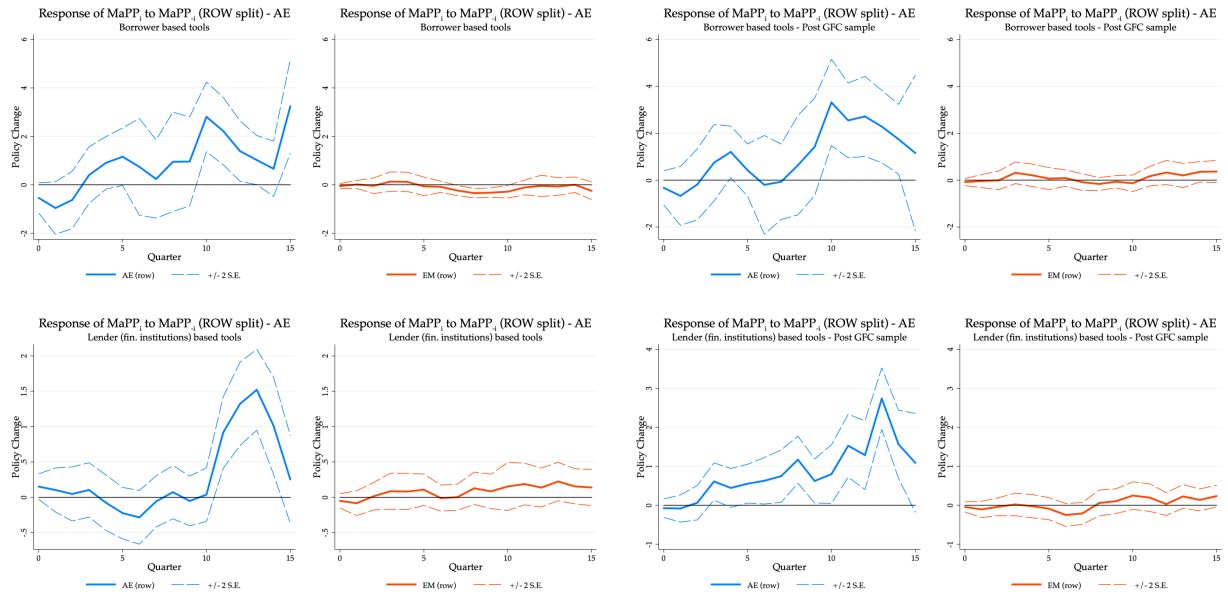
Note: the figure displays the Impulse Response Function from a local projection based on equation (1.3). The foreign MaPP indicator includes Borrower tools (left panel) and Lender tools (right panel). The figure shows result from the estimation for Advanced Economies (top panel), and Emerging Economies (bottom). Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4.

Similar to the case of the aggregate policy indicator, we can split the effects by type of foreign country. In that case we carry out an estimation based on the following equation,

$$\begin{aligned}\Delta MaPP_{i,t+h} = \alpha_i^{(h)} + \beta_1^{(h)} \Delta MaPP_{-i,t-1}^{Borrow,AE} + \beta_2^{(h)} \Delta MaPP_{-i,t-1}^{Lender,AE} \\ + \beta_3^{(h)} \Delta MaPP_{-i,t-1}^{Borrow,EM} + \beta_4^{(h)} \Delta MaPP_{-i,t-1}^{Lender,EM} \\ + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h}\end{aligned} \tag{1.4}$$

The figure 1.11 shows response for the model estimated for the advanced economies (AE). We can see that the positive reaction to changes in each type of instrument correspond to responses to the policies implemented in foreign advanced economies. Also, the result is driven by the post crisis reactions as expected by now.

Figure 1.11: Response of MaP policies to policy changes in the rest of the world. Model for Advanced Economies.



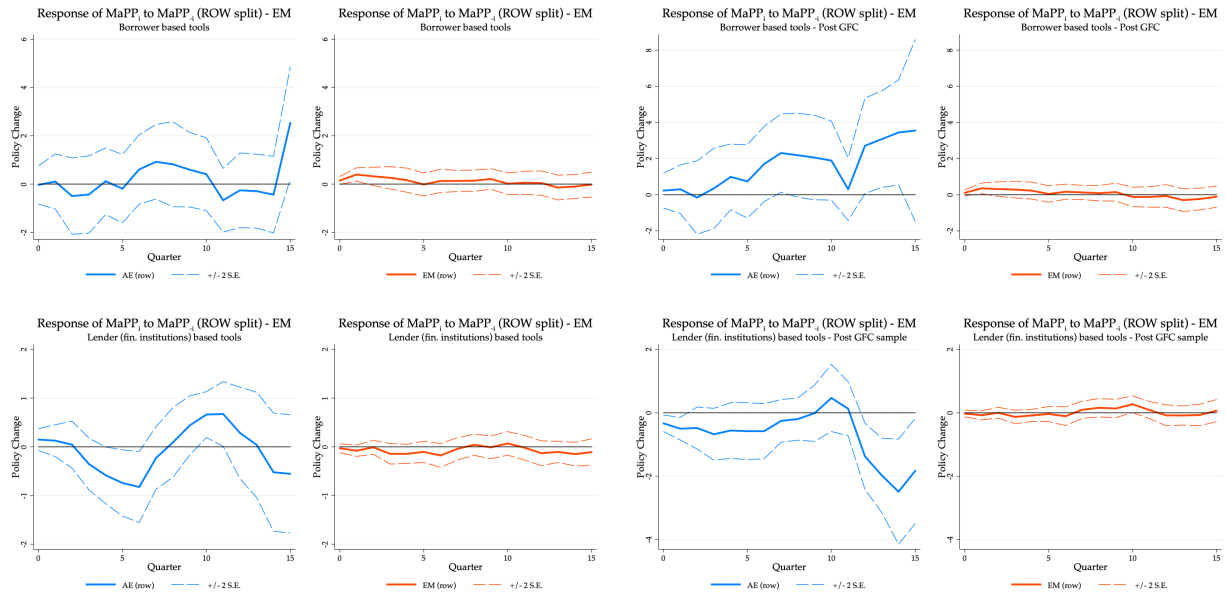
Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4

The responses for the emerging economies is shown in the figure 1.12. In that case we see that a positive response to foreign borrower tools' changes regardless of the origin (AE or EM). However, the response to the policies in advanced economies has a higher order of magnitude, i.e., one or more tightenings in response. Whereas the response to the policy changes in advanced economies is much lower (1/10 to 2/10 of a tightening).

On the other hand, we obtain that the negative policy response to changes in financial institutions' tools by emerging countries is driven by the reactions to the policy changes originated in advanced economies only. That is, the domestic policy relaxation in presence of stricter foreign policies only follows after policy tightenings in advanced economies.

This is an interesting finding, basically the emerging regulators are internalizing potential positive welfare spillovers from the stricter policies in financial centers that may be strong enough to allow them to relax their own domestic regulations. This aligns with the findings of Tripathy (2020), where policy effects targeting banks in the Spanish financial sector eventually leaked to the Mexican financial sector through Spanish banks' franchises (e.g. BBVA) operating in Mexico, thereby generating financial stability gains outside the inteded scope of the original regulation.

Figure 1.12: Response of MaP policies to policy changes in the rest of the world. Model for Emerging Economies.



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4.

The results for this first classification is summarized in the table 1.3. It depicts the sign of the impulse response for the possible estimations we have analized separately and others not shown (see appendix 1.B for the additional responses).

Table 1.3: Sub-sample results for Classification 1: Borrower and Lender tools (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Borrower	+	+	+	+	+	-	+		+
Lender	-	+,- net 0		+	+		-	-,+	+
Post GFC									
Borrower	+	+	+	+	+		+	+	+
Lender	-			+	+		-	-	
Pre GFC									
Borrower					+				
Lender				+	+	-		+	

Note: Sign of the IRF of each subcase for the Classification 1 of the policy tools. Units: Policy Change (+: tightenings, -: loosening).

In a nutshell, the positive policy reaction is explained by the reaction to borrower instruments

while a negative response emerges for reactions to foreign lender tools. When performing separate estimations for different countries, we see that for advanced economies, there is a positive response in any type of tool as expected. In contrast, the negative response can be tracked to the response of emerging regulators to financial institutions targeted tools' tightenigns in advanced economies.

Additionally, both type of economies (AE, EM) are reacting to the policy changes made in foreign advanced economies. But only emerging economies react to the foreign policies made in other emerging markets.

Finally, the responses are explained mostly by post-GFC behavior. In fact, the reactions in the post-crisis sample estimations have the same signs as the whole sample, but with a stronger effects.

Second Classification: Capital, Asset-side and Liquidity instruments

It can be argued that the borrower and lender tools categories are tro broad, particularly the lender related tools, since it still aggregates 15 out of the 17 instruments. In that vein, it can be important to to disentangle the effects of foreign policies that target the financial institutions. It is possible, that by accounting for more specific categories we discover more meaningful effects.

With that in mind, we analize the second classification, as proposed by Cabral et al. (2019) (ECB) and BIS (2012). This classification is also widely used in the literature. On one hand it pools Capital related tools, that are meant to affect the resiliency of the financial sector, then it consider the Asset-side tools that are more related to the Global Financial Cycle and asset prices fluctuations, and finally it includes Liquidity and Foreign Currency related tools that are meant to mitigate the liquidity and insolvency risk (in local or foreign currency).

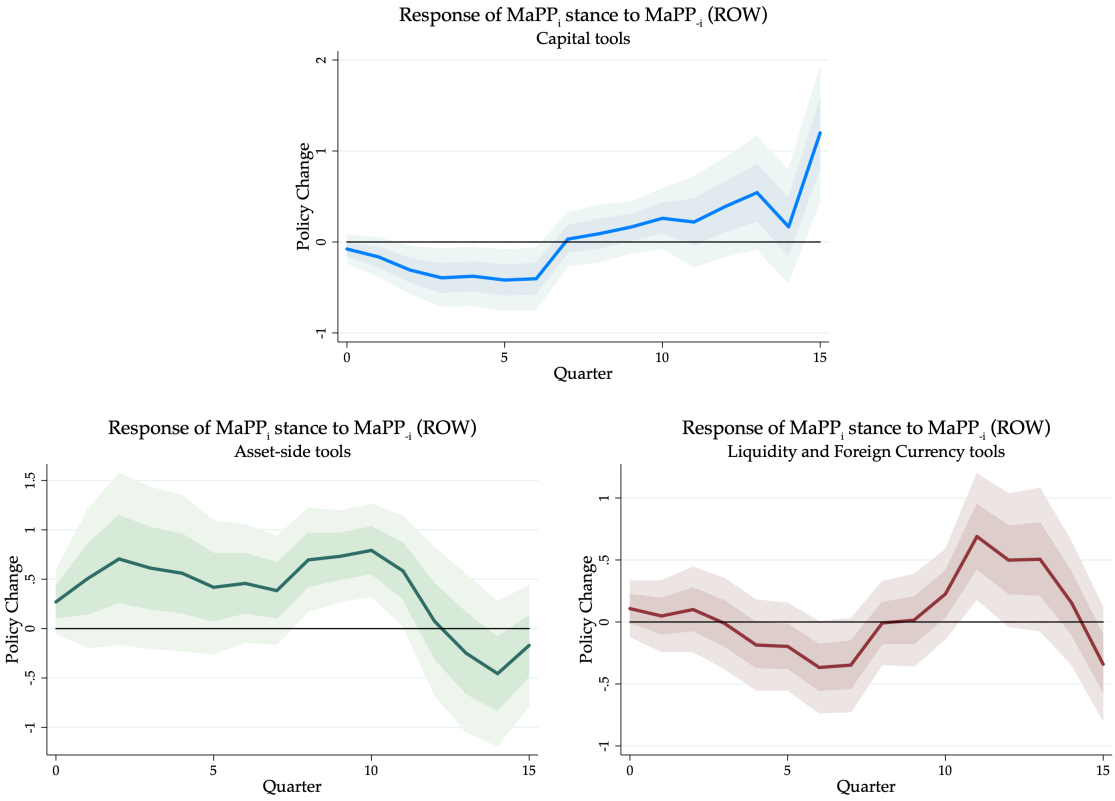
$$\begin{aligned}\Delta MaPP_{i,t+h} = \alpha_i^{(h)} + \beta_1^{(h)} \Delta MaPP_{-i,t-1}^{Capital} + \beta_2^{(h)} \Delta MaPP_{-i,t-1}^{Asset} + \beta_3^{(h)} \Delta MaPP_{-i,t-1}^{Liquidity} \\ + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h}\end{aligned} \tag{1.5}$$

The first two types of tool target types of risk that have been well identified since Basel I, while the liquidity tools target a source of risk that became relevant after the onset of the Global Financial Crisis. On the other hand, the Asset-type tools, relate to credit, income and asset prices and hence are associated to the global financial cycle. The dynamic domestic response to foreign policy changes in each of these type of tools is estimated based on the equation (1.5).

We show the results in the figure 1.13. The response to capital tools' changes is hard to

interpret as it displays a short term negative reaction and the opposite sign at the end. It is likely that this is reflecting opposite reactions by types of economies. This type of dynamics is the reason why we analyze different subsamples as well as the dynamic effect. On the other hand, the response to foreign changes in asset-side tools and liquidity tools is positive and delayed. This is consistent with the baseline results and most of the sub-sample estimates.

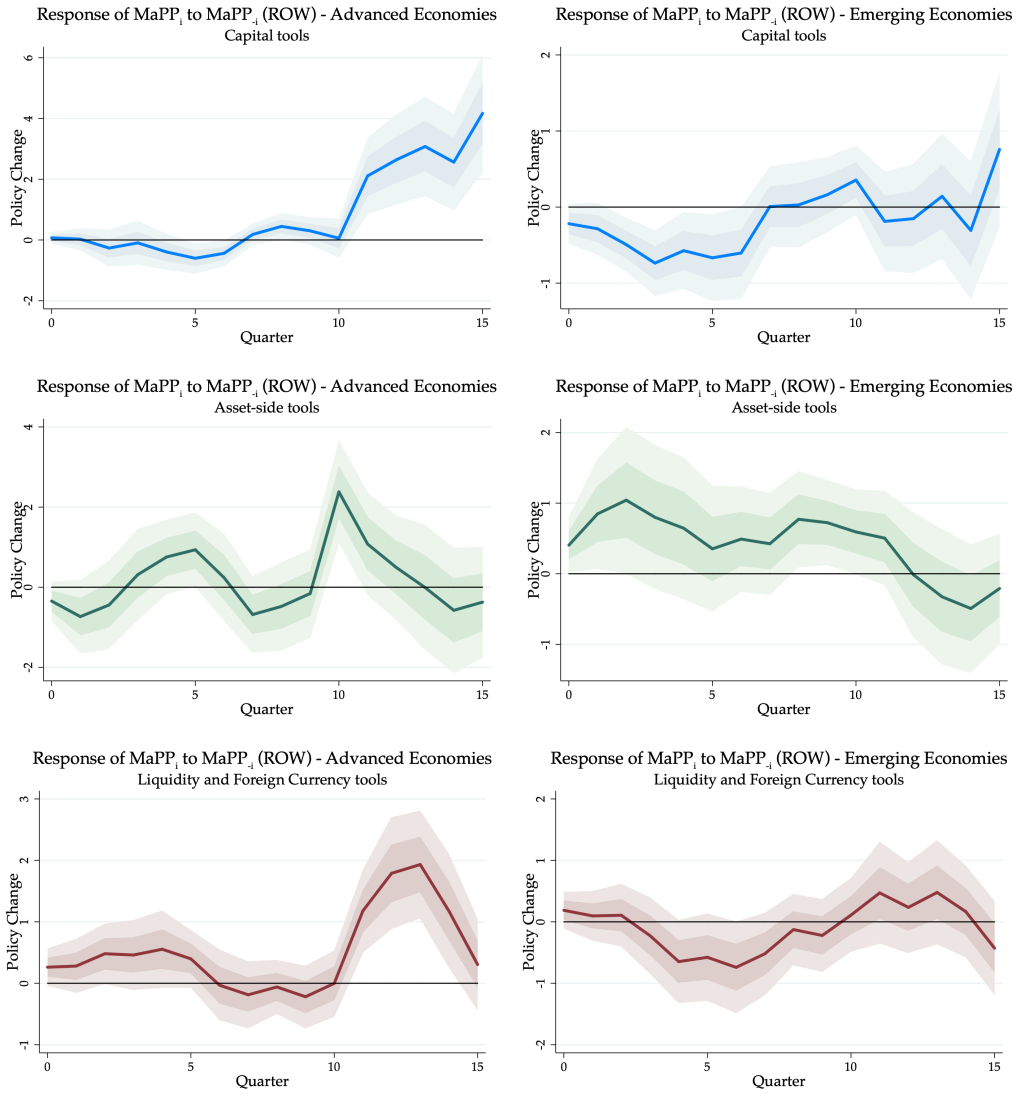
Figure 1.13: Response of MaP policies to policy changes in the Rest Of the World. Response to Capital instruments, Asset, and to Liquidity and FX flows based policies.



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.5). The foreign MaPP indicator includes Capital tools (response shown in top panel), Asset-side tools (bottom, left), and Liquidity and Foreign Currency tools (bottom, right) separately as explanatory variables. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4.

To understand better these effects, we estimate the effects for this classification separately for each type of economy (AE, EM). The results are shown in figure 1.14. We can see that the response in the Advanced Economies is positive as in the baseline result and first classification (i.e. a tightening is implemented in response to foreign tightenigns). This positive reaction holds for each type of instrument with similar magnitudes, about two tightenigns are applies in response to a single foreign tightening.

Figure 1.14: Response of MaP policies to policy changes in the Rest of the World. Response to Capital instruments, Asset, and to Liquidity and FX flows based policies. Model for Advanced Economies (left) and for Emerging Economies (right)



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.5) estimated separately for Advanced (left panel plots) and Emerging Economies (right panel plots). The foreign MaPP indicator includes Capital tools (first row), Asset-side tools (second row), and Liquidity and Foreign Currency tools (third row) separately as explanatory variables. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4.

On the other hand, in the model for Emerging Economies we can obtain the negative reponse in capital tools we see in the model for all countries in the initial periods. This means that it is the emerging regulators those that relax their capital related instruments in response to tightenings in capitla instruments abroad. At the same time, the relation with respect to the asset tools is positive as in the baseline and non-significant for the liquidity tools.

This means that for emerging regulators, tighter capital requirements abroad allow them to relax their own requirements, while asset-side tightenigns, more closely related to the global financial cycle, does not provide the scope for this. Instead they tighten their asset and credit requirements in response. Lastly, the liquidity tools spillovers may be less concerning for these economies, and then reacting in response is not as necessary.

As with the first classification we generated more results than what is shown in the paper or appendix. We provide a summary of these in the table 1.4. The conclusions are similar, the policy response in advanced economies is largerly positive for all instruments, and specially in reaction to foreign policy changes originating in other advanced economies. The policy response of emerging economies is negative for capital tools, and in particular to those implemented in advanced economies, while the response to policies in other emerging countries is positive for instruments related to the global financial cycle. Finally, the baseline result follows here too: the policy reactions dynamics are driven by post-GFC effects. Some responses for models with the rest of the world split in advanced and emerging economies are also shown in the figures 1.25 and 1.26 in the appendix 1.B.

When we estimate these results by sub-periods (after and before the financial crisis) we obtain that the responses in all cases, for both advanced and emerging economies become significant only in the post-crisis estimation. In the advanced, for all tools as in the full sample counterpart, and for emerging for capital and asset tools. The full sample signs of these responses are also captured by the post-crisis sample in all cases (see figure 1.24 in the appendix 1.B).

Table 1.4: Sub-sample results for Classification 2: Capital, Asset and liquidity tools (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Capital	-	-,+		+	+	+	-		
Asset	+	+	+	+	+	-	+		+
Liquidity	+	+	-	+	+	+		+	
Post GFC									
Capital	-	+		+	+	-	-	-	+
Asset	+			+	+	+	+		+
Liquidity		+	+	+	+	+			-
Pre GFC									
Capital		-				+			
Asset		+			+				
Liquidity	+	+		+	+	-		+	

Note: Sign of the IRF of each subcase for the Classification 2 of the policy tools. Units: Policy Change (+: tightenings, -: loosening).

1.4.3 Robustness Exercises

We verify the robustness of the results in the previous subsection with a number of additional estimations. To start, we change the baseline estimation equation by removing the global controls and replace them with time fixed effects. The results are qualitatively similar[6], although part of the propagation effects that we are intersted in capturing are now absorbed by the time effect, that is the cost of a perfect filtering out of potential global cofounding factors.

Additional Instrument classifications

We also consider additional classifications to verify some statements we made based on the results on the main ones (by targeted agent, borrowers or lenders, and by type of variable or risk affected, capital, asset, or FX and liquidity).

First, we mentioned that cyclical concerns are critical for the regulatory competition interactions in emerging economies. To verify this we analyze a new classification: by broad type of policy objective:

Structural tools: Countercyclical Capital Buffer, Conservation Cap. Buffer, Leverage Limits, Loan Loss Provission, Liquidity Requirements.

Cycle aimed tools: Limits to Credit Growth, Loan Restrictions, Limits on Forein Currency, Loan-to-Value, Debt Service to Income Ratio, Loan-to-Deposit Ratio, Limits on FX positions, Reserve Requirements, Tax.

The summarized results are shown in table 1.9 in Appendix 1.D. In this case the emerging economies planners are tightening in response to cycle related tools in other emerging economies as well. We also see that as the advanced economies' regulators are reacting actively to policies enacted in other advanced economies, but that relax their toolkit in presence of stricter cycle related tools in emerging economies.

On the other hand, we verify another classification based on tools that are particularly relevant for international finance concerns (e.g. capital flows, or foreign currency flows) with categories given as follow:

Foreign Currency Tools: Capital Requirements (FX targeted measures), Limits on Foreign Currency, Limits on FX positions, Reserve Requirements (Foreign Currency Denominated).

[6]We show a summary of these results for one of the classifications in the table 1.12 at the end of appendix 1.D. The rest are available on request.

Reserve Requirements: All Reserve Requirements but FCD (foreign currency related)

Credit Tools: Limits on Credit Growth, Loan Restrictions, Loan-to-Value Ratio, Limits on Debt to Service Ratio

The results are shown in table 1.11 in Appendix 1.D. For this classification we confirm the policy substitution efforts of both advanced and emerging regulators in presence of stricter regulations in the other type of economies. For the advanced ones, the domestic policies are relaxed in presence of stricter reserve requirements and credit tools in emerging economies. This reflects that hedging the foreign currency risk originated in emerging economies is not an important concern for developed economies. In contrast, the foreign currency hedging is key in emerging economies, which tend to relax their toolkit after stricter FX related policies in advanced countries.

Policy Tightenigns or Loosenings Considered Separately

We also showed that one of the changes in policy practices after the Global Financial Cycle was the tendency to apply more policy tightenigns of the prudential toolkit. This was the case in every type of economy. Then, it would be natural to verify whether these strategic interactions are only relevant for policy tightenings or if potential foreign policy loosenings could also be important benchmarks for domestic regulators. This type of exercise is also present in the literature, for example in Richter et al. (2019b).

Methodologically, now we consider the tightenigns and the loosenings in separate indicator variables, each increasing by one if a tool was tightened or loosened, respectively. In that regard, a positive reaction for the tightening has our usual policy competitive interaction interpretation, while on the contrary, a positive reaction to a loosening implies a policy substitution (tightening in response to a relaxation in policies abroad).

The results are shown in table 1.10 in Appendix 1.D. For this case we obtain that both tightenings and loosenings are relevant, i.e., the strategic interactions are present for both types of policy change, and quite importantly, show consistent signs (a positive reaction to tightenigns or negative to loosenings).

Accounting the Intensity of the Policy Changes

There have been substantial improvements in terms of the availability, coverage, and informativeness of the macroprudential policies data at the cross-country level. To make an idea of

this, a few years ago the data available and used by some seminal studies such as Cerutti et al. (2017) consisted on indicator variables denoting only the use of a policy instruments rather than the policy stance as in this work. Additionally, the number of tools available (only 12), and countries with information were lower too. This changed with the contribution of Alam et al. (2019) (integrated MAP database). We have certainly benefited form this new database that generated instruments and country specific indicators capturing the policy stance (tightenings or loosenings of tools).

However, as Richter, Schularick, and Shim (2019b) mentions, these policy indicators still fail to capture the intensity of the policy change. That is, in the "stance" indicator used until now, a small or a substantial increase in the capital requirements yields the same value of the policy variable. This is certainly a shortcoming, of the available data.

Despite this, the integrated database we use tries to fill this void by generating data on the Loan-to-Value ratio for a smaller number of economies (52 out of the 65 in our sample). We use this information and repeated our exercise. The baseline estimation is similar to (1.2) but now the policy variables on the equation is the LTV ratio.

The results (shown in the appendix 1.C) are not as conclusive as in the rest of the paper. We obtain a similar positive cross-country complementarity effects in presence of foreign tigthenings using the full sample. However, unlike in the rest of our exercises, neither subsample (period, splitting the rest of the world policies, or estimating separate models for advanced and emerging economies) estimation supports this result strongly.

We see this as an issue generated by the data limitation. Perhaps, if the same type of variable would be available for more instruments and countries we could use the actual level for our baseline exercises rather than the indicators. However, for now we consider more appropriately to stick to the conventional approach and use the indicator.

It should be noted that the outcome of this intensity-inclusive estimation is consistent with the rest of our results, although it is still limited as it ignores almost all of the macroprudential policy toolkit, and every instrument targeted at the financial institutions.

1.5 Policy Implications and Scope for Coordination

We obtain a number of important results on the evidence of cross-country co-movements between macroprudential regulations. On average, we find that these policies react to their foreign counterparts and usually in the same direction of the policy change abroad. This is the

case, even after controlling for the potential external (domestic and global) variables that these instruments react to.

We also obtained that for some instruments and sub-cases (e.g. the reaction of EM regulators to foreign capital tools in AE economies) the opposite relation holds, there is a local relaxation in presence of a foreign tightening. Both of these effects, a complementarity of these policies or a potential substitution are aligned with the findigns of empirical studies in the literature (Aiyar et al. (2014) for the positive, Tripathy (2020) for the negative), and the overall comovement is also consistent with the evidence indicating the policy leakages and international spillovers of these instruments.

Our motivation is to test whether these instruments are set with any strategic considerations, after the regulators internalize the international dimension of these policies, and the results support this hipothesis. These tools seem to be implemented not only in response to fundamentals (local and global), but also as part of an international regulation game.

We see these results as indicative of a potential scope for policy improvements in the form of internationally coordinated cooperative regulations.

This is consistent with the theoretical literature on prudential policy interactions and coordination. On one hand, we have a potential positive strategic complementarity between these instruments, that could generate welfare losses due to excessive regulatory interventions (see Korinek (2020), Davis and Devereux (2019), among others). On the other, a negative relationship may indicate a free riding incentive that could lead to issues of suboptimal levels of regulation (Kara, 2016).

Clearly, we cannot guaranty such scope from this study alone. A strategic policy interaction is only a necessary condition for it, but not a sufficient one. However, we still verify such interactions exists and extend beyond the effects intermediated by economic fundamentals which in itself is relevant.[7]

1.6 Conclusions

We study the empirical policy interactions between macroprudential regulators at the cross-country level. Our objective is to determine whether regulators set their policies with strategic considerations in mind and after internalizing the spillovers of foreign regulations in their economies, rather that only as a function of local and global economic conditions. For that

[7] A welfare exercise that evaluates the merits of policy coordination for different types of economies can be found in Granados (2021).

purpose, we exploit a recently available dataset on instrument-specific policy stance indicators in a panel of 65 economies. We generate an indicator of the policy of the rest of the world from the perspective of each economy and analyze the cross-border interactions using a panel local projection approach.

Our findings suggest that domestic regulators can react in response to foreign policy changes, and on average will tighten their policy instruments after witnessing a prudential tightening abroad. We also find that this behavior has gained traction after the onset of the Global Financial Crisis. To disentangle this effect, we implement a number of different specifications by type of local economy, foreign economy, sample period (pre and post-GFC), and type of foreign policy instrument change. This allows us to find additional case-specific effects that were less evident in the estimation for the aggregate policy indicator (all tools) and for all countries, namely: (i) there are strong domestic reactions to policies implemented in advanced economies, (ii) the countries reacting more strongly are the advanced economies too, (iii) although the reaction by emerging regulators is milder and null in many instances, these still can react to innovations related to some instrument categories, both at advanced or emerging economies.

Similarly, the exercises by type of instrument changing abroad reveal potentially important insights. In most cases we find positive interactions as in the baseline, however we also obtain instances in which there is a negative domestic response to foreign tightenings. Upon further inspection, we find that interactions between similar economies tend to portray a positive sign (tightening applied in response to foreign tightening), this is the case of advanced reacting to foreign advanced economies and emerging-to-emerging. Conversely, between non-similar economies, that is, for advanced-to-emerging and emerging-to-advanced responses, we find repeated instances with negative reactions, i.e., policy relaxations in response to stricter policy stances abroad.

The first case is consistent with a policy competition effort where domestic regulators implement stricter policies to protect their local markets from arbitrage by financial intermediaries looking to circunvent the foreign regulations (by expanding their business in other locations), while the second can be indicative of a policy substitution effort, where domestic planners rely on the stabilizing effects of the foreign policies. A key consideration leading to either reaction would be whether the foreign policy change exports financial instability or stability to the local economy. Noticeably, from our estimations, it seems this feature can be instrument-type specific and provides support to the idea that it's important to disentangle these interactions by type of tool, as in the aggregate these opposing effects could offset and be masked in the estimation for the pooled toolkit.

On the other hand, from our analysis by type of economy we have that emerging economies

would engage in competition mostly when reacting to policy tools related to the global financial cycle, while for other tools they are less reactive. In contrast, advanced economies policymakers are more reactive and will adjust their policies strategically for most of the categories of the prudential toolkit. We obtain these results based on estimates on our main two classifications, borrowers and lenders' targeted tools, and by type of variable or risk targeted (capital, asset, FX and liquidity), and verify its robustness with three additional classifications and in other auxiliar estimations (time fixed effects).

From a normative policy perspective, either effect, that is, a policy competition effort, or a policy substitution, could increase the scope for policy improvements through the implementation of coordinated regulatory frameworks. In the case of positive reactions, coordination could prevent situations of excessive policy interventions (race to the bottom or regulatory wars), or in the case of negative reactions, situations of suboptimal level of regulatory activity or of too unequal sharing of the burden of regulation.

Clearly, the determination of the viability and welfare gains of international cooperation goes beyond the scope of this study[8]. At the same time and on the empirical front, we leave for future work, contingent on the availability of new data, to carry out this analysis with data on the actual level of the tools rather than policy stance indicators.

[8]See Granados (2021) for a study on this topic

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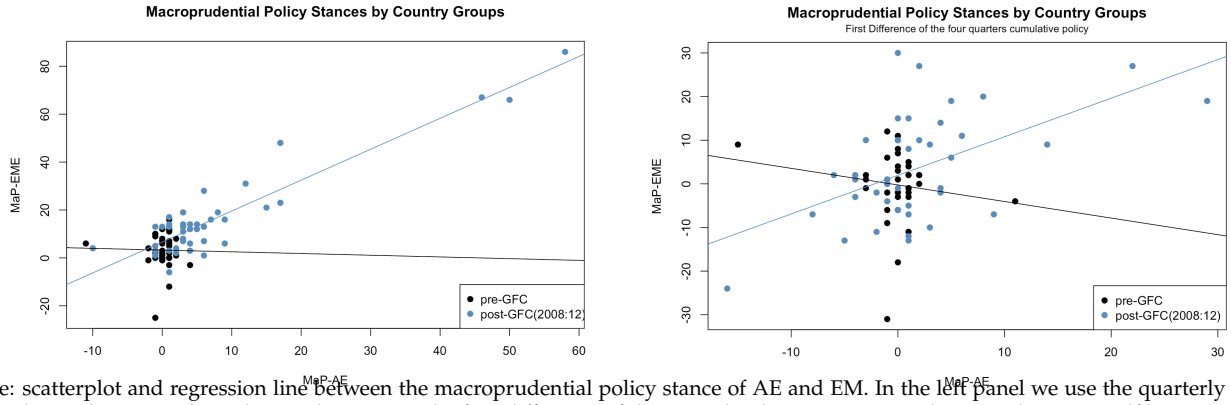
1.A Additional descriptive data

Co-movement of policy stances between country groups:

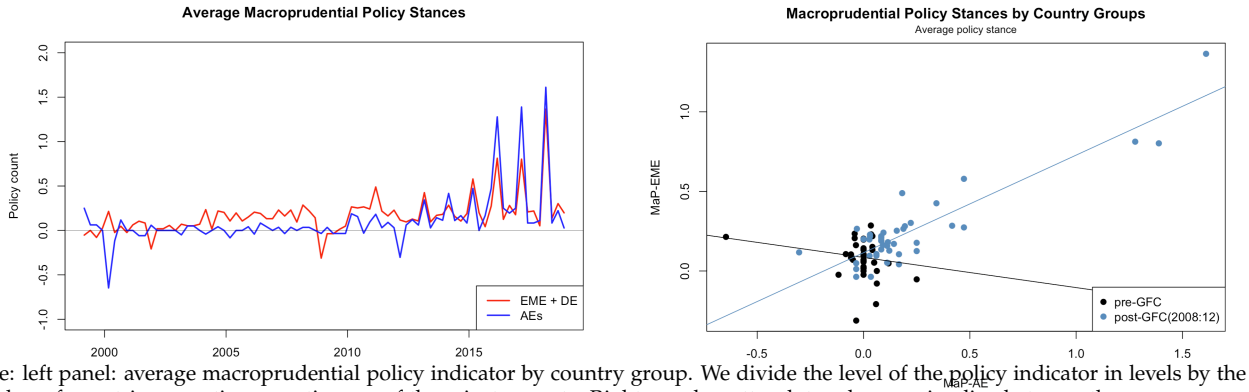
Figure 1.15: Macroprudential Policies in AE vs. EM, 1999-2018



Note: scatterplot and regression line between the macroprudential policy stance of AE and EM. In the left panel we use the quarterly level of the policy indicator, in the right panel we report the first difference of the annual policy stance given the annual stance itself becomes non-stationary.

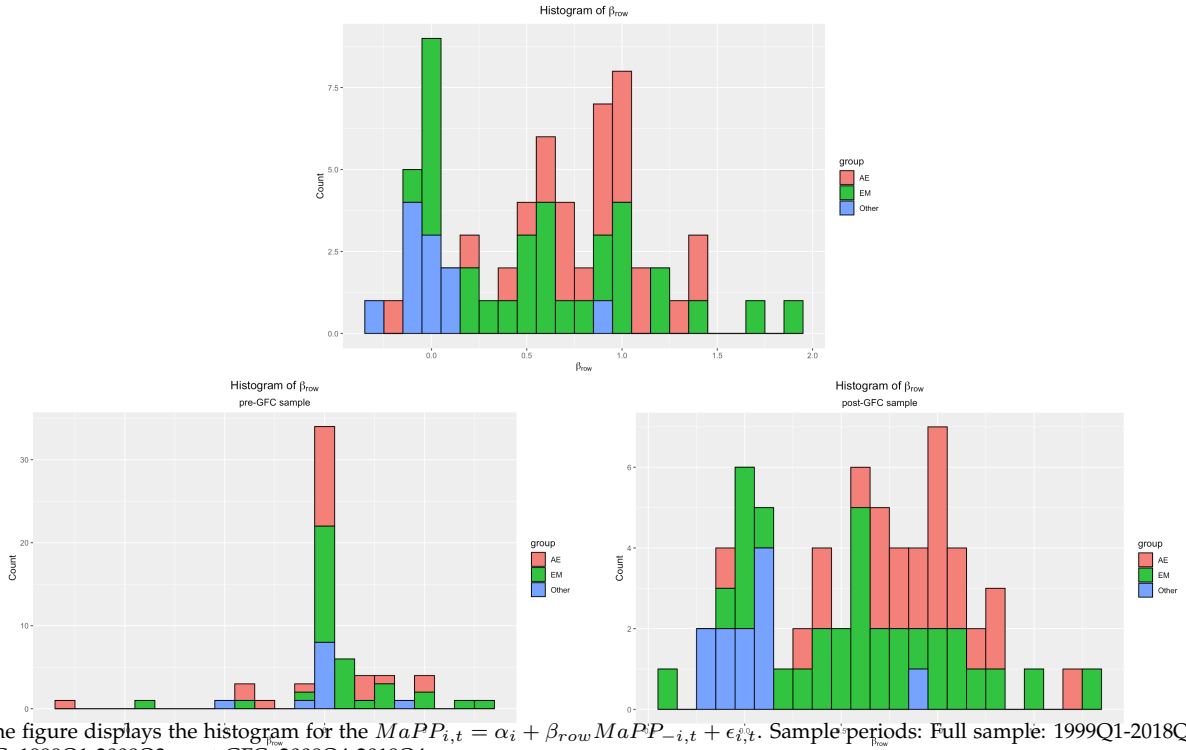
There is a co-movement between country groups' policies after the crisis. The correlations between policies in the AE and EM shown in the plots are -0.021 for the quartely and 0.298 for the annual policies and become 0.925 and 0.862 in the post-crisis sample.

Figure 1.16: Average Macroprudential Policies in AE vs. EM, 1999-2018



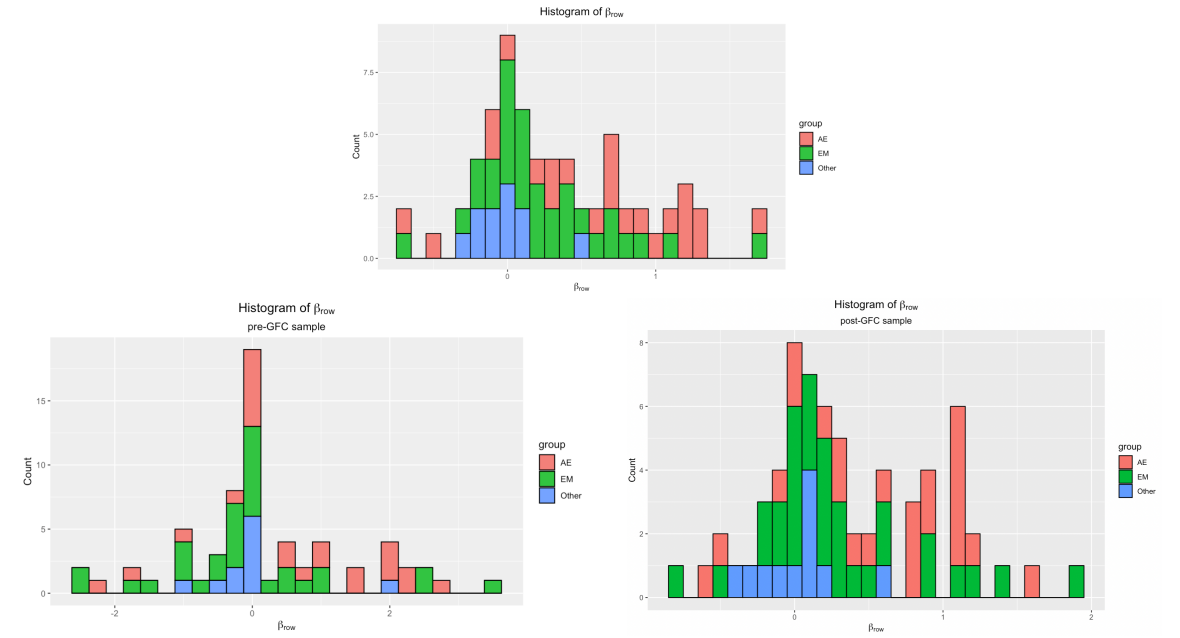
Note: left panel: average macroprudential policy indicator by country group. We divide the level of the policy indicator in levels by the number of countries reporting an active use of these instruments. Right panel: scatterplot and regression line between the average macroprudential policy stance of AE and EM. The correlation between the average policies in AE and EM before the GFC is 0.221, for the post-GFC period it becomes 0.812

Figure 1.17: Histogram for the coefficient of country-wise regressions for the policy vs. policy in the rest of the world (ROW)



Note: the figure displays the histogram for the $MaPP_{i,t} = \alpha_i + \beta_{row} MaPP_{-i,t} + \epsilon_{i,t}$. Sample periods: Full sample: 1999Q1-2018Q4, pre-GFC: 1999Q1-2008Q3; post-GFC: 2008Q4-2018Q4.

Figure 1.18: Histogram for the coefficient of country-wise regressions for the change in the annual policy vs. change in annual policy in the rest of the world (ROW)



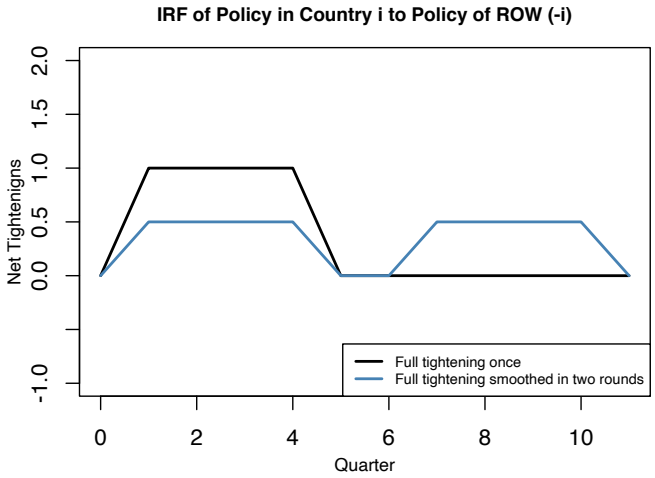
Note: the figure displays the histogram for the $MaPP_{i,t} = \alpha_i + \beta_{row} MaPP_{-i,t} + \epsilon_{i,t}$.

Table 1.5: Countries included in the sample

Advanced Economies	**Emerging Economies**	**Other**
Austria	Argentina	Albania
Australia	Azerbajan	Armenia
Belgium	Bulgaria	Cape Verde
Canada	Brazil	Georgia
Switzerland	Belarus	Jamaina
Germany	Chile	Kyrgyzstan
Denmark	China	Moldova
Spain	Colombia	Mongolia
Finland	Costa Rica	Mauritius
France	Cyprus	Nigeria
United Kingdom	Czechia	Paraguay
Greece	Dominican Republic	
Ireland	Hong Kong	
Iceland	Hungary	
Italy	Indonesia	
Japan	Israel	
Luxembourg	India	
Netherlands	South Korea	
Norway	Mexico	
New Zealand	Malaysia	
Portugal	Peru	
Sweden	Phillipines	
United States	Poland	
	Romaria	
	Russia	
	Singapore	
	Thailand	
	Turkey	
	Ukraine	
	Uruguay	
	South Africa	

1.B Additional Linear Projection Results

Figure 1.19: Conceptual LP-IRF for Annual Macroprudential Indicator



Note: The figure depicts conceptually a positive policy response in the annual policy indicator. In black the tightening is applied in period 1. In blue the tightening is applies in two rounds, half in period 1, the other in period 7.

The figure 1.19 shows a hypothetical positive policy response after a policy tightening abroad. It shows how a single policy change (or reaction) implemented in a single quarter persists in the annual policy indicator. A tightening in period one will be reflected in a higher policy indicator (hence a positive response) until period 4. In absence of additional policy changes the response would look like the black line.

Table 1.6: Local Projection: Response of domestic aggregate macroprudential policy stance to a change in foreign macroprudential policies.

	$h=1$	$h=4$	$h=8$	$h=10$	$h=12$	$h=16$
Dep. var.: Dom. Macroprudential Stance (full sample)						
Foreign Macroprudential Policy Change	0.048	-0.123	-0.036	0.268*	0.367*	-0.053
	(0.054)	(0.115)	(0.124)	(0.103)	(0.138)	(0.164)
R^2 (adj.)	0.019	0.038	0.040	0.027	0.024	0.027
Observations	4180	4004	3766	3577	3513	3257
Dep. var.: Dom. Macroprudential Stance (post-crisis)						
Foreign Macroprudential Policy Change	-0.030	-0.028	0.266	0.356*	0.280	-0.034
	(0.062)	(0.134)	(0.160)	(0.145)	(0.181)	(0.187)
R^2 (adj.)	0.038	0.049	0.054	0.042	0.036	0.086
Observations	2490	2314	2076	1951	1823	1567

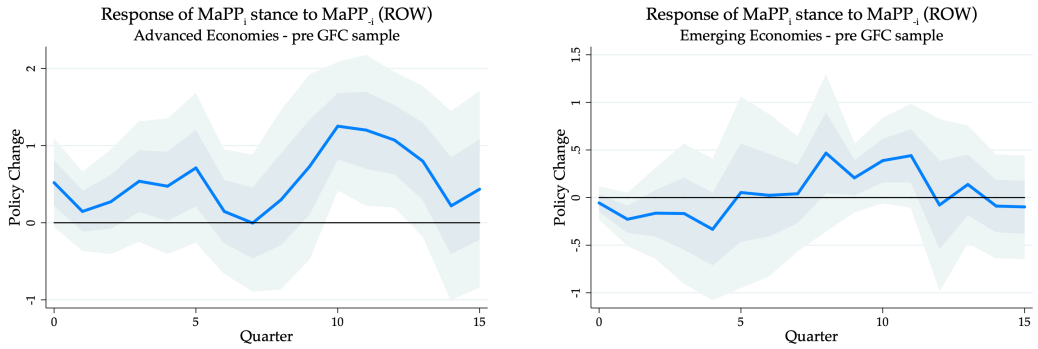
Note: * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Table 1.7: Local Projection: Response of domestic aggregate macroprudential policy stance to a change in foreign macroprudential policies.

	$h=1$	$h=4$	$h=8$	$h=10$	$h=12$	$h=16$
Dep. var.: Dom. Policy Stance (Advanced Economies)						
Foreign Macroprudential Policy Change	-0.091	0.510	0.688*	0.827**	1.707***	1.218**
	(0.107)	(0.269)	(0.289)	(0.258)	(0.409)	(0.397)
R^2	0.101	0.163	0.184	0.158	0.163	0.235
Observations	920	851	759	713	667	575
Dep. var.: Dom. Policy Stance (Emerging Economies)						
Foreign Macroprudential Policy Change	0.084	-0.216	-0.049	0.322*	0.145	-0.208
	(0.059)	(0.192)	(0.157)	(0.148)	(0.185)	(0.240)
R^2	0.024	0.059	0.065	0.033	0.021	0.009
Observations	2041	1954	1836	1746	1716	1596

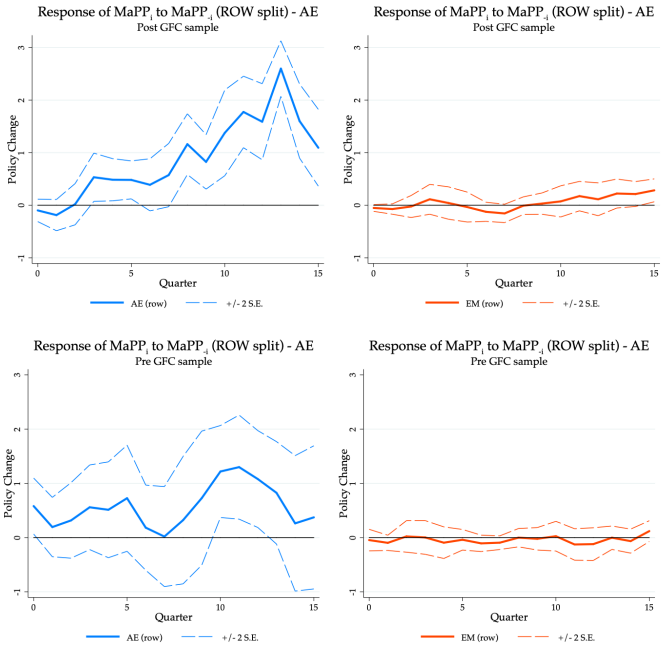
Note: Post-GFC (crisis) sample: 2008Q4-2018Q4. * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001

Figure 1.20: Response of MaP policies to policy changes in the rest of the world. Model for Advanced Economies (left panel) and for Emerging Economies (right panel).



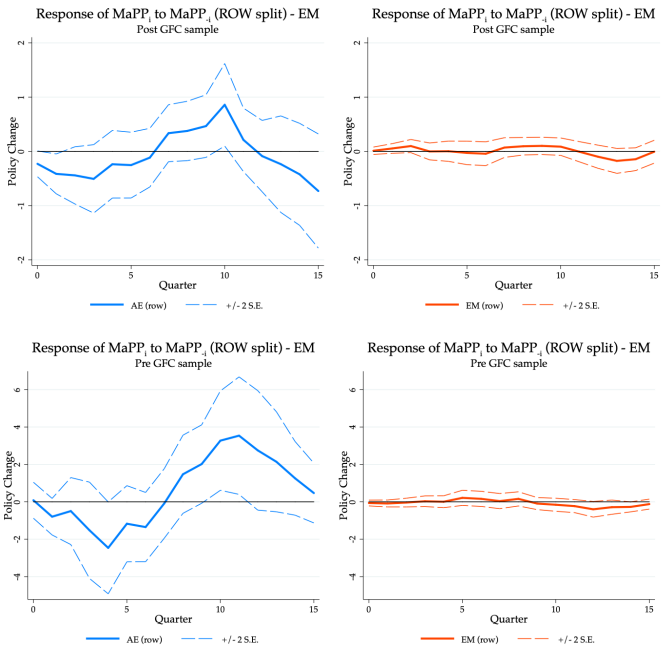
Note: Impulse Response Function from a local projection based on equation (1.1). Where the MaPP indicator comprises the information for all the 17 instruments. Left panel: estimation for Advanced Economies, Right panel: estimation for Emerging Economies. Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: complete sample: pre-GFC sample: 1999Q1:2008Q3

Figure 1.21: Response of MaP policies to policy changes in the ROW. Model for Advanced Economies.



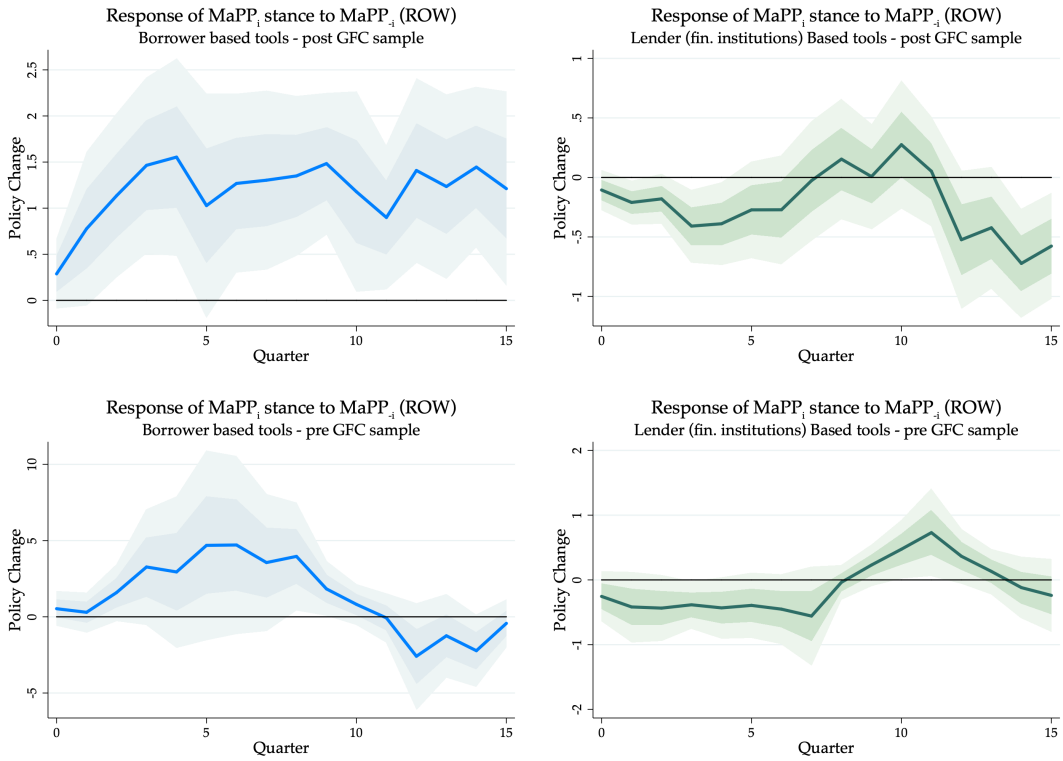
Note: Impulse Response Function from a local projection based on equation (1.2). MaPP Indicator: All 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: post-GFC sample: 2008Q4-2018Q4, pre-GFC sample: 1999Q1-2008Q3.

Figure 1.22: Response of MaP policies to policy changes in the ROW. Model for Emerging Economies.



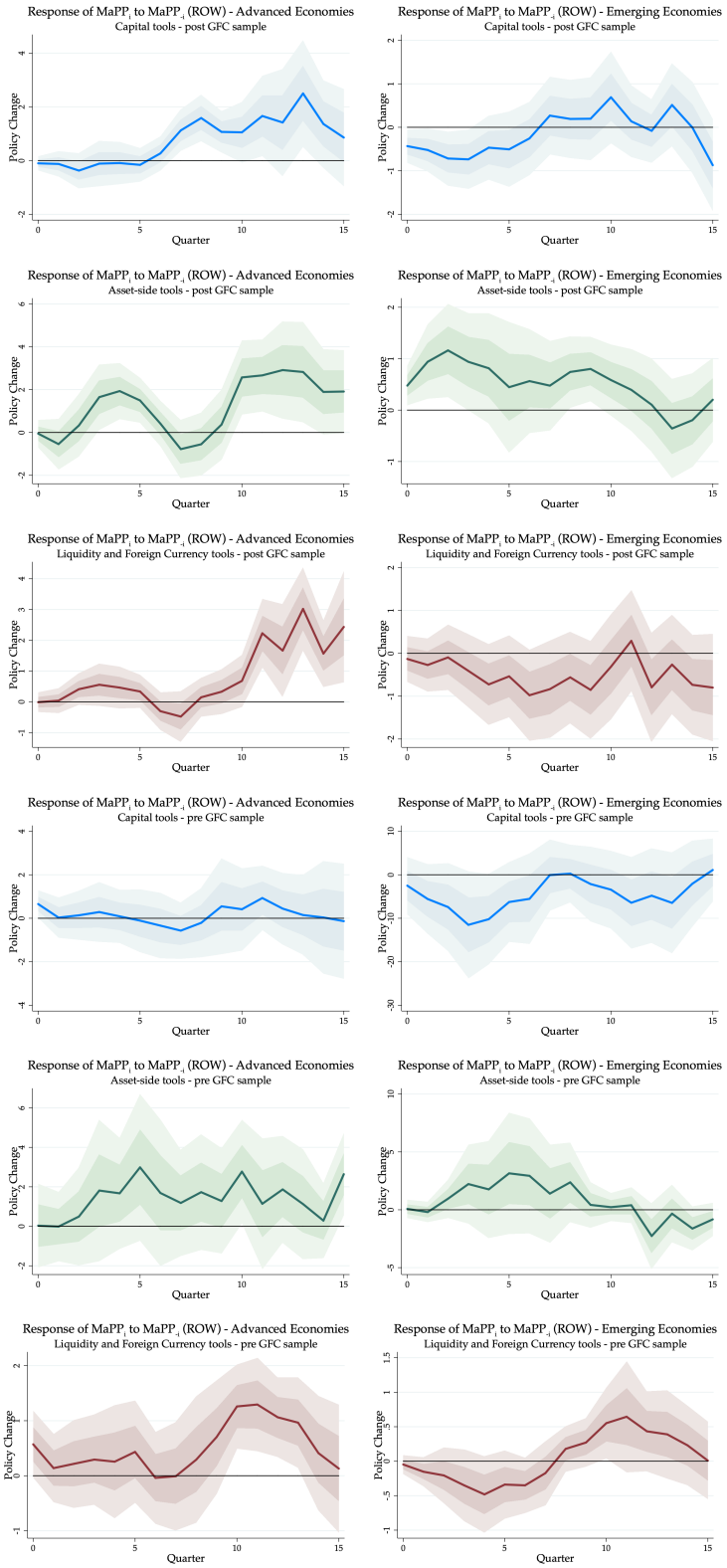
Note: Impulse Response Function from a local projection based on equation (1.2). MaPP indicator: All 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: post-GFC sample: 2008Q4-2018Q4, pre-GFC sample: 1999Q1-2008Q3.

Figure 1.23: Response of MaP policies to policy changes in the Rest Of the World. Response to Borrower instruments (left panel) and to Lender based policies (right panel).



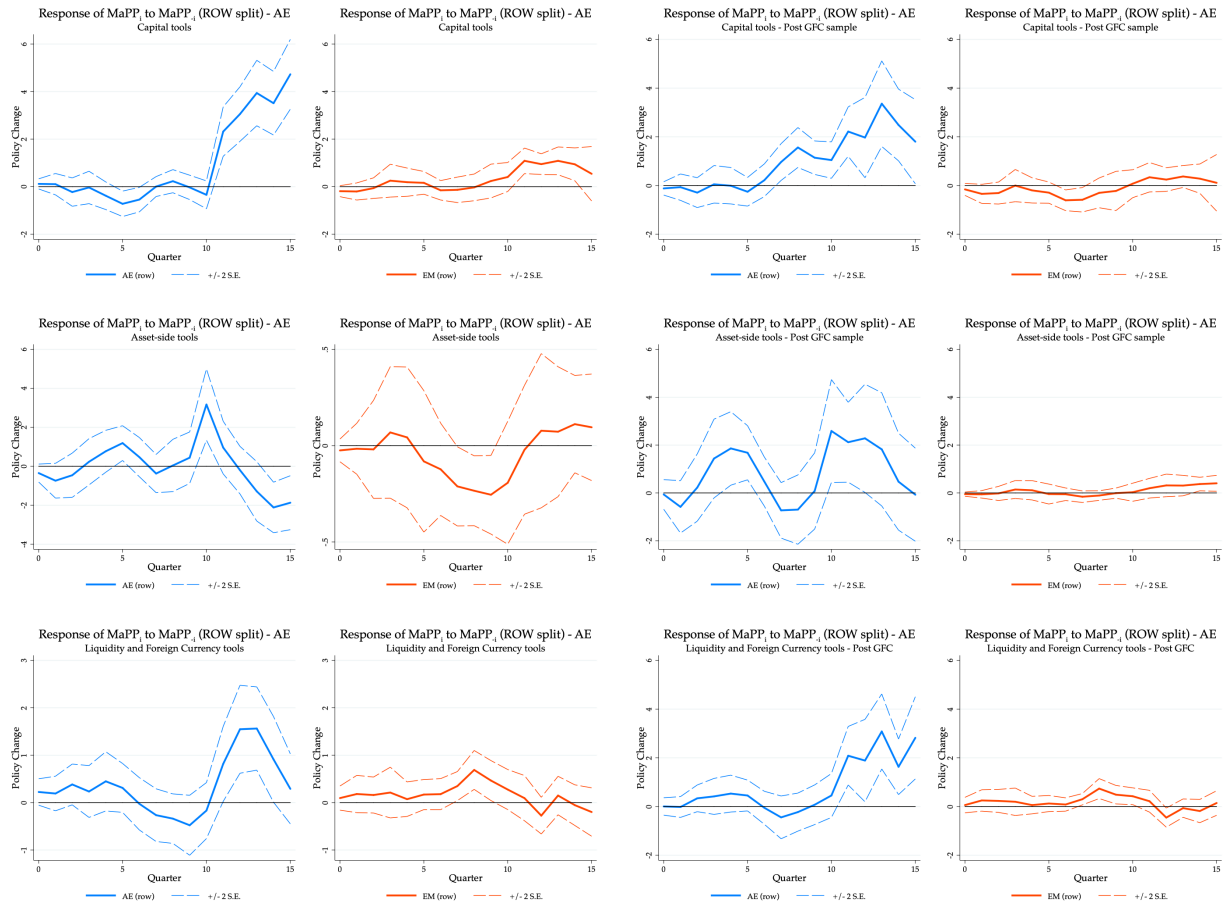
Note: the figure displays the Impulse Response Function from a local projection based on equation (1.3). The foreign MaPP indicator includes Borrower tools (response shown in left panel) and Lender tools (right panel) separately as explanatory variables. Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: post-GFC sample: 2008Q4-2018Q4; pre-GFC: 1999Q1-2008Q3,

Figure 1.24: MaPP Response to Capital, Asset, and to Liquidity policies. Model for Advanced Economies (left) and for Emerging Economies (right). Subsample periods.



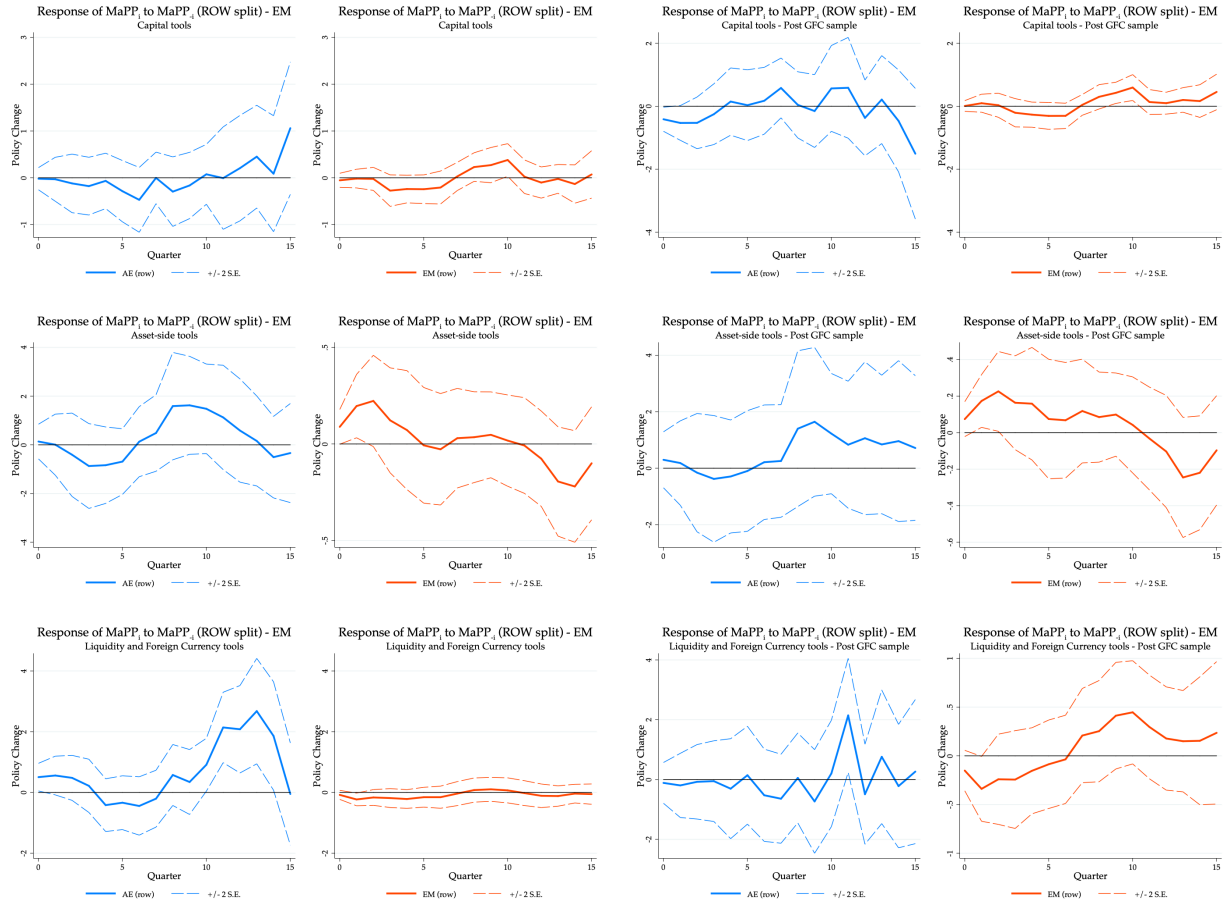
Note: Impulse Response from a local projection based on equation (1.5) estimated separately for Advanced (left panel plots) and Emerging Economies (right panel plots). The foreign MaPP includes Capital tools (first row), Asset-side tools (second row), and Liquidity and Foreign Currency tools (third row) separately as explanatory variables. Units: Policy Change (+1: tightenings, -1: loosening). Sample periods: complete: 1999Q4-2018Q4, post-GFC sample: 2008Q4-2018Q4, pre-GFC sample: 1999Q1-2008Q3.

Figure 1.25: Response of MaP policies to policy changes in the rest of the world. Capital, Asset-side, and Liquidity tools. Model for Emerging Economies.



Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4

Figure 1.26: Response of MaP policies to policy changes in the rest of the world. Capital, Asset-side, and Liquidity tools. Model for Emerging Economies.



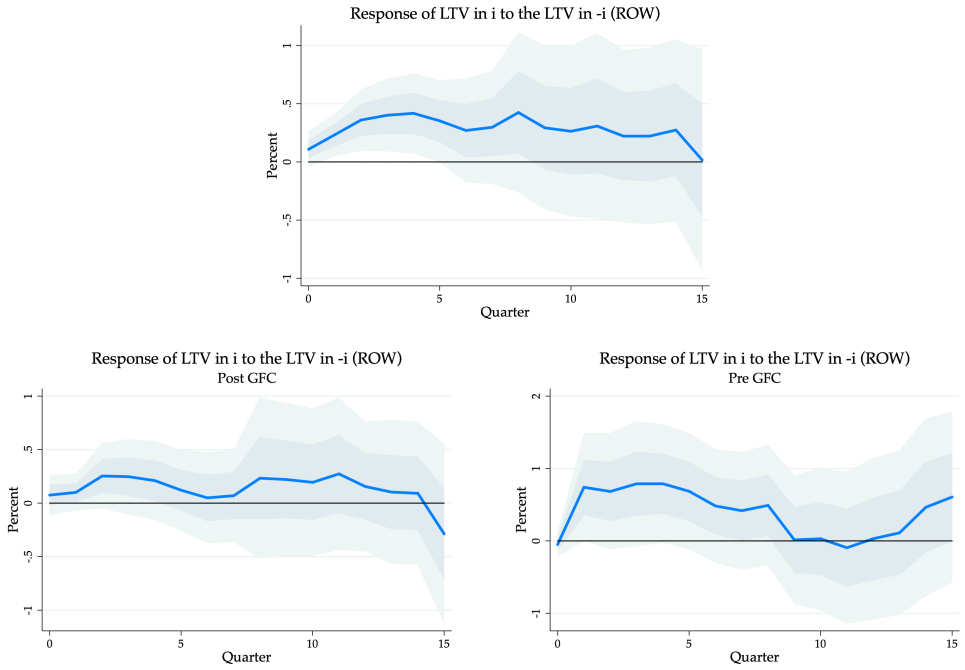
Note: the figure displays the Impulse Response Function from a local projection based on equation (1.2). Where the MaPP indicator comprises the information for all the 17 instruments. Top, left: AE policy response to Foreign AE policies; Top, right: AE policy response to Foreign EM policies; Bottom, left: EM policy response to Foreign AE policies; Top, right: EM policy response to Foreign EM policies. Units: Policy Change (+1: tightenings, -1: loosening). Sample period: 1999Q4-2018Q4

1.C Loan-to-Value Ratio Linear Projection Results

Estimation Equation for Loan-to-Value instrument:

$$\Delta_h LTV_{i,t} = \alpha_i^{(h)} + \beta^{(h)} \Delta LTV_{-i,t-1} + \varepsilon_{i,t+h} + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h} \tag{1.6}$$

Figure 1.27: Response of Local LTV MaP policies to policy changes in the LTV in rest of the world.



Note: the figure displays Impulse Response Function from a local projection based on equation 1.1. Where the MaPP indicator comprises the information for all the 17 instruments. Units: percentage. Sample period: 2008Q4-2018Q4 (left panel), 1999Q1-2008Q3 (right panel) .

Table 1.8: Summary of Sub-sample results for local LTV responses to foreign LTV changes

Coefficient for	**All Countries**			**Advanced Econ.**			**Emerging Econ.**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample	+					+	+		
Post GFC		-			-			-	
Pre GFC						+			

Note: Sign of the IRF of each subcase for the Loan to Value. Units: Policy Change (+: tightenings, -: loosening). In the cases where a sign is not reported the IRF was not significant at any horizon.

1.D Robustness Exercises Results

Table 1.9: Sub-sample results for Classification 3: Resilience and Cycle aimed tools (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Resilience	+	+	+	+	+	+			+
Cycle		+		+	+	-		+	
Post GFC									
Resilience	+	+		+	+	-			
Cycle		+		+	+				+
Pre GFC									
Resilience						+/-			
Cycle		+	-	+	+	-		+	

Note: Sign of the IRF of each subcase for the Classification 3 of the policy tools. Units: Policy Change (+: tightenings, -: loosening).

Estimation equation for tightenigns and loosenings considered separately:

$$\Delta MaPP_{i,t+h} = \alpha_i^{(h)} + \beta_1^{(h)} \Delta MaPP_{-i,t-1}^{Tightenings} + \beta_2^{(h)} \Delta MaPP_{-i,t-1}^{Loosenings} + \sum_{k=0}^{4} \phi_k^{(h)} X_{i,t-k} + \sum_{k=0}^{4} \gamma_k^{(h)} G_{t-k} + \varepsilon_{i,t+h} \tag{1.7}$$

In this case each foreign policy indicator will take values of 1 if there was a policy change in the direction indicated by the respective superscript (tightening or loosening) or zero otherwise. Additionally, for each indicator we consider the whole toolkit (17 instruments).

Table 1.10: Sub-sample results for Classification 4: Tightenings and Loosenings of instruments (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Tightenings	+	+		+	+				
Loosenings	-	-		-	-			-	
Post GFC									
Tightenigns	+	+		+	+		+	+	
Loosenings	-	-		-	-	-	+	-	+
Pre GFC									
Tightenings		+							
Loosenings		+	-	+	+	-		+	

Note: Sign of the IRF of each subcase for the Classification 4 of the policy tools. Units: Policy Change (+1: additional tightenig (loosening) or a policy tool).

Table 1.11: Sub-sample results for Classification 5: FX, Reserve Requirements, and Credit tools (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Foreign Currency (FX)	-	-		-	-			-	
Reserve Requirements		+		+	+	-		+	
Credit tools		+		+	+	-			
Post GFC									
Foreign Currency (FX)	-	-	+		+		-	-	+
Reserve Requirements		+		+	+	-		+	
Credit tools		+		+	+			+	
Pre GFC									
Foreign Currency (FX)				-	-				
Reserve Requirements		+		+	+	-		+	
Credit tools		+			+	-			+

Note: Sign of the IRF of each subcase for the Classification 5 of the policy tools. Units: Policy Change (+: tightenings, -: loosening).

Model with Time Fixed Effects instead of Global Controls:

Table 1.12: Sub-sample results for Classification 1 for model with Time Fixed Effects: Borrower and Lender tools (summary)

Response to	**All Countries**			**Advanced Economies**			**Emerging Economies**		
$\Delta MaPP_{-i,t}$	ROW	ROW (split)		ROW	ROW (split)		ROW	ROW (split)	
	All	AE	EM	All	AE	EM	All	AE	EM
Full Sample									
Borrower	+	+	+	+	+		+		
Lender	-	-	+	+	+	+	-	-	
Post GFC									
Borrower	+	+		+	+		+		
Lender	-	-	+	+	+	+	-	-	
Pre GFC									
Borrower	+				+				
Lender				+	+				

Note: Sign of the IRF of each subcase for the Classification 1 of the policy tools. Units: Policy Change (+: tightenings, -: loosening).

Chapter 2

MACROPRUDENTIAL POLICY COORDINATION IN OPEN ECONOMIES: A MULTICOUNTRY APPROACH

2.1 Introduction

A global trend towards the liberalization of financial markets have been observed in recent decades. The motivation is clear: resources should flow to their most productive destination. Alas, this comes a the cost of higher volatility in financial markets, global imbalances, and the global financial cycle, which is particularly hurtful for emerging economies (Rey (2013)). Naturally, a policy response aimed to mitigate this cost followed through implementation of new regulations such as the Basel accords and the establishment of institutions such as the financial stability board.

The economic implications of these regulations have been subject of numerous studies, ranging from those concerned with their effectiveness (Hahm et al. (2011) and Akinci and Olmstead-Rumsey (2018)), to the ones on the broader implications of the prudential toolkit, for example the policy leakages and interactions with other sectors (Aiyar et al. (2014) or Aizenman et al. (2017a)), policy goals (Coimbra and Rey (2017)), or even countries (Buch and Goldberg (2017)).

The cross-border spillover effect of these policies opens a question about the viability of coordinated regulation arrangements between economies. In fact, some features of these policies may indicate the scope for cooperation welfare gains, for example, these instruments are interdependent, as their effects extend beyond their country of origin and may induce foreign policymakers to change their own toolkit in response, but also their implementation is costly, and may be subject to trade-offs with other policy goals. As a result, nationally oriented policies that fail to internalize these effects may be inneficient.

This question is even more relevant for emerging economies where financial frictions are more prevalent as mentioned by Chang and Velasco (2001) and where their small economy features render them more fragile to the whims of global markets. Could this countries, helpless on their own, react in any way (e.g. cooperatively) to compensate for their fragility and keep pursuing the benefits of financial integration? We try to answer such question by setting a model with

multiperipheral features (several emerging economies) but where a financial center imposes strong spillovers on the rest of the world.

Our contribution to the literature consists on studying cooperation from a multiperipheral perspective while still allowing the rest of the world to adjust their toolkit when witnessing cooperative efforts in other regions. To the best of our knowledge, this is novel and still encompasses the usual approaches (center-periphery or periphery-periphery with exogenous center). More concretely, we study a wide menu of policy setups with different degrees of cooperation, as shown in table 2.1.

Table 2.1: Policy Setups to Analize

Case	Solutions
Nash	$RPP^i = \max \hat{W}^i, \quad \text{for } i = \{e_1, e_2, c\}$
Coalition 1 (Emergent Economies - EMEs)	$RPP^{e_1,e_2} = \max n_1 \hat{W}^{e_1} + n_2 \hat{W}^{e_2} \quad \text{vs} \quad RPP^c = \max \hat{W}^c$
Coalition 2 (Center and EME-1)	$RPP^{e_1,c} = \max n_1 \hat{W}^{e_1} + (1 - n_1 - n_2) \hat{W}^c \quad \text{vs} \quad RPP^{e_2} = \max \hat{W}^{e_2}$
Cooperation	$RPP = \max n_1 \hat{W}^{e_1} + n_2 \hat{W}^{e_2} + (1 - n_1 - n_2) \hat{W}^c$

Note: The world consists of 3 countries $i = \{e_1, e_2, c\}$ where the sizes are respectively $n_1, n_2, 1 - n_1 - n_2 > 0$ and $n_1 + n_2 \leq 1/2$.

In Table 2.1 RPP_i makes reference to the Ramsey Planner Problem of the social planner, consisting on maximizing an objective welfare function subject to the private equilibrium choices of the agents. Notice how the objective function under cooperation corresponds to a weighted welfare of the participating countries.

In our setup they key ingredient justifying policy interventions is the presence of financial frictions. In that spirit, the standard question in the literature (Fujiwara and Teranishi (2017), Banerjee et al. (2016) and Agénor et al. (2017)) is: do financial frictions call for policy cooperation?. Here in addition, we explore whether peripheric countries should cooperate when facing financial frictions and spillovers stemming from a center.

The financial friction we consider takes the form of a costly enforcement agency distortion, in the spirit of Gertler and Karadi (2011), that is more prevalent in the emerging markets. As a result, the interbank lending relationships of emerging economies will be subject to default premium. In that context, we verify the relative convenience our menu of policy setups aimed to mitigate this distortion and smooth the credit spread.

At first, intuition may dictate that the policy stance of a periphery, cooperative or not, is

inconsequential for shaping market outcomes given the relative size of the economy, and instead by cooperating, a financial center relinquishes more than what it gains. However, if the peripheric block is no longer very small in relative terms, for example, as a result of several small countries joining policy efforts, there could be a scope for cooperation.

Methodologically we set our model as a large open economy framework along the lines of Banerjee et al. (2016), Agénor et al. (2017), and Aoki et al. (2018). However, it differs from these setups in which we abstract from monetary policy concerns, a simplification that makes easier to extend the environment to that of a multiperipheral financially integrated economy, a feature that in turn, allows us to examine the strategic interactions between macroprudential regulators in different types of economies.

The international policy externalities manifest through two channels, first, the profits of exiting bankers are directly affected by domestic and foreign policy tools and enter the households' budget constraint since these are the banks' owners, second, on the real side the firms fund their input acquisitions with banking loans, whose cost depends on the policy instruments, which affect the investment decisions that shape the output dynamics. In this context, policymakers that act cooperatively will internalize the budget constraints of coalitions' participants which depending on the degree of coordination will lead to different policy prescriptions and equilibrium allocations.

Our results suggest the presence of important international policy spillovers that result from the interaction of two features. First, the cross-border effects stemming from the Center are strong, and second, the local effects of policy are weaker at the Center. As a result, Center based policymakers aiming to implement a given domestic effect are induced to apply stronger policies that ripple substantially to the rest of the world. Both features occur due to the role of the Center as a global creditor. For the former, the Center's policies affect the banking profits in every country, domestically via revenue rates, and globally via changes in the cost of interbank lending. On the other hand, the weaker local effect is explained by adjustments in the demand for funding by borrowers that partially offsets the intended effect on intermediation targeted by the regulators.

We obtain that the policy effects are increasing in the extent of the financial distortions, which is consistent with the conventional wisdom suggesting these policies are more useful in emerging markets (Alam et al. (2019)). Other features that determine these effects are the net foreign asset positions, the price and demand changes in the interbank sector, and lastly the disruption in real production activities, a concern that is ubiquitous in regulation circles and lately in empirical studies (e.g., Richter et al. (2019a)).

Regarding international policy coordination we find non-sizable welfare gains from coopera-

tion in our baseline setup. Relatedly, every policy setup (decentralized, semi-cooperative, and cooperative) can mimic the first best and undo the financial distortion. Interestingly, the optimal policies will differ by becoming more conservative as the degree of cooperation increases. The latter implies a property of the cooperative policy setups: they limit the level of interventionism necessary for mitigating the financial frictions.

We confirm these results in additional exercises, where we show that with costly policymaking the coordinated setups can generate substantial gains. Additionally, we show the inclusion of a second periphery yields results analogous to a two-country center-periphery setup if the new periphery is analogous to the first one. However, without symmetric features the peripheral interactions may lead to qualitatively different results.

Related Literature. Our work relates to the literature studying the macroeconomic effect of financial frictions that originate in the financial intermediaries sector. Then it incorporates elements from frameworks that model the banking sector explicitely (e.g., Gertler and Karadi (2011), Gertler and Kiyotaki (2010), Adrian and Shin (2010)) and its cycle amplifying implifications for the rest of the economy.[1]

This study is also concerned with the open economy dimension of the macroprudential policies and the presence of international financial spillovers between emerging and advanced economies. Then, it is related to the global financial cycle literature (Rey (2013), Rey (2016)) and to studies on the stabilizing role of financial regulations for emerging economies (Nuguer (2016), Cuadra and Nuguer (2018)).

Finally, a main theme of our work is that of strategic interactions between regulators in presence of financial frictions. One strand of this literature revises the case of monetary policy cooperation with financial imperfections (e.g., Sutherland (2004), Fujiwara and Teranishi (2017), or Bodenstein et al. (2020)), or study the coordination between monetary and financial regulators (De Paoli and Paustian (2017)). Our work, incorporates some of these features but is only concerned about the international coordination of macroprudential regulators. In that sense, it relates more closely to Davis and Devereux (2019), Korinek (2020), Bengui (2014), Jin and Shen (2020), and Kara (2016). Interestingly, these studies suggest cooperation is advisable from different, and seemingly contradicting perspectives. In some cases because it prevents unnecessary interventionism, or in the latter two studies by preventing sub-optimal levels of regulation. We align with the first group in that we find that one advantage of coordination is that the level of intervenionism is limited.

[1] See **?** for a complete literature survey on this topic.

However, we still differ from these articles in several dimensions, namely, we model the frictions at the banking model explicitely and we analyze a multiperipheral structure, hence allowing for potential retaliative policies from regulators outside the cooperative coalitions. The inclusion of these features, as discussed here and shown in Granados (2021) can be critical in determining whether or not cooperation is a good policy recommendation, and hence allows to reconcile these seemingly opposing results which, partly, constitutes our contribution to the literature.

The rest of the paper is organized as follows: section 2.2 explains the main model, section 2.3 describes the cross-border policy spillovers, then in section 2.4 we set the optimal policy problems. In section 2.5 we carry out the welfare comparison across policy setups for our baseline, while in the sections 2.6 and 2.7 we explore alternative versions of the model. Finally, we discuss the added value of considering a second periphery and conclude.

2.2 The Model

The model considered is based on Banerjee et al. (2016) and Agénor et al. (2017), meaning that it essentially follows the banking sector modelation of Gertler and Karadi (2011) applied to an open economy setup. At the same time it will include a macroprudential policy in the form of a tax to the return on capital such as Agénor et al. (2017) and Aoki et al. (2018), among others. The advantage of such formulation is that the policy instrument will be attached directly to the credit spread of the economy that drives the capital flows at the cross country level. Our formulation will be set in a finite horizon setup and will be amplified with a third economy to consider a more relevant role for the peripheral economic block.

2.2.1 Economic Environment

In this model the main feature defining whether a country is an emerging market economy is that its financial sector has a limited intermediation capacity, meaning that is unable to issue deposits claims for their households to some extent. Such feature implies that it will have to resort to the international financial banking sector to make up for the difference and being able to meet the funding needs of its firms. This setup is shown in Figure 2.1 (left), where the pointed red arrows represent financial flows.

Such structure implies that the emerging economies have a financial dependency on the funding stemming from center banks, and in an environment of imperfect information between

creditors and debtors, this could imply a double layer of agency frictions in the economy: that between center households and banks and another one between global banks and emerging country banks. However, we assume the friction is more prevalent in countries that are financially underdeveloped at a greater extent, i.e., the distortion is more accentuated in the peripheries.

For simplicity, and mainly because I focus solely on macroprudential policies, the real sector will consist only on one consumption good and there will be no deviations from the law of one price. In addition, preferences are identical between agents, which implies that the parity or purchasing power holds and the real exchange rate will be constant, playing no role in this version of the model.

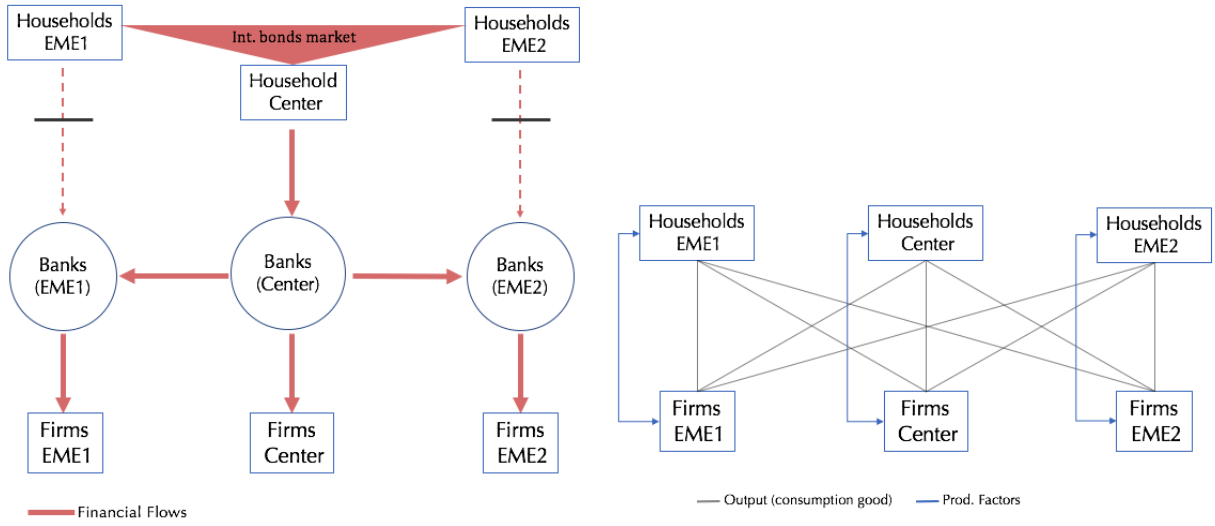


Figure 2.1: Financial (left) and Real (right) sector flows in the model

Finally, the households will have access to a non-contingent bond, traded internationally in a competitive market. Therefore, despite the lack of local financial capacity in the emerging countries banks, the household savings will not be curtailed. This implies that the resource fluctuations and differences between agents in each country will be driven mostly by wedges in credit spreads at the bank level rather than by constraints at the household level in achieving their intended optimal consumption/savings levels.

2.2.2 Model Setup

The world consists of three economies that live for two periods $t = 1, 2$. The economies are indexed by $j = a, b, c$, the first two will be emerging or peripheral countries (a and b) and the

third one is a developed economy that acts as financial center (c). The relative population sizes of the economies are n_j with $1-(n_a+n_b)\geq\frac{1}{2}$. There is an international financial market where the households trade in assets. There will be one final consumption good, freely traded and available to all economies.

Each economy has five types of agents: Households, final consumption good producers, capital producers, banks and a government sector.

In terms of notation, throughout the document, superindexes denote the country, while subindexes refer to other features such as the sector of the economy and time periods. Additionally, if a superindex is ommited it normally means that the variable or equation applies to the three countries, which is also taken into account when the equation is numbered (each additional number denotes the expression for one of the economies).

2.2.3 Investors

For simplicity, the investment decision is separated from the other household decisions and will be subject to adjustment costs. Physical capital is produced in a competitive market by using old capital and investment. The depreciation rate of capital is $1-(1-\delta)\xi_t^j$, where ξ_t^j represents a capital quality shock with expected value of one. The investment will be subject to convex adjustment costs, with the total cost of investing I_1^j being:

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

Where $\bar{I}$ represents the benchmark level of reference with respect to which the adjustment cost is defined. The reference level is usually set at the steady state, the previous level of investment or a combination of both. Most importantly, it must be satisfied that $C(0)=0,\ C''(\cdot)>0$. For simplicity we pick $\bar{I}$ as I_0, i.e., the predetermined level of capital.

The capital producing firms buy back the old capital stock from the banks at price Q_1^j and produce new capital subject to the adjustment costs.

The investor solves:

$$\max_{I_1}\ Q_1I_1-I_1\left(1+\frac{\zeta}{2}\left(\frac{I_1}{\bar{I}}-1\right)^2\right)$$

the F.O.C. is,

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

Similarly, for period 2 (when investment is zero),

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

2.2.4 Firms

The firms will operate with a Cobb-Douglas technology that aggregates capital. The capital in the first period will be provided directly by the households in the quantity predetermined (K_0). However, in the next period, the emergent economy will rely on foreign lending for funding capital accumulation, and then, the firms will rent the capital (K_1) from the banks instead.

The capital dynamics for the only period of accumulation are,

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

The technology that aggregates capital inputs into final goods is,

$$Y_1 = A_1(\xi_1 K_0)^\alpha \tag{10)-(12)}$$
$$Y_2 = A_2(\xi_2 K_1)^\alpha \tag{13)-(15)}$$

where K_0 is given.

Given the finite nature of the model, intermediation activities only take place in one period, whereas in the other the capital stock will be given and freely available for production. This implies that there is a different profit maximization problem for the final good firms to consider in each period:

In the first period the firm will solve:

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

the F.O.C. are,

$$[K_0]: \qquad r_1 = \alpha A_1 \xi_1^\alpha K_0^{\alpha-1} \tag{16)-(18)}$$

For the second period, the firms take into account the cost of funding and the revenue of selling the remaining capital stock to capital good producers that carry out the necessary investment to

build the capital stock for the next period.

In the second period the firm will solve:

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

the F.O.C. are,

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

To facilitate the model notation, we will follow the same definition for r_2, that is,

$$r_2 = \alpha A_2 \xi_2^{\alpha} K_1^{\alpha-1} \tag{19)-(21}$$

Substituting in the optimality condition for K_1 we obtain that the rate paid to the banks by the firms is given by $R_{k,2} = \frac{r_2+(1-\delta)\xi_2 Q_2}{Q_1}$. Moreover, by taking into account the possibility of a macroprudential tax on the marginal return on capital, such as in Agénor et al. (2017), we have that the effective rate obtained by the banks, that is, after paying the macroprudential taxes to the government is given by:

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

For the sake of clarity, it is important to notice that the firms will pay the pre-taxes banking rate. Only afterwards, the banks will consider the effect of the taxes in their profits. [2] We will elaborate on the policy tool and the role of this return rate in posterior subsections.

Capital dynamics and ownership

The dynamics of the model will be driven at every level (within and cross-country) by the capital flows. For that reason, and after laying out the problem the firm faces in a period with intermediation, it is relevant to clarify how capital is held, and profited from, by several types of agents in a single period.

There is only one period of capital accumulation ($t = 1$). The initial capital will be given for such period as K_0. Then, by the end of the accumulation period the capital in the economy will be given by K_1 as in (7)-(9).

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

The capital ownership between agents throughout each period is shown in the figure 2.2, which explains a typical period with intermediation. At first, the firms will hold the capital they bought to the households by the end of the previous period. The firms will use the capital for production and will sell the after-depreciation capital stock to capital goods producers that will generate the physical capital stock for the production of the next period (K_t). The new stock goes back to the households, that in turn, will sell it to the firms that will fund the purchase with banking loans. The loan is payable the next period at a promised gross rate R_{kt+1}

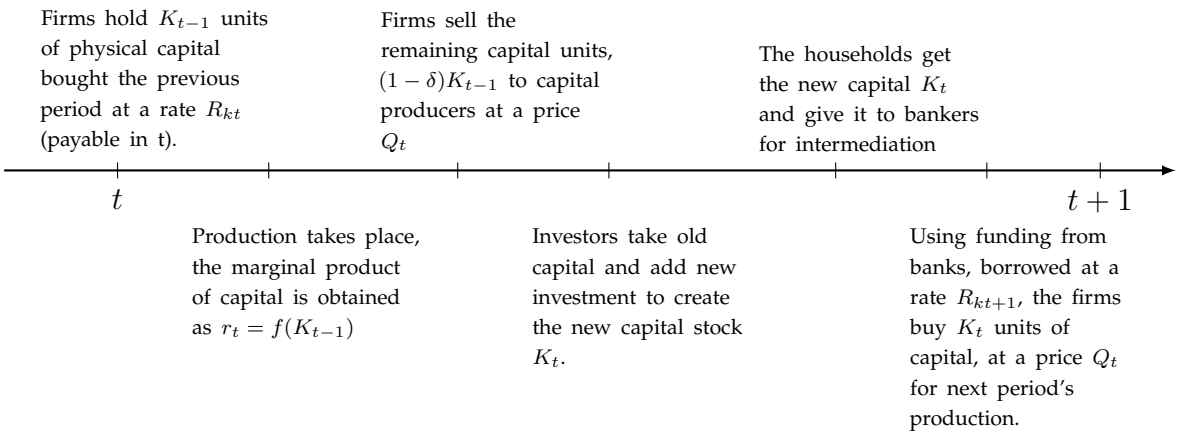


Figure 2.2: Capital ownership within a period

On the other hand, it should be noticed that the capital used for production in the period $t = 1$ cannot be subject to intermediation since there are no banks before the rest of the agents exist (the bankers themselves are household agents). Therefore, the pre-existing capital stock (K_0) will be provided directly from households to firms following the usual structure without explicit financial intermediation.

2.2.5 Banks

This is the target sector of the macroprudential policies. The set up is largely based on Gertler and Karadi (2011).

There is a financial intermediation sector in the first period that facilitates foreign funding from the center economy to the emerging countries. The creditors will be subject to an incentive compatibility constraint due to the fact that they can divert a portion of the assets intermediated (after realizing the return on the capital holdings).

The bank receives a start-up capital by their owner household and will try to maximize the value of the banking actitivies, given by the present value of its profits. Finally, at the end of its life, the bank will give back their net worth to the households in the form of profits.

Emerging Countries

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

The lending relationship between foreign and local banks will be subject to agency frictions, arising from the fact that creditor banks could default on their debt repayment and divert a portion κ of their (post-return) intermediated assets.[3] In either case (default or not) the gross return from intermediation for the bank is R_{k2} as given by the equations (22)-(24).

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

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

$$s.t. \quad L_1 = F_1 + \delta_b Q_1 K_0 \tag{25)-(26}$$

$$J_1 \geq \kappa\mathbb{E}_1\Lambda_{1,2}R_{k,2}L_1 \tag{27)-(28}$$

where the $L_1 = Q_1K_1$ is the total intermediated lending, F_1 is the foreign interbank lending borrowed from the center bank and $\delta_b Q_1 K_0$ is the bequest or start-up capital received from households. Finally, $\Lambda_{1,2} = \beta u'(C_2)/u'(C_1)$ is the stochastic discount factor.

The constraints correspond to the balance sheet of the bank and incentive compatibility constraint (ICC), in the former we impose that the value of the bank has to be larger or equal than the value they can abscond.

the F.O.C. with respect to the foreign debt (one for each emerging country $s = \{a, b\}$) are:

$$[F_1]: \qquad \mathbb{E}_1(R_{k,2} - R_{b,1}) = \mu\mathbb{E}_1\left(\kappa R_{k,2} - (R_{k,2} - R_{b,1})\right) \tag{29)-(30}$$

[3] A bank can divert assets as soon as they get the foreign funding or after the firms pay them the loan in the last period. I take into account only the second case when formulating the associated incentive compatibility constraint because it involves a stricter constraint which, when binding, makes redundant the constraint related to the first type of absconding.

where μ is the lagrange multiplier of the ICC (there will be one for each emerging economy).

Based on the F.O.C. we can obtain a result that we will use throughout several sections of the paper for analyzing the implications of the financial friction in the model:

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

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

$$R_{k,2} = \underbrace{\frac{1+\mu}{1+(1-\kappa)\mu}}_{\Phi} R_1$$

$\Phi > 1$ represents the proportionality scale between $R_{k,2}$ and $R_{b,1}$ and guarantees the credit spread is positive in the model. The larger Φ the greater the spread.

$\mu > 0$ by definition of the ICC. Hence, it follows that,

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

and,

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

The last inequality holds for $\mu > \frac{\kappa}{2(1-\kappa)}$ which is the case in every parametrization. ■

Advanced Economy

Given we are assuming there is no agency problem at the local level, the center economy bank solves:

$$\max_{F_1, L_1, D_1} J_1 = \mathbb{E}_1 \Lambda_{1,2} \pi^c_{b,2} = \mathbb{E}_1 \Lambda_{1,2} (R^a_{b,1} F^a_1 + R^b_{b,1} F^b_1 + R^c_{k,2} L^c_1 - R_{D,1} D_1)$$
$$s.t. \quad F^a_1 + F^b_1 + L_1 = D_1 + \delta_b Q^c_1 K^c_0 \tag{2.31}$$

The only restriction will be the balance sheet of the bank that now counts with the foreign interbank flows on the asset side and the local center deposits on the liability side (D_1).

the associated F.O.C. are:

$$[F_1^a]: \qquad \mathbb{E}_1(R_{b,1}^a - R_{D,1}) = 0 \tag{2.32}$$

$$[F_1^b]: \qquad \mathbb{E}_1(R_{b,1}^b - R_{D,1}) = 0 \tag{2.33}$$

$$[L_1^c]: \qquad \mathbb{E}_1(R_{k,2}^c - R_{D,1}) = 0 \tag{2.34}$$

2.2.6 Macroprudential policy and public budget

Among the number of possible prudential policies[4] (VaR regulations, leverage caps, loan/value ratios, etc) we consider a general type of policy that encompasses a broad set of macroprudential regulations: a tax on the return to capital. This will be a tax levied on the banking sector, as shown in equations (22)-(24).

The policy tool can be thought as a device to impose controls on international capital flows. This is the case because the tax has the advantage of affecting directly the wedge between the return on capital and borrowing rate (cost of funds for the bank), i.e., the credit spread, that in turn drives financial flows at the interbank level. Thus, we are taxing the source of inefficiencies directly.

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

$$\tau^j r_2^j K_1^j + T^j = 0, \qquad j = \{a, b, c\}$$

When setting the taxes optimally, each social planner will consider whether to join a cooperative arrangement or to do it independently (Nash). We consider several types of cooperation, namely worldwide, or smaller coalitions such as regional-emerging economies, or center with one of the peripheries. Each case will imply a different welfare function as explained in section 2.3.

Having set up the banks and policy tool, we can determine its effect on the leverage ratio of banks:

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

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

[4] see Cerutti et al. (2017) for a detailed classification of macroprudential policies

In the ICC (binding) we substitute the total foreign lending $F_1^e = Q_1^e K_1^e - \delta_B Q_1^e K_0^e$ for any emerging economy $e = \{a, b\}$ and solve for the total assets $L_1^e = Q_1^e K_1^e$ in terms of the initial net worth of banks:

$$L_1 = \underbrace{\frac{R_{b,1}^e}{R_{b_1}^e - (1-\kappa^e)R_{k,2}}}_{\phi_L} \delta_B Q_1^e K_0^e$$

Φ_L denotes the leverage ratio.

We can substitute $R_{k,2}^e = [(1-\tau^e)r_2^e - (1-\delta)\xi_2^e Q_2]/Q_1$ and differentiate with respect to τ^e:

$$\frac{\partial \phi_L}{\partial \tau^e} = -\frac{(1-\kappa^e)R_{b,1}^e(r_2^e)}{(R_{b,1}^e - (1-\kappa^e)R_{k,2}^e)^2 Q_1^e} < 0$$

This result takes into account that the denominator is never zero given the ICC is binding and the credit spread is positive (see equations (29)-(30)). ■

2.2.7 Households

The household derives utility from consumption and its lifetime utility is given by $U^j = u(C_1^j) + \beta u(C_2^j)$ with $u(C) = \dfrac{C^{1-\sigma}}{1-\sigma}$.

The budget constraints in each period are the following:

Emerging markets:

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

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

where C is the final consumption good, B a non-contingent international traded bond, r_1 the rental rate of capital, Q the relative price of capital, K the capital stock and T is a lump-sum tax.

π stands for profits which can come from production activies in final goods (f), capital goods (inv) or banking services (b).

Advanced Economy:

$$C_1^c + \frac{B_1^c}{R_1^c} + D_1 = r_1^c K_0^c + \pi_{f,1}^c + \pi_{inv,1}^c - \delta_b Q_1^c K_0^c \qquad (2.39)$$

$$C_2^c = \pi_{f,2}^c + \pi_{b,2}^c + B_1^c + R_{D,1} D_1 - T^c \tag{2.40}$$

The advanced economy also includes local deposits D in the budget constraint as these are intermediated by their banks.

the profits are given by:[5]

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

In the first period each household will maximize the present value of its life-time utility subject to the budget constraints for the first and second period. The associated F.O.C. for the three households are:

$$u'(C_1) = \beta R_1 \mathbb{E}_1[u'(C_2)] \tag{41)-(43}$$

$$u'(C_1^c) = \beta R_{D,1} \mathbb{E}_1[u'(C_2^c)] \tag{44}$$

The first three are the Euler Equations for bonds and the last one, applying only for country c, is the Euler Equation for local deposits.

2.2.8 Market Clearing

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

$$n_a B_1^a + n_b B_1^b + n_c B_1^c = 0 \tag{2.45}$$

The goods market clearing conditions for each period are,

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

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

$$+n_c\left(C_1^c+I_1^c\left(1+\frac{\zeta}{2}\left(\frac{I_1^c}{\bar{I}}-1\right)\right)\right)=n_aY_1^a+n_bY_1^b+n_cY_1^c$$

$$n_aC_2^a+n_bC_2^b+n_cC_2^c=n_aY_2^a+n_bY_2^b+n_cY_2^c$$

Finally, given that there is only one final good and the law of one price holds (so that the real exchange rate in all cases is one), we have by an uncovered interest rate parity argument that:

$$R_1^a=R_1^b \tag{2.46}$$

$$R_1^c=R_1^b=R_1 \tag{2.47}$$

where R_1 denotes the world interest rate on bonds in period 1.

2.2.9 Exogenous processes

I consider three sources of exogenous variation in the model that are subject to shocks. First a productivity technology shock:

$$A_t^j=\rho_A A_{t-1}^j+\sigma_A\epsilon_{A,t}^j \qquad \text{(48)-(50)}$$
$$\epsilon_{A,t}^j\sim N(0,1)$$

At the same time, I consider a capital quality shock ξ_t that affects the stock of capital in the production function and the depreciation rate,

$$\xi_t^j=\rho_\xi\xi_{t-1}^j+\sigma_\xi\epsilon_{\xi,t}^j \qquad \text{(51)-(53)}$$
$$\epsilon_{\xi,t}^j\sim N(0,1)$$

2.2.10 Equilibrium

Equations (1) to (2.47) solve for 47 endogenous variables:

$Q_1^a,Q_1^b,Q_1^c,Q_2^a,Q_2^b,Q_2^c,I_1^a,I_1^b,I_1^c,K_1^a,K_1^b,K_1^c,Y_1^a,Y_1^b,Y_1^c,Y_2^a,Y_2^b,Y_2^c,r_1^a,r_1^b,r_1^c,r_2^a,r_2^b,r_2^c$

$F_1^a,F_1^b,D_1,R_{b,1}^a,R_{b,1}^b,R_{D,1},R_{k,2}^a,R_{k,2}^b,R_{k,2}^c,C_1^a,C_1^b,C_1^c,C_2^a,C_2^b,C_2^c,B_1^a,B_1^b,B_1^c,R_1^a,R_1^b,R_1^c,\mu^a,\mu^b$

Notice that one budget constraint (or market clearing equation for the goods market) becomes redundant in each period due to the Walras law.

Also, for cases in which stochastic analysis is carried, the system would include a number of shocks, described by the equations (48)-(50) to (51)-(53).

2.3 Welfare Effects between economies

As a first approximation we can verify, both analitically, and numerically in the next subsection, what are the welfare spillover effects between economies in each policy setup.

We set the welfare based on a social planner problem and follow Davis and Devereux (2019) for finding the equilibrium welfare effects of a change in the policy tools: Let the welfare of country j be expressed as $W^j = U^j + \lambda_1^j BC_1^j + \beta\lambda_2^j BC_2^j$ for $j = \{a, b, c\}$

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

This problem is analogous to a standard planner problem. Nonetheless, the optimality conditions (equilibrium outcomes) for other agents are accounted for by the planner.

We substitute the profits for banks and firms in accordance with the Competitive Equilibrium (ICCs included) and the tax rebates:

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

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

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

From these welfare expressions we will obtain the effects of taxes, via implicit differentiation, and will simplify our resulting expressions by substituting the optimality conditions of the Private Equilibrium.

This method is convenient, because the number of variables we have to consider is decreased considerably since we can ignore the effects on decision variables of the households. For these, the optimality conditions (that bind and are equal to zero) will always be a factor of the tax effect on each variable and hence will be canceled out.

2.3.1 Nash Case

The planner of each economy will take W^j as their welfare objective function. In contrast, the cooperative welfare would be a weighted sum of the individual welfare expressions of the countries.

Direct Effects

The welfare effect of the tax for the emerging economies is given by[6],

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

The same functional form applies for b.

Each term in this expression is associated with a source of variations on the welfare:

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

[6]The derivation of these results is shown in detail in the appendix 2.A.

Changes in external assets position: The second term, reflects the welfare effects from changes in the international debt position. $\frac{dR_1}{d\tau^a}$ is negative as there is a lower demand for funds by the levied banks. The sign of the whole term, however, depends on the sign of $\frac{B_1^a}{R_1}$ which is positive for emerging markets (and negative for the center), given that, by purchasing these assets, the households save the resources that cannot be deposited in their own countries.

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

Finally the last term reflects the direct effect of the policy tool on welfare. This effect will not cancel out for the emerging markets, as in the center, because of the presence of a binding ICC for emerging countries. Its sign is positive.

We can see there are offsetting welfare effects. Moreover, the signs and magnitudes depend on the reference point and scale of the policy change that each country planner would plan to implement. In the subsection 2.3.3 we find these effects for a small change around the no policy case based on the numerical solution of the model.

For the center economy, the effect is:

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

The interpretations for the first three terms are analogous to those of the emerging country mentioned above. The final term corresponds to:

Welfare effect from changes in intermediation profits: this is the welfare effect coming from the change of the tax on the funding quantities or gross rates related to cross-border lending. Both terms in the squared brackets will be negative.

Cross-country Effects

The welfare effect between emergent countries is,

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

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

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

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

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

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

The interpretations of each term follow analogous intuitions to those explained in the subsection 2.3.1.

Optimal tax

For obtaining the optimal tax we set $\frac{dW^a}{d\tau^a} = 0$ and solve for τ^a:

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

The result for b will be analogous.

For c:

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

$$+(F_1^a + F_1^b)\frac{dR_{b,1}^{eme}}{dF_1^S} + (1-\delta)\xi_2^c\frac{Q_2}{Q_1^c}\Bigg\} + 1$$

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

These expressions allow us to get an idea about the effects driving the optimal taxes. We can see that the peripheral tax depends on the effect on prices and interest rates from changes in the capital stock, which is proportional to the investment and foreign bonds position. Other relevant features are the resale price of capital and the marginal product of capital, and in fact, the absolute value of the tax will decrease if the latter increases.

Here is useful to remember that, in equilibrium, the marginal product of capital is directly taxed by the prudential tool, and hence we could interpret that for having a meaningful effect, the tax (or subsidy) will have to be set more strongly in countries with lower marginal product of capital. Finally, the deepness of the financial distortion, captured by κ^a plays an amplifying role: the higher the distortion, the stronger would the policy stance (tax or subsidy) implemented by the policymaker.

Regarding the financial center optimal tax, we have a different structure with a more relevant role for variables related to cross-border lending, in fact a role similar to the one played by domestic capital in the optimal tax of the periphery, will be enacted by the foreign interbank lending for the center.

We can approximate the signs for these expressions based on a particular solution, for example with the zero tax equilibrium as reference point. By doing this, we obtain for both equations that the terms inside the square brackets will not have the same sign, meaning we have offsetting forces driving the tool towards subsidizing or taxing the banking sector. That will reflect the policy tradeoff these economies face, they can tax the banks and undo the friction, or they can subsidize and increase capital accumulation and production.

More importantly, both the right and left hand side of the equations depend on the taxes, i.e., the equilibrium solution is a function of the taxes themselves, that the agents are taking as given, and hence, we cannot draw general conclusions on signs and magnitudes easily from these equations. Instead, we have to follow a somewhat more nuanced approach and solve a Ramsey policy problem. In the section 2.4 we set and solve such policy problem based on the optimality conditions of the planners.

2.3.2 Cooperative cases

For the cooperative cases we follow a similar strategy but focusing on the objective welfare of interest as follows:

Table 2.2: Welfare spillovers in the model

Case	Planners	Obj. Function	Effect of taxes
Cooperation (all countries)	World	$W = n_a W^a + n_b W^b + n_c W^c$	$\frac{dW}{d\tau^j} = n_a \frac{dW^a}{d\tau^j} + n_b \frac{dW^b}{d\tau^j} + n_c \frac{dW^c}{d\tau^j}$
Semi-Cooperation (EMEs vs. Center)	Emerging block A+B	$W^{ab} = n_a W^a + n_b W^b$	$\frac{dW^{ab}}{d\tau^j} = n_a \frac{dW^a}{d\tau^j} + n_b \frac{dW^b}{d\tau^j}$
	Center	W^c	$\frac{dW^c}{d\tau^j}$
Semi-Cooperation (EME-A + C vs. EME-B)	Cooperative A+C	$W^{ac} = n_a W^a + n_c W^c$	$\frac{dW^{ac}}{d\tau^j} = n_a \frac{dW^a}{d\tau^j} + n_c \frac{dW^c}{d\tau^j}$
	EME-B	W^b	$\frac{dW^b}{d\tau^j}$

Note: $j = a, b, c$

It turns out that the effects in the cooperative cases can be recovered from the individual results in section 2.3.1, that is, the effects will be given by weighted averages of the individual effects for the Nash case.

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

2.3.3 Numerical Effects

The effects are computed around zero, meaning that we are assessing the effect of a marginal increase in the taxes with respect to a initial point when there is no policy in place.

This section includes the welfare effects of implementing a macroprudential tax in the baseline model. The paremeters used are shown in the table 2.B.1 in the appendix 2.B.

Table 2.3: Welfare effect of 1% increase in taxes - parameter changes

	Baseline	Symmetric country size	Smaller periphery	Lower financial friction	Larger financial friction
Direct Effects					
$\tau_a \to W^a$	-1.560	-1.637	-1.498	-1.375	-1.763
$\tau_b \to W^b$	-1.560	-1.637	-1.498	-1.375	-1.763
$\tau_c \to W^c$	-0.847	-0.877	-0.811	-0.819	-0.870
Cross-country Effects					
$\tau_a \to W^b$	-0.078	-0.045	-0.089	-0.092	-0.062
$\tau_a \to W^c$	-0.039	-0.012	-0.056	-0.056	-0.025
$\tau_b \to W^a$	-0.078	-0.045	-0.089	-0.092	-0.062
$\tau_b \to W^c$	-0.039	-0.012	-0.056	-0.056	-0.025
$\tau_c \to W^a$	-0.308	-0.221	-0.308	-0.254	-0.374
$\tau_c \to W^b$	-0.308	-0.221	-0.308	-0.254	-0.374

Smaller periphery: Center country's size increase to 2/3 of world population.
Units: Numerical approximation to the derivative $\frac{\Delta W}{\Delta \tau}$

Before analyzing this figures, we must note that the numbers just indicate how much is changing the welfare, relative to the change in the taxes. However, a change in terms of welfare units does not have any cardinal economic interpretation, given it is denotes in utility units. Instead, we intend to show the relative sizes of the effects between countries for changes in each type of taxes (e.g. the fact that the direct effects are stronger than the cross-country ones).

The results indicate that, departing from a no policy world, a marginal increment in the tax decreases welfare. This may indicate subsidizing the banking sector takes priority over taxing the capital spread to ameliorate the financial friction. At the same time the within country effect is stronger than the cross-country effect.

Additionally, the cross country effect is negative as well. This implies there are positive policy spillovers between economies from implementing the macroprudential tax, i.e., a welfare improving tax (or subsidy) for a country will have prosper-thy-neighbor effects on the other countries.

Jointly, this suggests that policies are interdependent and there can be some free-riding policy incentives. However, with a stronger local effect of the tool, there still would be an active policy implementation in each economy when applying an optimal level of the subsidy.

It can also be noted that, as expected, the stronger cross country effect comes from policies implemented at the center economy and the weakest from emergent economies towards the center. However, the effect between emerging economies is relatively strong. This can be considered a relevant welfare effect taking into account that, in contrast than with the center, there are no financial flows between emerging countries.

Finally, we find that depreciation plays a relevant role in facilitating the cross-border welfare spillovers. With complete depreciation the within country (direct) effects will be stronger and the cross country effect will be at most a fourth of the one with undepreciated capital (see table B2 in the appendix 2.B). In contrast, with incomplete depreciation, the within country (direct) welfare effects weaken and the cross country effects increase considerably. The cross country effect now can reach a level of about more than four times the maximum effect found in the case with complete depreciation.

We should remark that in any case, these results correspond to the numerical counterparts of the welfare effects explored at the beginning of this section and that the signs and magnitudes will hinge heavily on the reference point and magnitude of the change in the policy tools. The utility of this exercise, in our view, consists on verifying the presence of welfare spillovers and their drivers.

The take away from this exercise will be that the within country effects of taxes are stronger in peripheries. A result consistent with the fact that the optimal taxes for the center are larger in absolute value for every policy setup (see section 2.5). That is, given a weaker effect in the center, its tool is set to follow stronger policy stances for a similar inteded effect. At the same time this may have strong cross country unintended consequences since it also happens that the stronger cross-country effect is exerted by changing the center taxes.

For an actual determination of the taxes and effects of the policy tools we will go a step beyond the social planner framework and set up the associated Ramsey policy problems for these economies in the following section.

2.4 The Ramsey Planner problem

In the previous sections, we set up the model for these economies and explored the welfare spillovers from setting the macroprudential tools, including the within effect and the effect between economies. The objective was to understand what drives the welfare effect of setting the tools in general and across policy frameworks changing by their degree of cooperation between planners.

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

For such end, we will set a Ramsey problem consisting on maximizing a welfare objective function subject to the private equilibrium optimality conditions.

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

Second, following the notation for a Ramsey problem in Bodenstein et al., 2019, let $F(\cdot)$ be the set of equations representing the optimality constraints of private agents that characterize the private equilibrium, $\mathbf{x}$ the system of endogenous or decision variables for the agents, θ the parameters of the model and $\tau = \{\tau^a, \tau^b, \tau^c\}$ the vector of policy instruments for all countries. We will solve the following problem for each Ramsey planner involved:

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

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

The set up of this problem will vary in each policy framework by changing the objective function, whereas the constraints will always refer to all the equations defining the equilibrium of the model ((1) to (2.47)). The latter assumption is set for consistency with an open economy setup and implies that the planners acknowledge they have an effect in the endogenous variables of the other countries.[7]

2.4.1 Non-Cooperative Framework

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

$$\max_{\mathbf{x_t^j}, \tau_t^j} \quad W_{Nash,t}^j = W_t^j$$

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

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

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

2.4.2 Cooperative Framework

We will consider three types of cooperative frameworks. Full cooperation, where the tools for all countries are set cooperatively by a simple planner, and two semi-cooperative cases where regional coalitions are formed. First, between emerging economies, and second between the center and one emerging economy.

World Cooperation

The cooperative Ramsey planner solves:

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

Regional cooperation between emerging countries

A coalition between Emerging Economies implies a regional level planner solving:

$$\begin{aligned} \max_{\mathbf{x_t^a}, \mathbf{x_t^b}, \tau_t^a, \tau_t^b} \quad & W_{CoopEMEs,\, t} = n_a W_t^a + n_b W_t^b \\ s.t. \quad & \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta) \qquad \text{for } t = 1. \end{aligned}$$

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

Coalition between the advanced economy and one emerging country

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

$$\begin{aligned} \max_{\mathbf{x_t^a}, \mathbf{x_t^c}, \tau_t^a, \tau_t^c} \quad & W_{CoopAC,\ t} = n_a W_t^a + n_c W_t^c \\ s.t. \quad & \mathbb{E}_t F(\mathbf{x_{t-1}}, \mathbf{x_t}, \mathbf{x_{t+1}}, \tau_t, \theta) \qquad \text{for } t = 1. \end{aligned}$$

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

2.5 Welfare Accounting Comparison

Table 2.4 shows the welfare outcomes comparison between the cooperative policy frameworks and the Nash equilibrium. It is expressed in units of a proportional increase in the steady state consumption for a benchmark model, i.e., 1 would imply that the models compared are equivalent in terms of welfare, whereas a higher number, $\phi > 1$, would denote a welfare improvement, equivalent to what would be generated by a $(\phi - 1) \times 100\%$ increase in the stream of consumption. For example, 1.2 would denote a welfare gain with respect to the benchmark model equal to the improvement such economy would experiment if the steady state consumption generating their baseline welfare levels were to increase by 20%.

Table 2.4: Welfare comparison across policy schemes with respect to the Nash Equilibrium

	Policy Scheme		
Country	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.00	1.00	1.00
A	1.00	1.00	1.00
B	1.00	1.00	1.00
World	1.00	1.00	1.00
EME Block	1.00	1.00	1.00

Units: Proportional steady state consumption increase in the baseline (Nash) model

Our results suggests there are not gains from cooperative policy setups with respect to the Nash policy equilibrium. This includes the semi-cooperative setups where coalitions of countries, that is peripheries or the center with an emergent, set jointly their macroprudential policy tools.

This summarizes how the Ramsey equilibria fare with respect to each other, and how in the baseline framework they provide the same welfare outcomes. Just as importantly, we can examine what combination of policy leads to this result and whether the planners are effective in mitigating the agency financial friction in place.

2.5.1 Level of the policy tool in each arrangement

In section 2.3 we observed that the optimal action, around a no policy scenario, points to subsidizing the banking sector so as to induce a compulsory increment of savings from households in favor of the banks. The Ramsey equilibrium allocation results, conversely, show the opposite result in most of the cases.

The results, shown in table 2.5, reflect the policy trade-off the planners face: they can implement a tax to undo the financial friction, or instead, increase financial intermediation and production by subsidizing the banking sector. In general, we have that the planners want to implement a tax that will be higher for economies not engaging in cooperative arrangements.

Table 2.5: Ramsey-Optimal taxes under each policy setup

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

Units: proportional tax on banking rate of return

More specifically, we find that the uncooperative optimal policy by each planner consists on setting a tax on banking revenues. The tax rate imposed by the center will be about three times that of the emerging economies planners. We see a similar pattern in the remaining policy

frameworks, i.e., a center policy tool implemented more aggressively than in other economies. Our interpretation is twofold: First, the peripheral planners attempt to undo the financial friction by taxing the credit spread directly while, second, the financial center policy maker that is not subject to frictions, will tax the banking sector with a different aim. Its objective is to lower the expected returns of a number of assets and the price of bonds, which in turn, will facilitate the flow of resources at the country level.

Hence, we believe the center tool is used to fight the second shortcomming of our setup, the financial under development in peripheries that prevent them from intermediating local deposits directly. This is done by facilitating risk sharing at the international level by trading financial assets.

In that spirit, when a single planner sets all the policy tools with the world welfare in mind (cooperation) we see that the tax imposed in the center country is not as large as when they do not cooperate. This reflects the that the cross-country welfare effects of the center tax are being accounted for by the world-wide cooperative policymaker. As for the peripheries, we have that the non-cooperative tax is the largest across policy setups. Additionally, the global cooperation setup is the only one in which a subsidy to the banking sector is implemented.

In this case, the same planner has control over every policy tool, and thus, can replicate the first best allocation by using a more conservative combination of taxes that still maintains similar relative differences between the tools levels as in the Nash case. In that way, the planner still has additional space to further encourage capital accumulation in the emerging economies by subsidizing the financial intermediation. Notice that, in this spirit, no other policy framework includes subsidies to the banking sector.

Another contrast between policies is that, in the three setups with cooperation, the members of cooperative coalitions will implement lower taxes with respect to the uncooperative case counterparts. This occurs even in this simple framework where there are no explicit policy costs or trade-offs from setting the taxes. Along that line, if we could consider that policy makers prefer to distort the economy at the lowest possible extent, we would have that a cooperative planner attempts to treat the friction in the most conservative way, i.e. with lower taxes or subsidies.

However, in the most basic version we do not have explicit costs from setting taxes at different levels, instead, the cooperative planner is internalizing the policy spillover that a larger tax (or subsidy) would have on the other members of the coalition. This is consistent with the analytic result we obtain in section 2.3 where there is a negative policy spillover of a marginal tax increase on the welfare of other countries.

2.5.2 Approaching the First Best

A natural question about the Ramsey policy equilibria is whether these schemes can succesfully undo the distortion created by the financial agency friction and deliver an allocation equivalent to the First Best, that is, the allocation obtained when there is no friction in place.

Table 2.6: Welfare comparison across policy schemes with respect to the First Best allocation

	Policy Scheme			
Country	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.01	1.01	1.01	1.01
A	0.99	0.99	0.99	0.99
B	0.99	0.99	0.99	0.99
World	1.00	1.00	1.00	1.00
EME Block	0.99	0.99	0.99	0.99

Units: Proportional steady state consumption increase in the baseline (First Best) model

Table 2.6 shows a welfare comparison of the policy setups with the first best allocation. We can see that every policy framework mimics the first best, delivering the same welfare outcome at the world level. This implies the policy tool is flexible and effective enough that can be set by each type of policy planners at levels that allows them to mimic the best possible allocation. Nevertheless, there are still small asymmetric welfare differences in the resulting equilibria that affects the welfare distribution among countries in detriment of the emerging countries but in favor of the center economy. The latter suggests it would not be possible to implement a Pareto improvement on the Ramsey outcomes via transfers, as long as we assume no feasible equilibrium could Pareto dominate the first best.

This result is relevant for understanding why there are no apparent gains from coordination. In a nutshell, each combination of policy makers, cooperative or not, can approach the best possible allocations of the model with different combinations of the policy tools.

This is consistent with Korinek (2020) stance about the gains from international macroprudential coordination. Namely, that for these gains to be present the Nash equilibrium must be Pareto inefficient. That is, even with strong international spillovers the non-cooperative equilibrium

can have no scope for cooperation. In such case, we say the spillovers and externalities (e.g. pecuniary) are efficient.

We will discuss this result in more detail when proposing what features we would need to modify in our baseline model for obtaining such cooperation gains.

2.5.3 Gains with respect to a No Policy setup

With these mixed results, on one side indicating that the policy frameworks are equivalent from a welfare perspective and on the other that they mimic the first best allocation, it is unavoidable to inquire about whether the macroprudential tools are worth implementing to begin with. That is, is there even a gain at all from an active policy setting?. To answer that, we compare the model without any policy in place against the rest of setups. The results are shown in table 2.7.

Table 2.7: Welfare comparison across policy schemes with respect to the No Taxes allocation

	Policy Scheme				
Country	First Best	Nash	Cooperation (All)	Cooperation (EMEs)	Cooperation (Center and EME-A)
C (Center)	1.05	1.06	1.06	1.06	1.06
A	1.03	1.02	1.03	1.02	1.02
B	1.03	1.02	1.03	1.02	1.02
World	1.04	1.04	1.04	1.04	1.04
EME Block	1.03	1.02	1.03	1.02	1.02

Units: Proportional steady state consumption increase in the baseline (No Policy) model

Every Ramsey policy implies a substantial welfare improvement for every country with respect to the no policy equilibrium. The welfare loss of not setting any policy in presence of the financial frictions amounts approximately to a 4% consumption decrease at the world level, or more accurately, switching from a non existent policy making to any active (cooperative or not) optimal policy setup would be equivalent to a compensatory increase in steady state consumption of 4%. This welfare improvement is distributed asymmetrically across countries with the center absorbing thrice the improvement of the least favored economies that still would receive a welfare increase equivalent to a 2% change in consumption.

We then have, in light of these results, that setting actively these taxes would certainly be welfare improving.

2.6 Achieving Gains from Coordination

In the previous sections, we found that the baseline model, does not yield gains from policy coordination at any level (global or regional). We verified there are policy spillovers between the economies and that an active policy setting allows the planners to approach the best possible results, i.e., to undo the effect of the financial agency friction.

The equivalence, from a welfare perspective, between the outcome of policies designed while internalizing international spillovers and one abstracting from such effects is certainly puzzling. To understand it we can refer to Korinek (2020), who develops a first welfare theorem for open economies. In a nutshell, the premise from which a call for policy coordination departs is that the de-centralized equilibrium is inefficent and could be subject to Pareto improvements if coordinated. However, there is a number of sufficient conditions that allow the non-cooperative outcome to become efficient:

1. *Competition:* The policy makers act as price takers by not exerting market power over international assets prices.

2. *Sufficient Instruments:* The policy is flexible and effective enough to achieve the targeted level in the international variables of interest.

3. *Frictionless International Markets:* The international market for assets is free of imperfections or frictions that would impair risk sharing.

Notice that no other conditions are necessary, that is, there can be a number of domestic frictions in place and the non-cooperative outcome will still be efficient and coordination would be redundant.

The lesson from this theorem is that as long as the flow of resources in the international markets is efficient and we have an effective toolkit (and enough tools) to set external allocations at desired levels, any policy, even de-centralized, can achieve the first best and the international externalities represent only efficient spillovers.

We can verify that these three conditions hold in our baseline model: Our setup is competitive given it abstracts from nominal rigidities and market power features. At the same time, each economy has access to a tool and, most importantly, policy making is not explicitely costly.

The latter point is very important, since it is the usual motivation behind coordination policies, namely, there could be gains from (i) Sharing the regulatory burden or cost, and (ii) Avoiding wasteful competivite intervention. It turns out that there is not an actual burden to bear in our framework and hence wasteful intervention is not really detrimental.

Finally, the international markets of our framework are frictionless. The flow of bonds allow countries to allocate resources in the center as if they could deposit in their own market, this means that the savings of private agents are not hampered in any way, despite the financial underdevelopment. Simultaneously, the financial center, is completely frictionless, and in equilibrium will serve as the basis for setting the interest rates and prices of assets for the international markets.

Another way to state this is that our framework has two potential sources of distortions, agency frictions in the emerging countries and, as an additional drawback, lack of intermediation by banks in peripheries. But we count with three policy tools that we can change at no cost as well as an international financial assets structure that is flexible. Hence we have the conditions to allow each combination of planners to achieve efficiency.

With this in mind, in the following subsections we modify our framework in a number of directions. First, we allow the center economy to be subject to a financial agency friction in the lending relationship between depositors and banks. Second, we explore the addition of costs of policy making.

2.6.1 Financial Frictions in the Center

To explore the case when the whole world is subject to frictions, we consider a different version of the model with financial distortions in the center. In this case the center bank solves the following problem:

$$\begin{aligned}\max_{F_1,L_1,D_1} J_1 = \mathbb{E}_1\Lambda_{1,2}\pi^c_{b,2} = \mathbb{E}_1\left[\Lambda_{1,2}(R^a_{b,1}F^a_1 + R^b_{b,1}F^b_1 + R^c_{k,2}L^c_1 - R_{D,1}D_1)\right]\\ s.t. \quad F^a_1 + F^b_1 + L^c_1 = D_1 + \delta_b Q^c_1 K^c_0\\ J_1 \geq k^c\mathbb{E}_1\Lambda^c_{1,2}\left[R^a_{a,1}F^a_1 + R^b_{b,1}F^b_1 + R^c_{k,2}L^c_1\right]\end{aligned}$$

with associated F.O.C.,

$$\begin{aligned}[F^a_1]: \qquad \mathbb{E}_1(R^a_{b,1} - R_{D,1}) = \mu^c_1\left[\kappa^c R^a_{b,1} - (R^a_{b,1} - R_{D,1})\right]\\ [F^b_1]: \qquad \mathbb{E}_1(R^b_{b,1} - R_{D,1}) = \mu^c_1\left[\kappa^c R^b_{b,1} - (R^b_{b,1} - R_{D,1})\right]\end{aligned}$$

$$[L_1^c]: \qquad \mathbb{E}_1(R_{k,2}^c - R_{D,1}) = \mu_1^c \left[\kappa^c R_{k,2}^c - (R_{k,2}^c - R_{D,1})\right]$$

As a result, we no longer have that most interest rates in the model are equalized to R_1 (the world interest rate of bonds), but that the intermediation rates of the center ($R_{k,2}^c,\ R_{b,1}^a,\ R_{b,1}^b$) will also be subject to a premium and a positive credit spread. Finally, we will have a binding ICC for the center. These modifications imply a model with four more equations and variables.

The simulation results are shown in the appendix 2.C. In this version of the model we still obtain no gains from coordination and that the First Best allocation is achieved at the world level. However, a new result we get lower gains with respect to the no policy case and that the peripheries will apply subsidies in all cases.

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

2.6.2 Policy costs of macroprudential intervention

To account for the case where the policy tool cannot be set up flexibly we also consider the case when there is an explicit cost of regulation. We solve the modified Ramsey problems where we include a convex cost of policy implementation. The objective function of the planner will now be given for:

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

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

$f(\alpha^j, W_t^j)$ corresponds to the same objective functions considered in section 2.4 and $\Gamma(\tau^j) = \psi(\tau^j)^2$ denotes a quadratic policy implementation cost. We solved the model with several levels of ψ and report the results for the value of the parameter that generates different qualitative results with respect to the baseline ($\psi = 1$).

The results are reported in the table C5 and C6 in the appendix 2.C. We obtain that there are

significant gains from coordination for every country and at the world level. Additionally, the high cost of policy implementation leads the countries to set their tools much more conservatively compared to the baseline. Finally, every cooperative setup matches the first best.

2.7 Additional exercises

In this section we explore whether some changes in the parameters structure of the model are relevant for shaping the welfare outcomes across policy setups. We consider changes ranging from deepening the effect of the financial agency distortions, to increase the asymmetry between center and peripheral countries, among others.

2.7.1 The degree of the agency distortion

First, we consider how the incentives of cooperation change when interacting with economies that count with a worse extent of agency problems, or in the context of this study with a larger divertable portion of the intermediated assets by the banks (κ).

The gains from coordination after increasing the degree of the financial distortion is shown in appendix 2.C, in table C7. Initially, we consider an increment of 20% in the abscondable portion of the intermediated assets. This implies that the banks can now divert 50% of the assets. In that case, there are still no gains from any type of cooperation and the first best is still achieved by every policy setup. As expected, we have a larger welfare gain with respect to the no policy allocation, reflecting the fact that the distortion is stronger in general. As a result, we have the same qualitative results that are achieved with stronger policy stances, i.e., larger taxes or subsidies with respect to each policy in the baseline case.

Then, we consider models in which one of the peripheries suffers from a stronger distortion, that is, $\boldsymbol{\kappa} = \{\kappa^a, \kappa^b\} = \{0.399, 1/2\}$ or $\boldsymbol{\kappa} = \{1/2, 0.399\}$. The results are shown in table C9. We find there are small gains from worldwide cooperation and also that the planners can match the first best.

In terms of the policy stance we find that planners will set the tool for the country with the larger distortion as a subsidy, or a lower tax in one of the cooperative cases, while the center will set a stronger tax in all cases compared to the baseline. This is consistent with the results from section 2.3 where the welfare effects increase in κ. With stronger effects, the peripheral planner can set its tool more conservatively and obtain the same intended effects.

2.7.2 Different economies sizes

Secondly, we study whether different relative population sizes of the economies play a role in shaping the gains from cooperation. The results are shown in table C11.

In a first exercise, we consider whether having a larger center can change the baseline results, which also implies smaller countries subject to agency frictions and hence, that the presence of distortions in the world economy is less prevalent. For that, we change the vector of sizes from $\mathbf{n} = \{n_a, n_b, n_c\} = \{1/4, 1/4, 1/2\}$ to $\mathbf{n} = \{1/6, 1/6, 2/3\}$. The simulation results show that with a larger center size there will be a generalized welfare increase in every economy. This result is straightforward as the center departs from a higher initial pre-existing capital level. As in the baseline model there are no significant gains from cooperation. On the other hand, a new result is that the planners are no longer able to match the first best allocation, possibly because with a smaller country size the global effect of the taxes in the emerging countries will not be as relevant and effective as in the baseline. Moreover, the policy framework with the smallest departure from the first best is the one with worldwide cooperation.

When we consider only a smaller periphery, i.e., $\mathbf{n} = \{1/3, 1/6, 1/2\}$ we find that there are small gains from cooperation, in every cooperative framework for the smaller periphery and for both peripheries in the semi-cooperative framework where these two countries form a coalition. Consistently with this result, cooperative planners are able to match the first best allocation although the Nash equilibrium does not depart by much.

However, the size of the gains at the world level is small and could not be subject to redistributions leading to Pareto improving outcomes so as to enforce cooperation for all planners.

Finally, in terms of the tools, in every setup we notice that the optimal policy for the tool of the now smallest economy usually implies a subsidization to the banking sector, meaning that boosting the financial intermediation will become a priority and will precede the correction of the financial friction.

2.7.3 Aggresive subsidization

Finally, an experiment, we allowed the economies to apply very large subsidies (or taxes), even beyond what could be considered feasible. The results as shown in table C15 indicate that there are some semi-cooperative solutions to the Ramsey policy problems that can outperform the first best (making a stronger case for unfeasibility than merely the tools levels) and that would imply gains from cooperation, although the model with more potential for gains still display welfare

losses for the country outside of the cooperative coalition. Nonetheless, as we hinted before, the policy tools levels that would make this possible imply subsidies that are prohibitively large (see table C16).

2.8 Value added from considering a second periphery

Some of the exercises carried in the previous sections explore the possibility of having asymmetric peripheries for delivering different equilibrium outcomes relative to the baseline model. Such exercises are only possible if we account for a three-country structure. In light of the results, here we comment how such multicountry structure is meaningful for allowing us to obtain results both in terms of the equilibrium solution and consequences of cooperation that would be omitted in simpler versions of the model.

Most of the results reported are given in a deterministic environment where idiosyncratic shocks are absent and do not play a role. In that environment, the third country will essentially be a replicate of the other EME in the baseline parametrization of the model and its inclusion represents only a scale effect where the features of the peripheral block would now describe a half of the world population. This is also seen in versions of the model with symmetric changes in the EMEs where the results are equivalent to two country model with a larger periphery.

For example, in one of the exercises where we decrease the relative size of the periphery block to a third of the population we obtain that the EMEs will be worse off by forming a coalition and that the first best is no longer achievable.

However, if we consider versions of the model where the second periphery is not a replicate of the first one, we obtain results that differ qualitatively from the baseline model. When we include a smaller second periphery (population size $1/6$) we find cooperation gains from any cooperative setup for the new country and gains for both EMEs in the case they cooperate regionally. Additionally, when we include a periphery with a stronger financial friction the first periphery benefits from any cooperation setup (table C9), while the second one would be better off only when worldwide cooperation is implemented. Only in the latter case we get a larger non-trivial welfare gain at the world level.

It is also important to remark how, by having a framework where the inclusion of an asymmetric second periphery leads to different resutls, we would have that when performing an stochastic analysis, the inclusion of the third country becomes meaningful, even if this one is identical to the other EME (unless we consider a special case when the shock faced by both EMEs is identical).

In this spirit, the stochastic component is abstracted for now in the most basic version of the model but remains one of the features we intend to explore in future research.

2.9 Conclusions

In this document we studied whether there are gains from international coordination of macroprudential policies, specifically aimed to the banking sector, in an environment with financial integration of emerging economies and a center. More specifically, we attempt to answer whether emerging countries are able to engage in cooperative arrangements that will improve the equilibrlium outcome imposed by bilateral banking relationships with a center in the presence of financial agency frictions.

To approach this question we set a three-country center-periphery model, with two emerging economies and one center. We add an additional emerging market to enhance the interaction leverage of the peripheral block, as well as to analyze policy interactions between emerging markets at the regional level, a feature not yet explored in the literature.

The baseline results show that the cooperative and semi-cooperative arrangements do not deliver sizable coordination gains and that the small gains found are usually concentrated on the participating parties in the cooperative arrangement.

With respect to the optimal taxes we find that in general, the optimal action is to tax the banking sector in order to decrease the credit spread created by the friction, that is, the policy makers attempt to undo the financial friction in place, rather than facilitating the intermediation made by the financial sector. Another result is that, for all policy setups, the center planner would choose to implement larger taxes, possibly because the center country banks, in their role as global lenders, are the most affected by the friction-augmented credit spread at the interbank level.

To explore this result, we analize a version of the model where every country is subject to the financial friction and where the policy instruments are not perfect because they are subject to implementation costs. The results with global frictions (agency costs in every country) are qualitatively equivalent to the baseline model. However, when we consider explicit implementation costs of policy making or restrictions to the usage of the taxes we find gains from cooperation in most cases. In these cases we are either increasing the burden of regulation, or decreasing the effectiveness of the tools. Either option limits the ability of regulators to hit their targets.

In additional exercises we explore departures from our baseline assumptions to assess the

relative importance of our model's ingredients. For this end, we change the relative sizes of the peripheries and degree of financial frictions. The results are similar if both peripheries are changed symmetrically, but there are qualitative changes when we impose asymmetric features between the peripheries.

The baseline results, do not depart by much from the findings of studies that abstract from banks or use other policy tools. However, this remarks a contribution of this study: the consideration of the role of an second periphery in the world economy, with different features than the incumbent one. This feature generates different results with respect to the baseline Nash or global cooperation, as opposed to the case when the third country is a replicate of the other periphery.

For future research it is important to study whether features such as the timing of the policies, either prudential or as crisis management tools, can make any difference in creating incentives for coordination. Finally, the interaction with other frictions, such as the created by nominal rigidities, at the banking or final goods level can be relevant. The first one for augmenting the cycle-amplification effects of financial distortions (see Mandelman (2010) and Fujiwara and Teranishi (2017)) and the second one for generating a scope for gains from coordination with other policies (e.g. monetary as in De Paoli and Paustian (2017)) and instruments.

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2.A Analytic welfare effects derivations

This section explain the derivations of the expressions shown in the section 2.3.

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

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

To obtain the direct welfare effect of the tax we substitute the equilibrium expression for the price of capital for the competitive investor ($Q_1^a = C'(I_1^a)$) and the Euler equation for the consumer ($\lambda_1 = \beta R_1 \lambda_2$). After rearranging we obtain the expression shown in the main section:

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

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

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

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

$$+\beta\lambda_2^c\left(R_{b,1}^a\frac{dF_1^a}{d\tau^c}+F_1^a\frac{dR_{b,1}^a}{d\tau^c}+R_{b,1}^b\frac{dF_1^b}{d\tau^c}+F_1^b\frac{dR_{b,1}^b}{d\tau^c}\right)$$

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

$$\frac{dW^c}{d\tau^c}=\lambda_1^c I_1^c\frac{dQ_1^c}{d\tau^c}+\beta\lambda_2^c\frac{B_1^c}{R_1}\frac{dR_1}{d\tau^c}+\beta\lambda_2^c\left(\alpha A_2^c\xi_2^{c\ \alpha}K_1^{c\ \alpha-1}+(1-\delta)\xi_2^cQ_2\right)\frac{dK_1^c}{d\tau^c}$$
$$+\beta\lambda_2\left[R_{b,1}^{eme}\left(\frac{dF_1^a}{d\tau^c}+\frac{dF_1^b}{d\tau^c}\right)+\frac{dR_{b,1}^{eme}}{d\tau^c}\left(F_1^a+F_1^b\right)\right]$$

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

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

$$\phi(\tau^a)=-\frac{1}{\alpha A_2^a\xi_2^{a\ \alpha}K_1^{a\ \alpha-1}}\left[R_1I_1^a\frac{dQ_1^a}{dK_1^a}+\frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a}+\kappa^a(1-\delta)\xi_2^aQ_2\right]$$

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

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

$$\tau^{a\ *}=-\frac{1}{\alpha(1-\kappa^a)}\left\{\frac{1}{\alpha A_2^a\xi_2^{a\ \alpha}K_1^{a\ \alpha-1}}\left[\left(R_1I_1^a\frac{dQ_1^a}{dK_1^a}+\frac{B_1^a}{R_1}\frac{dR_1}{dK_1^a}\right)+\kappa^a(1-\delta)\xi_2^aQ_2\right]+1+\alpha(\kappa^a-1)\right\}$$

The result for b is analogous.

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

$$-R_{k,2}^c=R_1I_1\frac{dQ_1^c}{dF_1^S}+\frac{B_1^c}{R_1}\frac{dR_1}{dF_1^S}+(\alpha A_2^c\xi_2^{c\ \alpha}K_1^{c\ \alpha-1}+(1-\delta)\xi_2^cQ_2)\frac{dK_1^c}{dF_1^S}+(F_1^a+F_1^b)\frac{dR_{b,1}^{eme}}{dF_1^S}$$

We substitute $R_{k,2}^c=[(1-\tau^c)\alpha A_2^c\xi_2^{c\ \alpha}K_1^{c\ \alpha-1}+(1-\delta)\xi_2^cQ_2]/Q_1^c$ and solve for τ^c:

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

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

2.B Parameters and other model simulation results

2.B.1 Parameters of the model

The table contains the parameter used in the baseline 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	
Depreciation rate	δ	0.6	Targets a longer period duration than quarterly
Capital share	α	0.333	Standard

Table B1: Parameters in the model

2.B.2 Welfare effects with complete depreciation

Table B2: Effects in welfare of 1% increase in taxes

		Shock and recipient country							
	No Shocks	Productivity (+)			Capital Quality (-)			Financial (+)	
		a	b	c	a	b	c	a	b
Direct Effects									
$\tau_a \to W^a$	-1.843	-1.768	-1.834	-1.825	-1.838	-1.841	-1.839	-1.848	-1.845
$\tau_b \to W^b$	-1.843	-1.834	-1.768	-1.825	-1.841	-1.838	-1.839	-1.845	-1.848
$\tau_c \to W^c$	-1.064	-1.056	-1.056	-1.007	-1.062	-1.062	-1.046	-1.065	-1.065
Cross-country									
$\tau_a \to W^b$	-0.044	-0.056	-0.022	-0.050	-0.047	-0.044	-0.046	-0.040	-0.043
$\tau_a \to W^c$	-0.014	-0.022	-0.018	-0.002	-0.016	-0.015	-0.011	-0.012	-0.013
$\tau_b \to W^a$	-0.044	-0.022	-0.056	-0.050	-0.044	-0.047	-0.046	-0.043	-0.040
$\tau_b \to W^c$	-0.014	-0.018	-0.022	-0.002	-0.015	-0.016	-0.011	-0.013	-0.012
$\tau_c \to W^a$	-0.072	-0.037	-0.078	-0.097	-0.072	-0.073	-0.078	-0.071	-0.070
$\tau_c \to W^b$	-0.072	-0.078	-0.037	-0.097	-0.073	-0.072	-0.078	-0.070	-0.071

2.C Ramsey Policy Equilibria results

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

Table C3: Welfare comparison for model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$)

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

Units: Proportional steady state consumption increase in the benchmark model

Table C4: Ramsey-Optimal taxes for the model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$)

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

Units: proportional tax on banking rate of return

Table C5: Welfare comparison for model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$) and policy implementation costs $\psi = 1$

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

Units: Proportional steady state consumption increase in the benchmark model

Table C6: Ramsey-Optimal taxes for the model with frictions in every economy ($\kappa^a = \kappa^b = 0.399$ and $\kappa^c = 0.1$) and policy implementation costs $\psi = 1$

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

Units: proportional tax on banking rate of return

Table C7: Welfare comparison for model with higher financial friction in both emerging economies ($\kappa^a = \kappa^b = \frac{1}{2}$)

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

Units: Proportional steady state consumption increase in the benchmark model

Table C8: Ramsey-Optimal taxes for the model with higher financial friction in both emerging economies ($\kappa^a = \kappa^b = \frac{1}{2}$)

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

Units: proportional tax on banking rate of return

Table C9: Welfare comparison for model with higher financial friction in one emerging economy ($\kappa^a = \frac{1}{2}$, $\kappa^b = 0.399$)

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

Units: Proportional steady state consumption increase in the benchmark model

Table C10: Ramsey-Optimal taxes for for model with higher financial friction in one emerging economy ($\kappa^a = \frac{1}{2}$, $\kappa^b = 0.399$)

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

Units: proportional tax on banking rate of return

Table C11: Welfare comparison for model with larger financial center. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{6}, \frac{1}{6}, \frac{2}{3})$.

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

Units: Proportional steady state consumption increase in the benchmark model

Table C12: Ramsey-Optimal taxes for the model larger financial center. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{6}, \frac{1}{6}, \frac{2}{3})$.

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

Units: proportional tax on banking rate of return

Table C13: Welfare comparison for model with smaller periphery. Population sizes: $(n_a, n_b, n_c) = (\frac{1}{3}, \frac{1}{6}, \frac{1}{2})$.

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

Units: Proportional steady state consumption increase in the benchmark model

Table C14: Ramsey-Optimal taxes for model with smaller periphery. $(n_a, n_b, n_c) = (\frac{1}{3}, \frac{1}{6}, \frac{1}{2})$.

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

Units: proportional tax on banking rate of return

Table C15: Welfare comparison for model with unfeasibly aggresive subsidization

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

Units: Proportional steady state consumption increase in the benchmark model

Table C16: Ramsey-Optimal taxes for model with unfeasibly aggresive subsidization

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

Units: proportional tax on banking rate of return

2.D Solution of the Model

Original System (follows the numbering in the body of the paper):

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

We replace the following profits:

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

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

$$\pi_{b,2}^s = R_{k,2}^s Q_1^s K_1^s - R_{b,1}^s F_1^s, \quad for\ s = \{i,e\}$$

$$\pi_{b,2}^c = R_{b,1}^a F_1^a + R_{b,1}^b F_1^b + R_{k,2}^c Q_1^c K_1^c - R_{D,1}D_1$$

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

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

- *S2:* Remove already solved equations (function of parameters or pre-defined variables, hence we drop $Q2, Y_1$). Replace $Y_2,\ r_1,\ r_2$, $F_1^s = Q_1^s K_1^s - \delta_b Q_1^s K_0^s$. From (41) and (42) obtain $R_1 = R_{D,1}$ and replace.

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

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

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

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

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

$$K_1^a = I_1^a + (1-\delta)\xi_1^a K_0^a \tag{4}$$

$$K_1^b = I_1^b + (1-\delta)\xi_1^b K_0^b \tag{5}$$

$$K_1^c = I_1^c + (1-\delta)\xi_1^c K_0^c \tag{6}$$

$$R_{k,2}^a = \frac{(1-\tau^a)\alpha A_2^a {\xi_2^a}^{\ \alpha} {K_1^a}^{\ \alpha-1} + (1-\delta)\xi_2^a Q_2}{Q_1^a} \tag{7}$$

$$R_{k,2}^b = \frac{(1-\tau^b)\alpha A_2^b {\xi_2^b}^{\ \alpha} {K_1^b}^{\ \alpha-1} + (1-\delta)\xi_2^b Q_2}{Q_1^b} \tag{8}$$

$$R_1 = \frac{(1-\tau^c)\alpha A_2^c \xi_2^c \ {}^{\alpha} K_1^{c\ \alpha-1} + (1-\delta)\xi_2^c Q_2}{Q_1^c} \tag{9}$$

$$R_{k,2}^a Q_1^a K_1^a - R_1 Q_1^a K_1^a + R_1 \delta_B Q_1^a K_0^a = \kappa^a R_{k,2}^a Q_1^a K_1^a \tag{10}$$

$$R_{k,2}^b Q_1^b K_1^b - R_1 Q_1^b K_1^b + R_1 \delta_B Q_1^b K_0^b = \kappa^b R_{k,2}^b Q_1^b K_1^b \tag{11}$$

$$R_{k,2}^a - R_1 = \mu^a \left(\kappa^a R_{k,2}^a - (R_{k,2}^a - R_1) \right) \tag{12}$$

$$R_{k,2}^b - R_1 = \mu^b \left(\kappa^b R_{k,2}^b - (R_{k,2}^b - R_1) \right) \tag{13}$$

$$Q_1^a K_1^a - \delta_B Q_1^a K_0^a + Q_1^b K_1^b - \delta_B Q_1^b K_0^b + Q_1^c K_1^c = D_1 + \delta_B Q_1^c K_0^c \tag{14}$$

$$C_1^a + \frac{B_1^a}{R_1} = A_1^a (\xi_1^a K_0^a)^\alpha + Q_1^a I_1^a - I_1^a \left(1 + \frac{\zeta}{2} \left(\frac{I_1^a}{\bar{I}^a} - 1 \right)^2 \right) - \delta_B Q_1^a K_0^a \tag{15}$$

$$C_1^b + \frac{B_1^b}{R_1} = A_1^b (\xi_1^b K_0^b)^\alpha + Q_1^b I_1^b - I_1^b \left(1 + \frac{\zeta}{2} \left(\frac{I_1^b}{\bar{I}^b} - 1 \right)^2 \right) - \delta_B Q_1^b K_0^b \tag{16}$$

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

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

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

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

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

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

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

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

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

2.E Steady State of the Model

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

We depart from the system of equations (1)-(24) at the end of the appendix 2.D. Some variables are pinned down directly from a static version of the equations:

$$Q^j = 1$$

$$I^j = \delta K^j$$

$$B^j = 0$$

$$R = \frac{1}{\beta}$$

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

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

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

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

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

Chapter 3

STRATEGIC MACROPRUDENTIAL POLICYMAKING: WHEN DOES COOPERATION PAY OFF?

3.1 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. On the other hand, 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 (e.g., leverage caps, loan-to-value ratios, or taxes). Crucially, these regulations affect domestic and international agents as the balance sheets' links of these banks extend beyond national borders, raising immediate questions over the potential gains from international policy cooperation.

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, i.e., over the business cycle?, (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 regulations. Afterward, I set a quantitative model and obtain the optimal macroprudential policies of several regimes that vary by their degree of international cooperation. Based on this framework, I perform

[1] See Rey (2013, 2016).

a comprehensive welfare comparison and study the regulatory arrangements' short-run and cyclical performance.

The macroeconomic framework I use for modeling the banking sector follows Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), extended to an open economy environment. Unlike other open economy studies that consider the banking sector explicitly (e.g., Banerjee, Devereux, and Lombardo (2016) and Aoki, Benigno, and Kiyotaki (2018)) I abstract from the role of monetary policy. This assumption allows me to focus solely on financial regulators' interactions while easily extending the framework to one of multiple peripheral economies that interact with a Center (three countries environment). In that regard, and to the best of my knowledge, this is the first paper that studies the macroprudential policy coordination of emerging economies featuring general equilibrium effects, but that are still considerably fragile to a financial center. [2] [3]

The addition of the third economy is meaningful since it allows me to consider a wider array of policy regimes with varying degrees and types of cooperation. Based on these results, I can identify when coordination is beneficial or even counterproductive. Just as importantly, I can consider the potential regional cooperation of peripheral economies in the presence of considerable policy spillovers by a center that may want to adjust its policies in response.

In this setup, I account for agency frictions in the banking lending relationships that create a costly enforcement distortion due to the possibility of default by financial intermediaries. Consequently, the interest rates are adjusted to reflect the higher risk, which ultimately translates in higher credit spreads and financially augmented credit cycles in the same spirit as Bernanke, Gertler, and Gilchrist (1999) and Kiyotaki and Moore (1997). This distortion opens the scope for policy interventions in the form of macroprudential taxes on the banking revenue rates.[4] Simultaneously, the rates affected by these policy tools shape the balance sheet dynamics of these intermediaries and the international links between banks, which potentially opens a scope for coordinated financial regulations. [5]

Using the simplified model, I set a modified social planner problem following Davis and Devereux (2019) to determine the mechanisms driving these policies' welfare effects. I find

[2] Here an emerging economy is defined as an economy with an underdeveloped financial sector (in the spirit of Céspedes, Chang, and Velasco (2017)) and that in consequence relies on the funding from a center.

[3] See Jin and Shen (2020) for a setup with small open economies interactions and an exogenous center.

[4] This policy is chosen for its analytical and interpretation convenience, but also because it encompasses several types of actual macroprudential instruments.

[5] Other papers that study the policy coordination in presence of financial frictions have focused on revisiting the monetary policy case (Sutherland (2004), Fujiwara and Teranishi (2017)) or in the interaction between different types of policy makers (De Paoli and Paustian (2017) and an application of Bodenstein, Guerrieri, and LaBriola (2019))

that these effects are substantially stronger when using forward-looking policy instruments because their effect builds on into the future through retained profits and net worth dynamics of the banking sector. This feature underscores the relevance of accounting for these policies' persistency and total effect over time when assessing different policy regimes.

Similarly, the magnitude of the policy effects will increase with the extent of financial frictions. Implying these policies can be more effective for more distorted economies, something consistent with the fact that the financial distortion is the feature that creates a role for policy in this environment.

I identify the formation of two fundamental mechanisms that shape macroprudential policy incentives under cooperation: a portfolio cancellation effect and a capital relocation motive. The portfolio cancellation effect consists of the elimination of national (individual) incentives for manipulating the global interest rate to improve the net foreign assets position. The relocation of capital motive refers to an incentive for increasing capital inflows to peripheries at the expense of the capital accumulation at the center. The first mechanism 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 any national economic performance.

Based on these insights, I set a larger scale dynamic general equilibrium model to perform a comprehensive assessment of an array of policy regimes. Each policy problem is set in a timeless perspective formulation under commitment and relies on the open-loop Nash equilibrium as the solution criterion.[6]

I find that there are sizable social welfare gains from international cooperation. Crucially, however, the gains are only present for policy frameworks where the center acts cooperatively. The gains are maximized under worldwide cooperation, followed by the cooperation between the center and a subset of the peripheries, then by the non-cooperative (Nash) regime, and finally by the regional (emerging) cooperation where the peripheries form a coalition and play against an independent center. Thus, another salient implication of this ranking is that the emerging cooperative efforts can be counterproductive.

The primary sources of welfare gains are the two policy mechanisms that arise under cooperation (portfolio cancelation effect and relocation of capital). 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.

[6]See Bodenstein et al. (2019) for a discussion on macroeconomic games in this setup and the open loop Nash equilibrium framework.

Furthermore, both mechanisms work better 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 the social gains increase for regimes where more peripheries participate in the cooperative arrangement with the center.

The intuition behind this result is that the cooperative planner relies on the welfare effects from the increased intermediation with the peripheries to boost its objective quantity, the global welfare (a weighted average of the national welfares). Naturally, the strategy of implementing welfare increases at the peripheries despite the welfare cost from limiting the investment flows at the center is worth pursuing if the net social welfare gain is positive. The former only occurs when the planner cares comparably enough about the welfare effects originated in the emerging economies (or when the peripheral economies' size is large enough). Consequently, for small open economy environments, the gains of cooperation will be absent.

These mechanisms, or lack thereof, also help understand why the emerging economies' regional cooperation regime fails to yield gains. The first channel is not present as all involved national incentives (in the coalition) to manipulate the interest rate go in the same direction; that is, for the cancellation to take effect, we need both global creditors (Center) and debtors (EMEs) to cooperate. In contrast, the debtor's portfolio incentives are pooled for the emerging coalition, strengthening the peripheral capacity to manipulate the interest rates. As a result, the center exerts a strong retaliative effort, engaging in a marked regulatory struggle that creates salient social and individual welfare losses. On the other hand, the second welfare inducing mechanism will not be present either, as it relates only to coordinated policy efforts with a global intermediator (center).

The first mechanism (portfolio cancelation effect) is similar to the source of cooperation gains in Davis and Devereux (2019) and Korinek (2020) when studying the case of capital controls with collateral constraints, or Bengui (2014) for the case of liquidity regulations in endowment economies. Here, however, I prove that a similar result holds for banks with agency frictions, which is less straightforward, as I do not rely on a direct off-setting of the variables targeted by the policies.

Simultaneously, this source of welfare gains contrasts with Jin and Shen (2020), where regional cooperation is welfare improving because the peripheric block internalizes and uses their increased capacity to manipulate the interest rates. Here, conversely, the same reasoning delivers welfare losses. The explanation behind the difference is that I consider potential retaliative actions by the financial center.

Notably, the national distribution of welfare across regimes shows that enforcing the best policy framework can be challenging. On the one hand, cooperation seems likely as the peripheries

always want to collaborate with the center; actually, they would prefer to have an exclusive partnership with that economy. However, the center prefers to cooperate with a subset of peripheries rather than with the rest of the world. In the former case, the coalition participants, i.e., the center and one periphery, will join efforts and improve their outcomes substantially at the expense of the second, left out periphery that ends up worse than under any other regime.

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

Furthermore, I find that the policies under the welfare-improving coordination regimes imply a more modest regulatory response by the policymakers; that is, the associated taxes will be smoother and conservative relative to their nationally-oriented counterparts. This result is consistent with the portfolio cancellation policy effect and captures a desirable property of cooperative (with the center) regimes: they limit the scope for excessive regulatory interventions and the potential detrimental effect on the macroeconomic performance.[7]

This result contrasts with Kara (2016), where decentralized planning leads to welfare losses due to inefficiently low levels of policy actions. However, in this case, the economic environment is not symmetric between economies. Furthermore, the instruments' additional movements, eliminated under cooperation, are motivated by yield-seeking purposes rather than financial stability objectives. Consequently, the cooperative planners have a comparative regulatory advantage relative to nationally-oriented policymakers because they can focus entirely on their financial stabilization goals, as they are no longer concerned about inducing value increasing fluctuations in the net foreign assets.

On the other hand, I find another benefit of cooperation (with the center) in the short run exercise: the deleveraging processes, documented in studies like Bianchi (2011) and Jeanne and Korinek (2010, 2019) to hinder the economic recoveries after financial shocks, are noticeably mitigated by the centralized policies, thereby making a stronger case for coordinating regulatory efforts.

Finally, the cyclical component of these policy frameworks suggests that unlike in any other regime (or economies), cooperative efforts at the center leads to a countercyclical implementation of its instruments. Thus, this model recognizes the general procyclicality of these policies,

[7] See Richter, Schularick, and Shim (2019a) for a discussion on the macroeconomic effects of the macroprudential policies.

documented in the literature in studies like Fernández, Rebucci, and Uribe (2015) and Uribe and Schmith-Grohe (2017), but also that among optimal regimes, the best performing policies tend to adopt countercyclical features, as intuition dictates and as stated by other studies (Bianchi (2011) and Jeanne and Korinek (2019)).

The rest of this paper is structured as follows. Section 3.2 describes the recent empirical trend of capital flows and associated policy responses. In section 3.3, I set a simplified model used to describe the main policy mechanisms. Sections 3.4 and 3.5 describe the main model and policy regimes under consideration. In Section 3.6, I show the results and address the research questions. Finally, Section 3.7 concludes.

3.2 Capital Flows 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 3.1), such phenomenon, denoted as the global savings glut[8], 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,[9] 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.

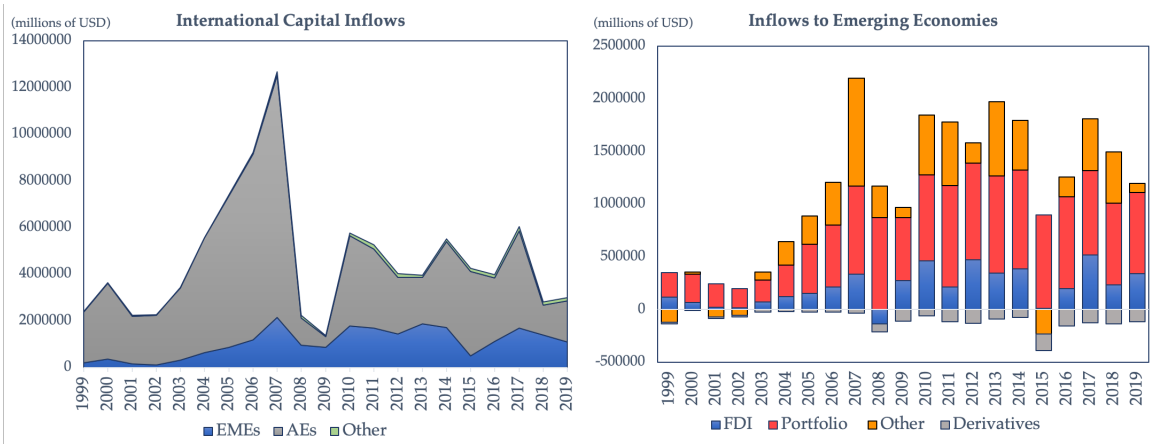
Once the bubble burst and the crisis ensued there was a strong institutional effort towards strengthening the financial regulation, and a higher recognition of the threat posed by the risk of financial contagion prompted an urgent revision of the Basel accords. The G-20 met for the first time in history 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

[8]See Justiniano et al. (2013) and Bernanke (2005) for a discussion on this topic.
[9]In the USA the Glass-Steagal Act of 1933

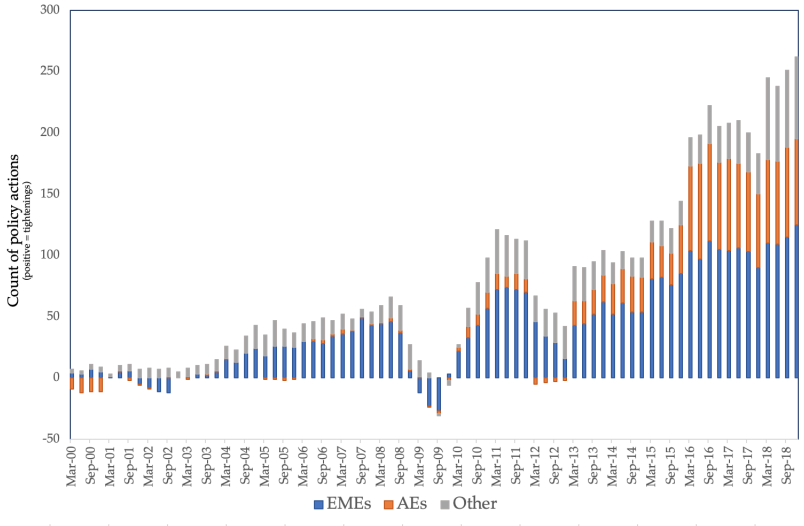
flows (Other in the figure 3.1). These items, that take place within the financial intermediation sector, represent the most volatile types of capital flows. Thus, the banking sector in the emerging economies happens to be at the core of the post-global financial crises potential sources of risk.

Figure 3.1: 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 3.2: 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 60 developing countries (other in the graph). The figure shows a four-quarter rolling window sum of the stances in each date.

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 3.2 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), this is computed and aggregated for 17 policy instruments and then by country groups. It can be seen that globally, and in during 2018 there were more than 200 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 eventually in advanced economies, it can also be suggested, from the overall and compositional policy stance dynamics in figure 3.2, 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 spill over through the interbank lending, and Aiyar, Calomiris, and Wieladek (2014) show how stricter capital requirements on UK-owned banks made the foreign banks operating in UK to increase their lending, in a regulatory arbitrage attempt to substitute the curtailed intermediation generated by the policy change, and thereby, (partially) off-setting the intended effect of the new regulations. 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.

3.3 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.[10] 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 3.4 I review it more briefly here, and instead focus more in the sectors with meaningful differences, the banks and the households.

3.3.1 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), 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.

[10] 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).

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.

3.3.2 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 Kiyotaki (2010) and Céspedes, Chang, and Velasco (2017).

In the first period of intermediation (end of t=1) the bank aims to maximize its expected

franchise value, given by J_1 and solves:

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

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

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

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

Where the country index for emerging economies is e with $e = \{a, b\}$, $L_t = Q_t K_t$ is the total lending intermediated with the local firms, F_t is the cross-border borrowing they obtain from 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. [11] 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 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.[12]

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.[13] For simplicity, this

[11] 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

[12] 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.

[13] 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.

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 3.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.

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:

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

$$\begin{aligned} s.t \quad & L_1^c + F_1^a + F_1^b = D_1 + \delta_B Q_1^c K_0^c && \text{[Balance sheet in t=1]} \\ & L_2^c + F_2^a + F_2^b = D_2 + \delta_B Q_2^c K_1^c \\ & \qquad + \theta [R_{k,2}^c L_1^c + R_{b,1}^a F_1^a + R_{b,1}^b F_1^b - R_{D,1} D_1] && \text{[Balance sheet in t=2]} \end{aligned}$$

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.

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

$$s.t$$

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

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.

3.3.3 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.

3.3.4 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:

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

$$s.t.$$

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

$$C_2^e + \frac{B_2^e}{R_2^e} = \pi_{f,2}^e + \pi_{inv,2}^e + \pi_{bank,2}^e - \delta_B Q_2^e K_1^e + B_1^e - T_2^e$$

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

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:

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

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

3.3.5 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 3.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.

3.3.6 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 3.6. I solve this system of equations non-linearly and using a perfect foresight approximation.

3.3.7 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 3.7. 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 3.1.

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.

Table 3.1: 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.

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.

$$\begin{aligned} W_0^a = u\left(C_1^a\right)+\beta u\left(C_2^a\right)+\beta^2 u\left(C_3^a\right)+\lambda_1^a\left\{A_1^a {K_0^a}^{\alpha}+Q_1^a I_1^a-C(I_1^a,I_0^a)-\delta_B Q_1^a K_0^a-C_1^a-\frac{B_1^a}{R_1}\right\} \\ +\beta\lambda_2^a\left\{\varphi(\tau_2^a)A_2^a {K_1^a}^{\alpha}+Q_2^a I_2^a-C(I_2^a,I_1^a)-\delta_B Q_2^a K_1^a+\kappa\left(\frac{Q_1^a K_1^a}{\Lambda_{12}}-\Lambda_{23}\theta Q_2^a K_2^a\right)+B_1^a-C_2^a-\frac{B_2^a}{R_2}\right\} \\ +\beta^2\lambda_3^a\left\{\left(1-\alpha\left(1-\tau_3^a\right)\right)A_3^a {K_2^a}^{\alpha}+\kappa\frac{Q_2^a K_2^a}{\Lambda_{12}}+B_2^a-C_3^a\right\} \end{aligned} \tag{3.1}$$

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

$$\begin{aligned} W_0^c = u\left(C_1^c\right)+\beta u\left(C_2^c\right)+\beta^2 u\left(C_3^c\right)+\lambda_1^c\left\{A_1^c {K_0^c}^{\alpha}+Q_1^c I_1^c-C(I_1^c,I_0^c)-\delta_B Q_1^c K_0^c-C_1^c-\frac{B_1^c}{R_1}-D_1\right\} \\ +\beta\lambda_2^c\Big\{\left(1-\alpha\theta\left(1-\tau_2^c\right)\right)A_2^c {K_1^c}^{\alpha}+Q_2^c I_2^c-C\left(I_{2,}^c I_1^c\right) \\ +(1-\theta)\left((1-\delta)Q_2^c K_1^c+R_{b1}^a F_1^a+R_{b1}^b F_1^b\right)-\theta R_1 D_1-\delta_B Q_2^c K_1^c+B_1^c-C_2^c-\frac{B_2^c}{R_2}-D_2\Big\} \\ +\beta^2\lambda_3^c\Big\{A_3^c {K_2^c}^{\alpha}+(1-\delta)Q_3 K_2^c+R_{b2}^a F_2^a+R_{b2}^b F_2^b+B_2-C_3^c\Big\} \end{aligned} \tag{3.2}$$

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,[14] 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:

[14]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.

For the EMEs:

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

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

with $\alpha_1(\kappa) = \kappa R_1 Q_1^a + \varphi\left(\tau_2^a\right) r_2^a$, $\alpha_2(\kappa) = R_1\left(I_1^a + \kappa K_1^a\right)$, $\alpha_3(\kappa) = \kappa\left(1-\theta\Lambda_{23}\right)Q_2^a + \varphi\left(\tau_3^a\right)\Lambda_{12} r_3^a$, $\alpha_4(\kappa) = I_2^a + \kappa\left(1-\theta\Lambda_{23}\right)K_2^a$, $\alpha_5(\kappa) = \kappa\left(1-\theta\Lambda_{23}\right)Q_2^a + \varphi\left(\tau_3^a\right)\Lambda_{23} r_3^a$, and $\frac{\partial\alpha_s}{\partial\kappa} > 0$ for $s = \{1,2,3,4,5\}$.

and for the Center:

$$\frac{dW_0^c}{d\tau_2^c} = \overbrace{\beta\lambda_2^c\left\{\gamma_1\frac{dK_1^c}{d\tau_2^c} + \left(\frac{B_1^c}{R_1} - \theta D_1\right)\frac{dR_1}{d\tau_2^c} + \frac{K_1^c}{R_1}\frac{dQ_1^c}{d\tau_2^c} + \alpha\theta Y_2^c + (1-\theta)\left(F_1^{ab}\frac{dR_{b,1}^{eme}}{d\tau_2^c} + R_{b,1}^{eme}\frac{dF_1^{ab}}{d\tau_2^c}\right)\right\}}^{\text{static effects}}$$

$$\underbrace{+\beta^2\lambda_3^c\left\{\gamma_2\frac{dK_2^c}{d\tau_2^c} + \frac{B_2^c}{R_2}\frac{dR_2}{d\tau_2^c} + \gamma_3\frac{dQ_2^c}{d\tau_2^c} + F_2^{ab}\frac{dR_{b,2}^{eme}}{d\tau_2^c} + R_{b,2}^{eme}\frac{dF_2^{ab}}{d\tau_2^c}\right\}}_{\text{dynamic effects}}$$

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

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

The interpretation of these effects goes as follows: First, we can see that there are more sources of variations for taxes that are forward-looking in nature (τ_2), whereas for the terminal taxes we only get the static 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.[15] 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 3.A. Here, as an example, I show the expression for the optimal national-oriented tax for the Center:

$$\tau_3^c = \frac{Q_2^c}{r_3^c}\left\{\gamma_2 \frac{dK_2^c}{dF_2^{ab}} + \Lambda_{23} B_2^c \frac{dR_2}{dF_2^{ab}} + \gamma_3 \frac{dQ_2^c}{dF_2^{ab}} + F_2^{ab}\frac{dR_{b2}^{\text{eme}}}{dF_2^{ab}}\right\} + \frac{(1-\delta)Q_3}{r_3^c} + 1 \tag{3.3}$$

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 (3.3) or the reciprocal in the other taxes expressions in the appendix 3.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

[15] 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

when understanding the importance of the Center in generating gains from the international coordination of policies in the main model of the section 3.4.

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.

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 3.2. 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 3.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.

$$\tau_3^{c,coop} = \tau_3^{c,nash} + \overbrace{\frac{Q_2^c}{\Lambda_{23} r_3^c}\frac{\lambda_2^a}{\lambda_2^c}\left\{\alpha_5(\kappa)\frac{dK_2^a}{dF_2^{ab}} + \alpha_4(\kappa)\frac{dQ_2^a}{dF_2^{ab}}\right\}}^{\text{New substitution of Center capital accumulation for foreign intermediation (EMEs) motive under cooperation}} - \frac{\lambda_2^a}{\lambda_2^c}\overbrace{\frac{Q_2^c}{r_3^c}\frac{B_2^c}{R_2}\frac{dR_2}{dF_2^{ab}}}^{\text{NFA-led interest rate manipulation motive at Center}} \tag{3.4}$$

Where $\tau_3^{c,nash}$ is the optimal tax for the non-cooperative planner as in (3.3).

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.

3.4 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.

3.4.1 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:

$$\max_{\{C_t, H_t, B_t, D_t\}_{t=0}^{\infty}} W_0^i = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{i(1-\sigma)}}{1-\sigma} - \frac{H_t^{i(1+\psi)}}{1+\psi} \right) \tag{3.5}$$

s.t.,

$$C_t^i + B_t^i + \frac{\eta}{2}(B_t^i)^2 + D_t^i + \frac{\eta}{2}(D_t^i - \bar{D}^i)^2 = R_{t-1}^i B_{t-1}^i + R_{D,t-1}^i D_{t-1}^i + w_t^i H_t^i + \Pi_t^i \tag{3.6}$$

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:

$$\begin{aligned}
\mathbb{E}_t \left[R_t \Lambda_{t,t+1}^c \right] &= 1 + \eta(B_t^c) \\
\mathbb{E}_t \left[R_{D,t}^c \Lambda_{t,t+1}^c \right] &= 1 + \eta(D_t^c - \bar{D}^c) \\
C_t^{c\ -\sigma} &= \frac{H_t^{c\ \psi}}{(1-\alpha) A_t^c \xi_t^{c\ \alpha} K_{t-1}^{c\ (\alpha)} H_t^{c\ (-\alpha)}}
\end{aligned}$$

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.

3.4.2 Final Goods Firms

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

$$Y_t^i = A_t^i \left(\xi_t^i K_{t-1}^i\right)^{\alpha} H_t^{i(1-\alpha)} \tag{3.7}$$

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:

$$\max_{K_{t-1}^i, H_t^i} \Pi_t^{i,prod} = Y_t^i + (1-\delta)\xi_t^i Q_t^i K_{t-1}^i - w_t^i H_t^i - \tilde{R}_{k,t}^i Q_{t-1}^i$$
$$\text{s.t.} \quad (3.7)$$

I define the marginal product of capital as $r_t^i \equiv \alpha A_t^i \xi_t^{i\ \alpha} K_{t-1}^{i\ \alpha-1} H_t^{i\ 1-\alpha}$, and obtain the wages and gross rate of returns paid to the banking sector from the FOCs with respect to labor and capital:

$$w_t^i = (1-\alpha) A_t^i H_t^{i(-\alpha)} \xi_t^{i\ \alpha} K_{t-1}^{i(\alpha)}$$

$$\tilde{R}^i_{k,t} = \frac{r^i_t + (1-\delta)\xi^i_t Q^i_{t-1}}{Q^i_{t-1}}$$

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.[16]

3.4.3 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:[17]

$$K^i_t = I^i_t + (1-\delta)\xi^i_t K^i_{t-1} \tag{3.8}$$

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

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

$$\max_{\{I^i_t\}_{t=0}^{\infty}} E_0 \sum_{s=0}^{\infty} \Lambda^i_{t,t+s}\left\{Q^i_{t+s}I^i_{t+s} - I^i_{t+s}\left(1 + \frac{\zeta}{2}\left(\frac{I^i_{t+s}}{I^i_{t+s-1}} - 1\right)^2\right)\right\}$$

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

$$Q^i_t = 1 + \frac{\zeta}{2}\left(\frac{I^i_t}{I^i_{t-1}} - 1\right)^2 + \zeta\left(\frac{I^i_t}{I^i_{t-1}} - 1\right)\frac{I^i_t}{I^i_{t-1}} - \mathbb{E}_t\left[\Lambda^i_{t,t+1}\zeta\left(\frac{I^i_{t+1}}{I^i_t}\right)^2\left(\frac{I^i_{t+1}}{I^i_t} - 1\right)\right] \tag{3.9}$$

[16] 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: $\Pi^{i,prod}_t = Y^i_t - r^i_t K^i_t + W^i_t H^i_t$.

[17] 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.

3.4.4 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:

$$Q^e_t Z^e_{jt} = N^e_{jt} + F^e_{jt} \tag{3.10}$$

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:

$$N_t^e = \overbrace{\theta N_{j,t}^e}^{\text{surviving banks}} + \overbrace{\delta_T Q_t^e K_t^e}^{\substack{\text{new banks} \\ \text{start-up K}}}$$

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, $N_{j,t}^e$ is the net-worth of surviving banks which displays the following dynamics:

$$N_{j,t}^e = R_{k,t}^e Q_{t-1}^e K_{j,t-1}^e - R_{b,t-1}^e F_{j,t-1}^e \tag{3.11}$$

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

$$R_{k,t}^e = \frac{(1-\tau_t^e) r_t^e + (1-\delta)\xi_t^e Q_t^e}{Q_{t-1}^e}$$

with $\tau_t^e \gtrless 0$ 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:[18]

$$J_{j,t}^e(N_{j,t}^e) = \mathbb{E}_t \max_{N_{j,t}^e, Z_{j,t}^e, F_{j,t}^e} \Lambda_{t,t+1}^e \left[(1-\theta) N_{j,t+1+s}^e + \theta J_{j,t+1}^e(N_{j,t+1}^e) \right]$$

subject to the net worth dynamics (3.11), the balance sheet constraint (3.10) and the associated ICC:

$$J_{j,t}^e \geq \kappa^e Q_t^e K_{j,t}^e \tag{3.12}$$

This Incentive Compatibility Constraint condition states that the continuation value of the bank is larger than the potential profit of defaulting.[19]

The bank problem yields the following optimality conditions:

[18] An analogous sequential problem is given by maximizing: $J^e(N_{j,t}^e) = E_t \max_{\{N_t, Z_t^e, F_{j,t}^e\}_{t=0}^{\infty}} (1-\theta) \sum_{s=0}^{\infty} \Lambda_{t,t+1+s}^e [\theta^s N_{j,t+1+s}^e]$

[19] 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.

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

$$[K^e_{j,t}]: \qquad \mathbb{E}_t \Omega^e_{t+1|t} \left(R^e_{k,t+1} - R^e_{b,t} \right) = \mu^e_t \kappa^e \tag{3.13}$$

and envelope condition:

$$[N^e_{j,t}]: \qquad J^{e'}(N^e_{j,t})(1-\mu^e_t) = \mathbb{E}_t \Omega^e_{t+1|t} R^e_{b,t} \tag{3.14}$$

where μ^e_t is the lagrange multiplier associated with the ICC and $\Omega^e_{t+1|t} = \Lambda^e_{t,t+1}\left(1-\theta+\theta J^{e'}_{t+1}\right)$ 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:

$$F^a_{j,t} + F^b_{j,t} + Q^c_t Z^c_{j,t} = N^c_{jt} + D^c_t \tag{3.15}$$

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 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 (3.15) and

to an incentive compatibility constraint given by:

$$J^c_{j,t} \geq \kappa^c_{F_1} F^a_{jt} + \kappa^c_{F_2} F^b_{jt} + \kappa^c Q^c_t Z^c_{j,t} \tag{3.16}$$

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

The optimality Conditions are:

$$[Z^c_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}(R^c_{k,t+1} - R^c_{D,t}) = \kappa^c \mu^c_t \tag{3.17}$$

$$[F^a_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}\left(R^a_{b,t} - R^c_{D,t}\right) = \kappa^c_{F_1} \mu^c_t \tag{3.18}$$

$$[F^b_{j,t}]: \quad \mathbb{E}_t \Omega^c_{t+1|t}\left(R^b_{b,t} - R^c_{D,t}\right) = \kappa^c_{F_2} \mu^c_t \tag{3.19}$$

and the envelope condition,

$$[N^c_{j,t}]: \quad J^{c'}(N^c_{j,t})(1 - \mu^c_t) = \mathbb{E}_t \Omega^c_{t+1|t} R^c_{D,t} \tag{3.20}$$

3.4.5 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.

$$\tau^i_t r^i_t K^i_{t-1} + T^i_t = 0 \qquad i = \{a, b, c\}$$

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:

$$J^e_{jt} = \nu_t Q^e_t K^e_{jt} + \eta_t N^e_{jt}$$

with,

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

Where $x_{t,t+i} = Q^e_{t+i}K^e_{j,t+i}/Q^e_t K^e_{j,t}$ and $z_{t,t+i} = N^e_{j,t+i}/N^e_{j,t}$

I now substitue J^e_{jt} from (3.12) when it binds and obtain the leverage as ϕ^e_t:

$$\frac{Q^e_t K^e_t}{N^e_t} = \phi^e_t = \frac{\eta_t}{\kappa^e - \nu_t} \tag{3.21}$$

Where I removed the j sub-index as the components of the leverage will not depend on firm-specific factors. It also follows that $z_{t,t+1} = [(R^e_{k,t+1} - R_{b,t})\phi^e_t + R^e_{b,t}]$ 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 (3.21), 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.

3.4.6 Market Clearing Conditions

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

$$\text{Goods market:} \quad \sum_i n_i Y^i_t = \sum_i n_i \left(C^i_t + I^i_t \left(1 + \frac{\zeta}{2}\left(\frac{I^i_t}{I^i_{t-1}} - 1 \right)^2 \right) + \frac{\eta}{2}(B^i_t)^2 + \frac{\eta}{2}\left(D^i_t - \bar{D}^i \right)^2 \right)$$

$$\text{Bonds market:} \quad \sum_i n_i B^i_t = 0, \qquad \forall t$$

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 (3.8), and the goods and bonds market clearing conditions hold for each t.

In the table 3.11 in the appendix 3.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.

3.5 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 3.2: 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 3.2, 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.

3.5.1 Planning Problems

In every case I consider the planning problem under commitment with a timeless perspective. [20] 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.

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:

$$W_0^{coop} = \max_{\mathbf{x}_t, \boldsymbol{\tau}_t} [n_a W_0^a + n_b W_0^b + (1 - n_a - n_b) W_0^c] \tag{3.22}$$

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

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

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

where W_0^i denotes the welfare of the country i as in (3.5), $\mathbf{x}_t$ 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:

$$W_0^{coop(C+A)} = \max_{\mathbf{x}_t, \tau_t^a, \tau_t^c} [n_a W_0^a + n_c W_0^c] \tag{3.23}$$

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

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:

$$W_0^{coopEME} = \max_{\mathbf{x}_t, \tau_t^a, \tau_t^b} [n_a W_0^a + n_b W_0^b] \tag{3.24}$$

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

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:

$$W_0^{i,nash} = \max_{\mathbf{x}_t, \tau_t^i} W_0^i \tag{3.25}$$

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

3.5.2 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.

3.6 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 3.2 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 3.8 in the appendix 3.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 3.3 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 3.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 3.3: 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

3.6.1 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 3.4: 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 3.4 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 3.10 in the appendix 3.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%.[21] 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)),

[21]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 3.9 in the appendix 3.B.

the third best policy would be the non-cooperative one (Nash) and, finally, the worst performing one is the regional cooperation between peripheries (CoopEMEs).

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 3.4 would be similar.

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

$$\tau_3^{c,coop} = \tau_3^{c,nash} - \overbrace{\varphi_3^{c,NFA}}^{\substack{\text{NFA-led Interest rate} \\ \text{manipulation motive} \\ \text{under Nash}}} + \overbrace{\psi_3^{eme}(\kappa)}^{\substack{\text{local capital for foreign (EME)} \\ \text{intermediation substitution motive}}} \tag{3.26}$$

This equation is obtained in the appendix 3.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 (3.3).

The equation (3.26), 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 (3.26) 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 (3.26), 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 3.5: 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 3.5 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 procyclicallity 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.

Given these features, it turns out that the inclusion of additional peripheral countries in the cooperative interactions, such as when we switch to the two economies coalition (Coop(A+C)) to one with three economies (Coop), represents a way to balance the incentives of these economies in a welfare improving fashion. That is, to boost the social gains, we can either consider Center interactions with larger peripheries, or include more smaller economies into the cooperative arrangement to prevent national biases in the cooperative planners.

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 3.10 in the appendix 3.B.

3.6.2 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 3.3 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 3.3). 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. [22]

The financial variables tell a similar story. I show these in the figure 3.4. Consistently with

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

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 3.4). 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 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 3.3: Response to a negative financial shock at the Center economy

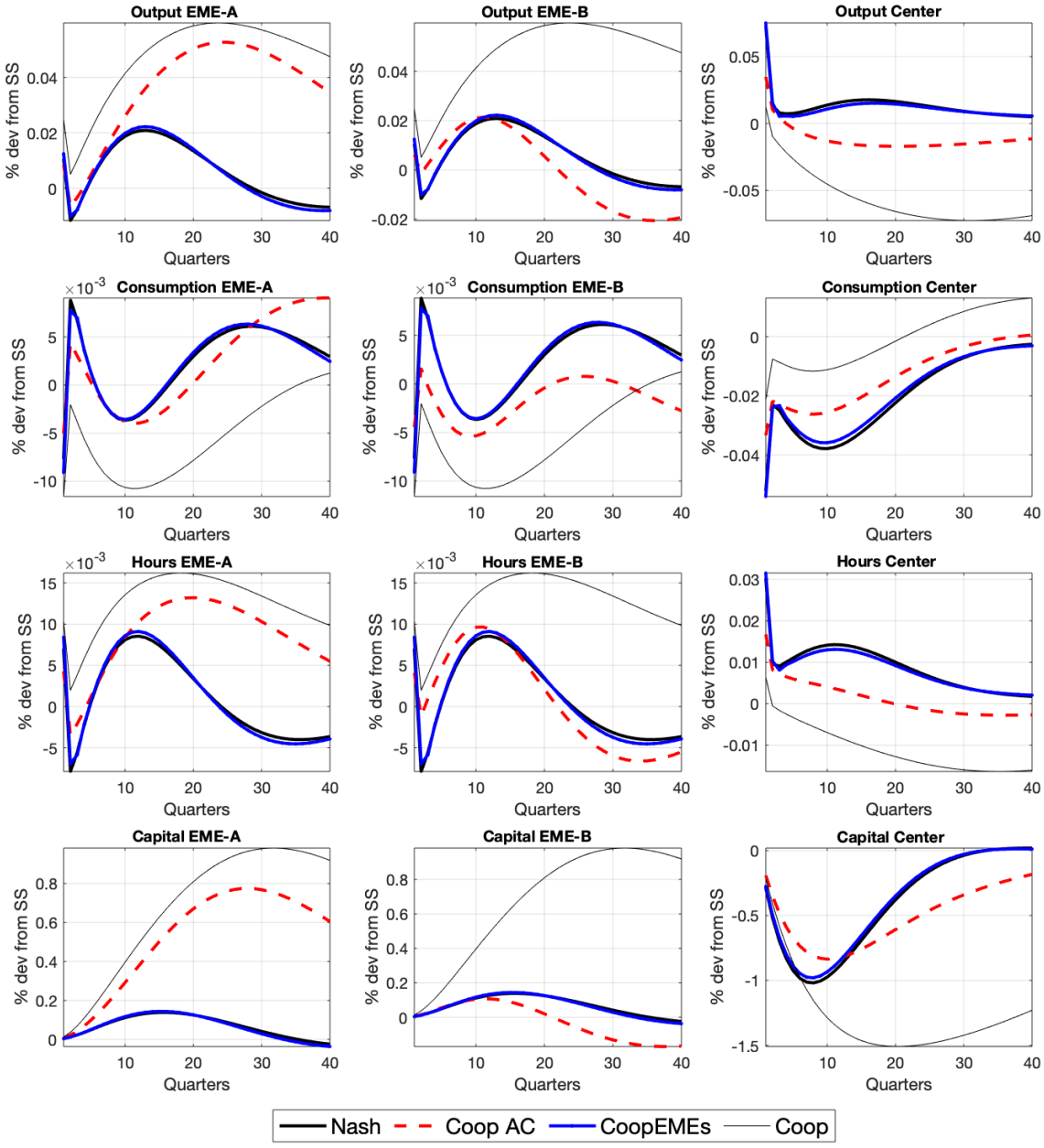
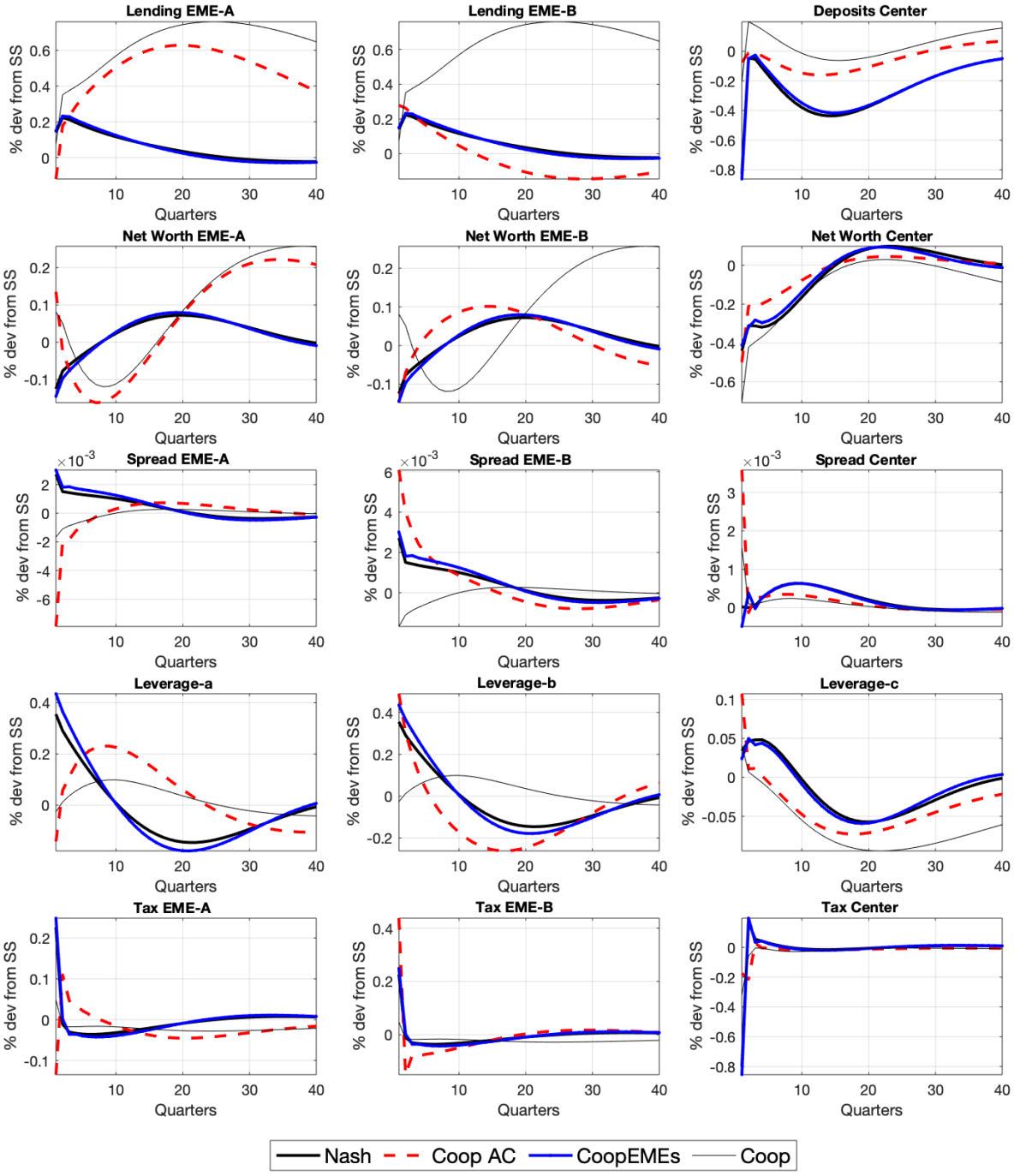
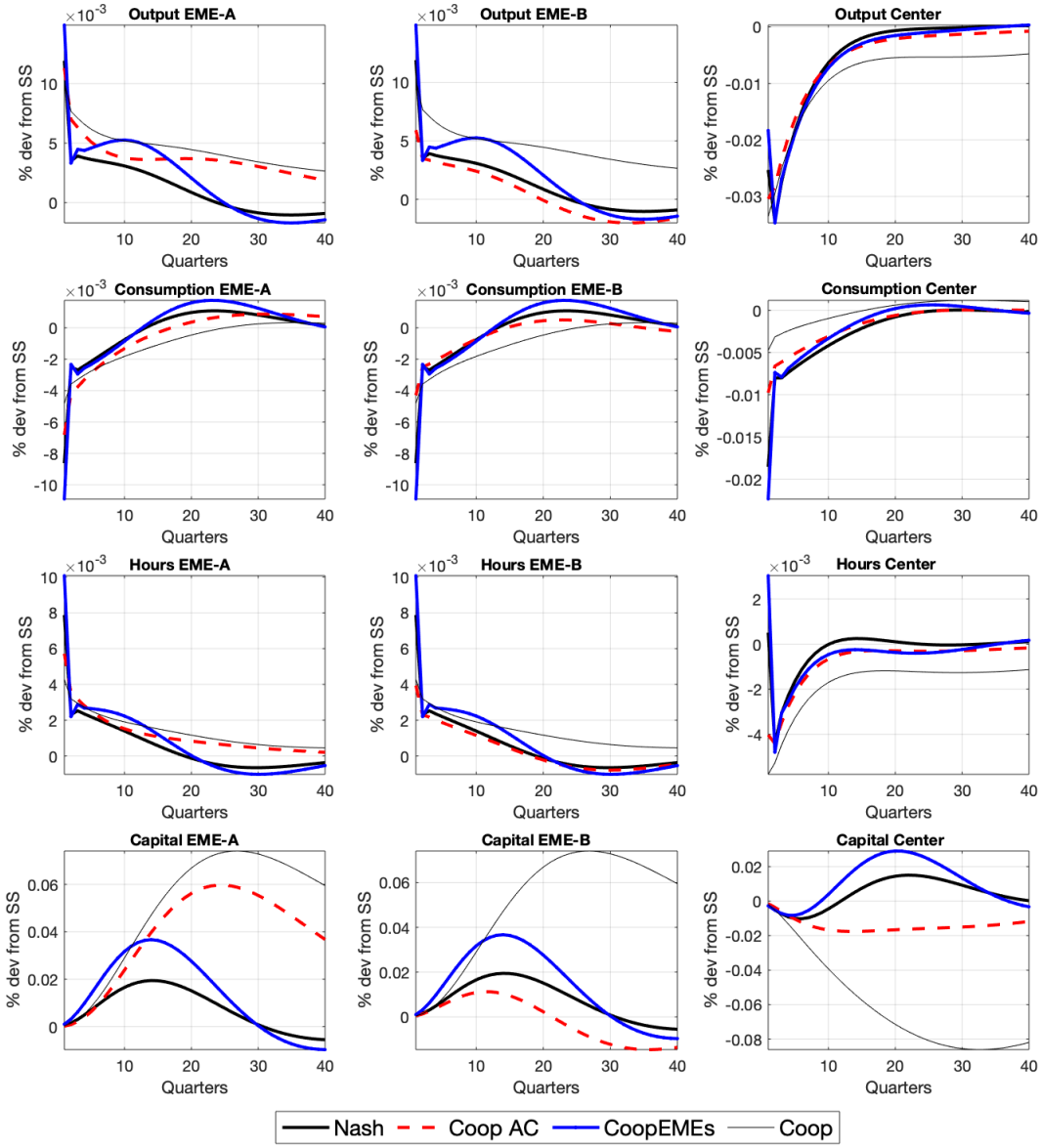


Figure 3.4: Response to a negative financial shock at the Center economy - Financial Variables and tools



Real Shock. I also report the dynamic response to a negative technological shock in the Center in figure 3.5. 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 3.5: Response to a negative productivity shock at the Center economy

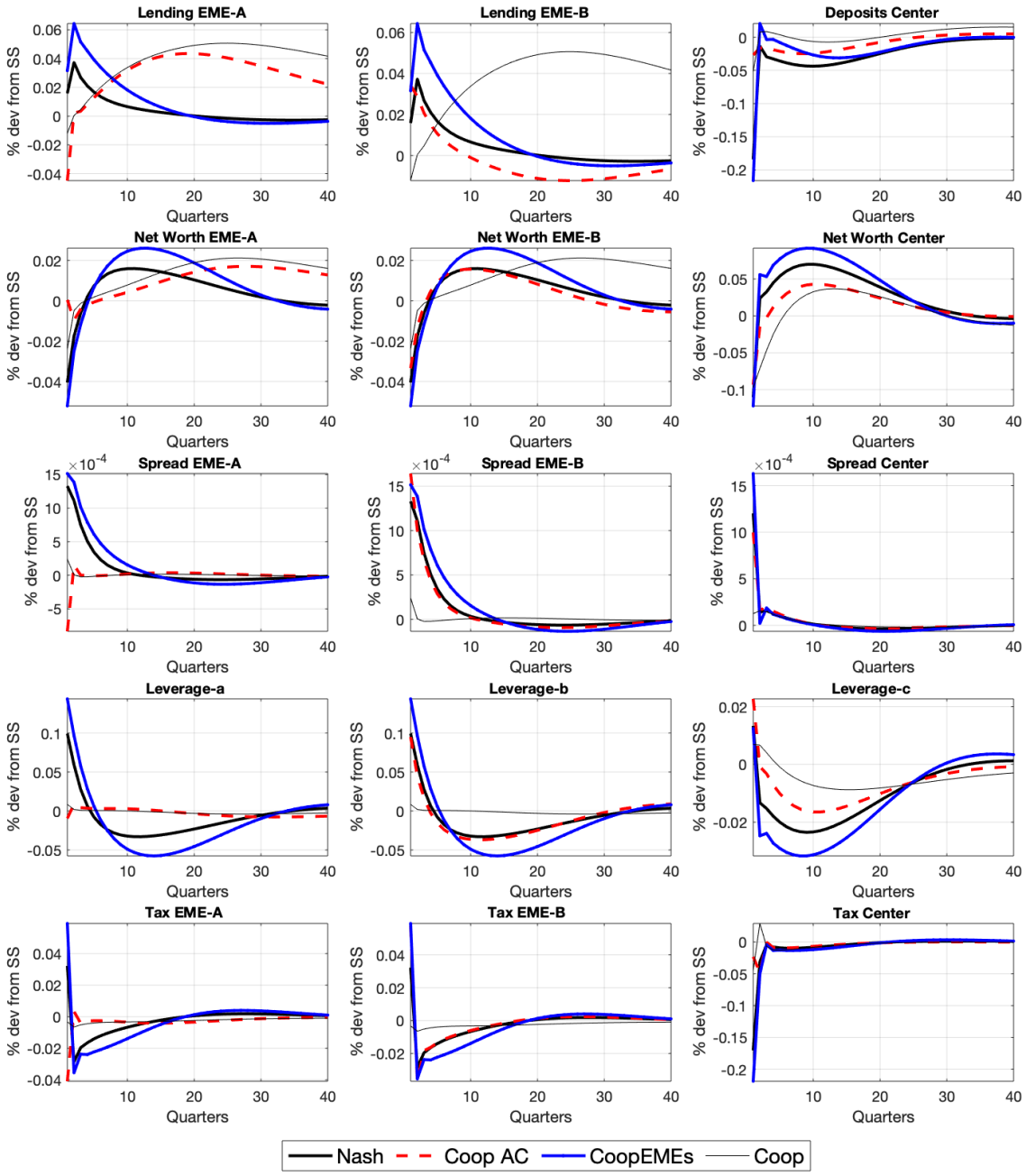


The same occurs with the financial variables as these comove with the level of intermediation. This delayed response feature, characterized by hump shaped responses, for example in the

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



3.7 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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3.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 3.6: 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]
$(1-\theta)\Lambda_{1,2}\left(R_{k,2}Q_1 K_1 - R_1 F_1\right) + \Lambda_{1,3}\theta\left(R_{k,3}Q_2 K_2 - R_2 F_2\right) = kQ_1 K_1$	[ICC, t=1]
$\Omega_1(1+\mu_1)\left(R_{k,2} - R_1\right) = \mu_1\kappa$	[Credit spread, t=2]
$\Lambda_{2,3}\left(R_{k,3}Q_2 K_2 - R_2 F_2\right) = kQ_2 K_2$	[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: $\pi^e_{b,3} = R^e_{k,3} Q^e_2 K^e_2 - R_2 F^e_2, \qquad$ 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 3.7: 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

3.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_3^c 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.

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

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

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

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

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 (3.26).

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:

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

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

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

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 $\tau_3^{c,coop}$:

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

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

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

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 3.3. 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[23], for a clearer argument and assume the $\lambda_2^a = \lambda_2^c$ which leads to the equation (3.26).

An analogous procedure can be carried out with the welfare effects of the peripheral taxes under cooperation which would generate the following optimal tax:

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

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 3.6 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.

3.B Results from the Main Model

3.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: $\mathbf{x_t}$

[23] 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 $\lambda_2^a > \lambda_2^c$.

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 $\bar{\tau}$ such that: $\bar{\tau} = \arg\min_{\tau} \mathbf{u}$

3.B.2 Parameters of the Model

The table contains the parameter used in the baseline model.

Table 3.8: 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

3.B.3 Welfare Accounting Supplementary Exercises

Table 3.9: 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 3.10: 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 3.11: 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]
$\mathbb{E}_t \Omega_{t+1\|t}^i\left(R_{k,t+1}^i - R_{b,t}^i\right) = \mu_t^i \kappa^i$	[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]
$j_t^e\left(1-\mu_t^e\right) = \mathbb{E}_t\left[\Omega_{t+1\|t}^e R_{b,t}^e\right]$	[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]
$\mathbb{E}_t \Omega_{t+1\|t}^c\left(R_{k,t+1}^c - R_{D,t}^c\right) = \mu_t^c \kappa^c$	[Credit Spread for Local Intermediation]
$\mathbb{E}_t \Omega_{t+1\|t}^c\left(R_{b,t}^a - R_{D,t}^c\right) = \mu_t^c \kappa_{F_a}^c$	[Spread for Foreign Lending to EME-A]
$\mathbb{E}_t \Omega_{t+1\|t}^c\left(R_{b,t}^b - R_{D,t}^c\right) = \mu_t^c \kappa_{F_b}^c$	[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]
$j_t^c\left(1-\mu_t^c\right) = \mathbb{E}_t\left[\Omega_{t+1\|t}^c R_{D,t}^c\right]$	[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:

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

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

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