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The International Dimensions of Macroprudential Policies[1]

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Abstract

The large economic costs associated with the Global Financial Crisis have generated renewed interest in macroprudential policies and their international coordination. Based on a core-periphery model that emphasizes the role of international financial centers, we study the effects of coordinated and non-coordinated macroprudential policies when financial intermediation is subject to frictions. We find that even when the only frictions in the economy consist of financial frictions and financial dependency of periphery banks, the policy prescriptions under international policy coordination can differ quite markedly from those emerging from self-oriented policy decisions. Optimal macroprudential policies must address both short run and long run inefficiencies. In the short run, the policy instruments need to be adjusted to mitigate the adverse consequences of the financial accelerator, and its cross-country spillovers. In the long run, policymakers need to take into account the effects of the higher cost of capital, due to the presence of financial frictions. The gains from cooperation appear to be sizable. Nevertheless, their magnitude could be asymmetric, pointing to potential political-economy obstacles to the implementation of cooperative measures.

Keywords: Macroprudential policies, International spillovers, Financial Frictions, International cooperation.

JEL: E3, E5, F3, F5, G1.

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1. Introduction

The Global Financial Crisis of 2007-09, and the unprecedented speed and scale with which it was amplified and propagated internationally, has given renewed impetus to research on the various channels through which international financial spillovers can occur – including trade linkages, asset prices and portfolio balance effects, cross-border balance sheet exposures, confidence effects, as well as policy interventions.[2]

In many jurisdictions, policymakers were confronted with unusually hard trade-offs. Advanced Economies (AEs) had to push their tools, in particular monetary policy, to limits.[3] That, in turn, made macroeconomic and financial stability more difficult to achieve for policymakers in the rest of the world. These countries had to cope with exchange rate appreciation, large asset price increases, excessive credit growth and inflationary pressures, without being capable of using textbook policy responses because of the fear of further destabilizing effects. This state of affairs can be related to the idea of monetary policy "dilemma" (Rey, 2013). Recourse to macroprudential (MaP) measures then appeared desirable, if not necessary, because of the growing concerns about risks to financial stability, triggering in the process a further wave of cross-country spillovers (e.g. Forbes et al., 2016).[4]

The purpose of this paper is twofold. First, it aims to quantify the gains associated with countercyclical MaP coordination in a core-periphery DSGE setting, relative to the case where countries pursue their own policies. Second, it aims to assess the extent to which these gains depend on differences in the scope of financial frictions across countries. We address these issues by comparing the welfare properties of two alternative scenarios: the cooperative equilibrium where countries set MaP to maximize global welfare and the noncooperative Nash equilibrium, where each country maximizes its own welfare. After providing empirical evidence on the effectiveness of MaP interventions in stabilizing output volatility and on the interdependence of MaP policy, we develop a simple two-country model where there are two related inefficiencies consisting of: *i)* an agency problem (limited enforceability of contracts) in the transaction between depositors and banks à la Gertler and Karadi (2011), and Gertler et al. (2010), and *ii)* full financial dependency of the peripheral banking system from the center-country banking sector. Prices are fully flexible and inflation is constant, so that we can abstract from the monetary policy problems. The only types of exogenous shocks considered in our model are

[2] See Bagliano and Morana (2012), Fratzscher et al. (2014), Anaya et al. (2015), Bowman et al. (2015), Aizenman et al. (2016), Barroso et al. (2016), Tillmann (2016), and MacDonald (2017).

[3] In this paper we refer to an advanced economy or a core country as synonyms, likewise for emerging and periphery economy.

[4] An overview of the experience that central banks have gathered with the use of macroprudential instruments is reported in CGFS (2016b).

country-specific technology shocks (TFP) and capital-quality shocks à la Gertler and Karadi (2011).

In order to gain intuition, we furthermore adopt a stylized representation of MaP regulation. In most of the literature, MaP instruments take the form of taxes on deposits, taxes on loans, and taxes on the net worth of banks. All of these instruments alter the balance sheet composition of banks and their net worth (or franchise value) because they affect directly or indirectly the cost of borrowing or the interest margin on lending. A tax on loans, for instance, reduces the interest margin obtained from lending activities, thereby making lending less profitable.[5] Alternatively, a tax on deposits, just like reserve requirements, affects the cost of liabilities for banks. In our analysis, we introduce a tax on bank lending revenue, which in equilibrium reduces the amount of credit extended by banks.

This stylized characterization of MaP instruments clearly falls short of capturing important details (eg implementation constraints, communication etc.) of real world measures.[6] Nevertheless, it captures their common and salient features.[7]

With these caveats in mind, our results can be summarized as follows. First, even in the presence of one type of inefficiency, the gains from coordination are sizable, reaching more than 1% per quarter of permanent consumption in our baseline calibration. These gains are larger than those typically documented in the literature on monetary policy. Second, the gains are not equally distributed across countries. While our model suggests that each country gains from cooperation, the gains of the peripheral, financially dependent economy are markedly larger than those accruing to the larger core country. In most cases the latter would lose out by cooperating if transfers across countries were not feasible. This could point to potential political-economy obstacles to the implementation of cooperative policies. Third, in the long run, MaP policies aim at reducing the cost of capital to borrowers, which is higher than the first-best level due to the agency problem. In the short run, though, the cyclicality of taxes depends on the source of shocks. In the linearized version of our model, under the global cooperative policy, and upon an unexpected domestic expansionary TFP shock, subsidies (negative taxes) are increased. This notwithstanding, credit spreads fall by less than without intervention since subsidies are

[5]For instance, Kannan et al. (2010), Gertler et al. (2010), Quint and Rabanal (2014), and Levine and Lima (2015) specify a tax on loans, as do also De Paoli and Paustian (2013) in a model without banks. Correia et al. (2016) focus on credit subsidies. By contrast, Suh (2011) specifies a tax on deposits whereas Quint and Rabanal (2014) introduce a MaP instrument that operates by affecting the supply of credit, and ultimately the lending-deposit spread. These specifications are in almost all cases assumed to be neutral in terms of their fiscal impact.

[6]The main challenges in objective setting and communication of macroprudential policies are discussed in CGFS (2016a).

[7]See Gerali et al. (2010), Agénor et al. (2012), Agénor and Zilberman (2015), Agénor et al. (2017), and Agénor and Pereira da Silva (2017) for models with explicit MaP measures.

quickly withdrawn or reduced for a prolonged period of time once uncertainty vanishes. The major effect of this cooperative policy turns out to be on the cross-border spillovers, which are visibly muted. The fact that the policymaker aims to mitigate spillovers emerges throughout our analysis. A positive capital-quality shock has ambiguous effects on domestic (and foreign) GDP, as the increased availability of capital reduces investment temporarily. The fall in asset prices hits negatively the balance-sheet of banks, which raise credit spreads, with a negative impact on real activity. The optimal cooperative policy has a marked effect on spreads, mitigating their increase, or even inverting the sign of their response: a larger GDP response (at least on impact) ensues. Moving to non-cooperative policies we observe sizable, intuitive changes in policymakers' behavior. Even in the long run, the burden of the adjustment becomes more asymmetric. In the short run, the lack of cooperation is visible in the first place in the response of the policy instrument to shocks: when shocks take place in the foreign (periphery) country, the domestic (core) response is notably more muted than under cooperation. As a consequence, spillovers are larger and sizable.

Our paper is related to a large and growing literature. In particular, the scope for international MaP policy coordination has also been the subject of a number of recent contributions. Bengui (2013), Jeanne (2014), Korinek (2014) and Kara (2016) have provided insights based on small analytic models. Other authors have used two-country dynamic stochastic general equilibrium (DSGE) models with financial market imperfections. Some of these contributions, which include Rubio (2014), Quint and Rabanal (2014), Mendicino and Punzi (2014), Brzoza-Brzezina et al. (2015), Palek and Schwanebeck (2015), Agénor and Jia (2016), and Rubio and Carrasco-Gallego (2016) have studied a currency union where national central banks and a common central bank may possibly take on a MaP regulatory role. Closely related to our paper is the work by Aoki et al. (2016), who study monetary and fiscal policy in emerging markets. In terms of macroprudential policies, these authors derive the welfare implications for a small open economy of introducing taxes on risky investments as well as on borrowing in foreign currency. The former, assumed to be of permanent nature, generates little welfare gains. The latter, assumed to change cyclically, has instead larger positive welfare implications. Our paper differs from theirs in that we focus on optimal MaP policy and the gains from cooperation in a two-country model. Furthermore, we do not study the interaction with monetary policy. This interaction is instead the focus of Ozkan et al. (2014), who assess the optimal mix of monetary and MaP policies in small open economies. One of their main findings points out that monetary policy need not be used for financial stabilization purposes in the presence of MaP tools. Others, including Kollmann et al. (2011), Kollmann (2013), and Nuguer and Cuadra

(2016) have considered more general core-periphery models where global banks play a key role in the international transmission of shocks.[8] These contributions have considered a number of MaP instruments, including loan-to-value (LTV) ratios (Rubio, 2014, Brzoza-Brzezina et al., 2015, and Rubio and Carrasco-Gallego, 2016), capital requirements (Kollmann et al., 2011 and Kollmann, 2013) and reserve requirements (Agénor and Jia, 2016), often in the form of simple countercyclical rules.

Our paper is also strongly inspired by the literature on the international dimensions of monetary policy. Beyond the earlier contributions, for instance by Hamada (1976) and Canzoneri and Gray (1985) (see also Canzoneri and Henderson, 1992, and the literature cited therein), more recent seminal papers in this area are Obstfeld and Rogoff (2002), Clarida et al. (2002), Devereux and Engel (2003), Corsetti and Pesenti (2005), Benigno and Benigno (2003), Benigno and Benigno (2006), and Engel (2011). While this literature has shed more light on the sources of possible gains from cooperation, it has also concluded that quantitatively the gains are generally small.[9] Finally, the recent paper by Banerjee et al. (2016) shows in a model similar to ours that cooperative and non-cooperative policies require very similar monetary policy interventions, thus with negligible gains from cooperation.

The remainder of the paper proceeds as follows. Section 2 surveys recent international experiences of MaP interventions and provides an overview of the measured effects of these policies. Section 3 describes the model, which dwells largely on Banerjee et al. (2016). We focus on the key features of relevance to the issue at stake, namely, the financial system and the MaP regime. A benchmark parametrization is presented in Section 4 where we provide the numerical results, going through a number of exercises. In that Section, both impulse-responses (to first order of accuracy) and welfare analysis (up to second order of accuracy) are discussed. Finally, in Section 5 we provide concluding remarks and discuss some potentially fruitful directions for future research.

[8] Some of these contributions have also looked at the combination of monetary policy and MaP regulation (see Mendicino and Punzi (2014), and Quint and Rabanal (2014)), which is beyond the scope of this paper.

[9] See also Canzoneri et al. (2005) and the general framework proposed by Corsetti et al. (2010). Sutherland (2006) has pointed out that the gains are very sensitive to trade elasticity. This said, for empirically plausible values, the gains remain small and mainly due to the risk-sharing effect of terms of trade movements, in the spirit of Cole and Obstfeld (1991), and Obstfeld and Rogoff (2002). Coenen et al. (2009) assess the gains from cooperation in a medium size two-country DSGE model (without financial frictions). Their baseline results suggest that the gains are rather small. Nevertheless, they also point out that the degree of openness plays a crucial role, so that growth in international trade could engender larger gains from international cooperation.

2. Macroprudential policies and macroeconomic volatility

Before moving to the theoretical analysis, this section provides some "first pass" evidence on two stylized facts that characterize our model: i) macroprudential-policy effects on macroeconomic volatility; ii) interdependence in the use of macroprudential tools among countries.

The first stylized fact (impact of macroprudential tool on output volatility) is ultimately the main factor driving macroprudential policy in our theoretical model. While financial stability can be seen as the overarching objective of MaP tools, different MaP policies tend to be motivated by different specific (or intermediate) objectives. Borio (2011), and Claessens et al. (2013) distinguish between the goals and the types of policy that are commonly used. MaP tools whose main objective is enhancing the resilience of the financial sector include: a) capital-based instruments (countercyclical capital requirements, leverage restrictions, general or dynamic provisioning) and b) liquidity-based requirements. Within the category of MaP tools aimed at dampening the credit cycle, we can consider: c) asset-side instruments (credit growth limits, maximum debt service-to-income ratio, limits to bank exposures to the housing sector as maximum loan-to-value ratio); d) changes in reserve requirements; and e) currency instruments (variations in limits on foreign currency exchange mismatches and net open positions). As Figure 1 shows, the large majority of MaP policies can be classified as aiming at smoothing business cycle fluctuations induced by financial frictions. On the basis of this evidence, and for the sake of tractability, our theoretical model addresses mainly this class of MaP policies.

Based on the above classification and available data, the chart pie on the left-side of Figure 1 splits the different type of MaP policies adopted in 64 countries in the period 1990-2014. Interestingly, only one quarter of the policies are intended to increase directly the resilience of the financial sector using capital, liquidity or provisioning requirements (slices in blue color). By contrast, the vast majority have the purpose of dampening the cycle - i.e. those used by authorities countercyclically to dampen an expected credit boom or credit crunch. More than half are represented by changes in reserve requirements. The chart pie on the right-hand side of Figure 1 shows that in three quarters of the cases MaP tools have been tightened.

Our benchmark econometric model follows Beck and Levine (2004, Table 4) but it is adapted to study the link between output volatility and the use of MaP tools. In particular, we estimate:

$$\begin{aligned}\sigma_{\Delta y,i,t} \quad = \quad & \alpha\sigma_{\Delta y,i,t-1} + \beta FD_{i,t} + \gamma OPEN_{i,t} + \delta MaP_{i,t} + \zeta FD_{i,t} \times OPEN_{i,t} + \nu FD_{i,t} \times MaP_{i,t} \\ & + \lambda MaP_{i,t} \times OPEN_{i,t} + \xi FD_{i,t} \times MaP_{i,t} \times OPEN_{i,t} + \omega' X_{i,t} + \eta_i + \varepsilon_{i,t} \qquad (2.1)\end{aligned}$$

where $\sigma_{\Delta y,i,t}$ is the five-year rolling standard deviation of real per capital GDP growth, i and t represent country and time period respectively. The key variables in the specification are the three indicators of financial dependence (FD, taken from Sahay et al., 2015), openness (where we use the Chinn-Ito index) and MaP activism (MaP, given by the logarithm of the five-year rolling sum of the number of changes in MaP measures in a given country). $X_{i,t}$ represent a set of control variables. The regression also includes interactions of these three measures and time-fixed effects (η_i).[10] More details are provided in Boar et al. (2017).

Table 1 shows the result of the panel regression. The dependent variable is our measure of output volatility ($\sigma_{\Delta y,i,t}$). Columns (4) to (8) refer to different types of MaP policies. Column (2) and (3) refer to the total of each class, whereas column (1) reports the results for all types and classes of MaP. The main explanatory factors of interest for this paper concern MaP activism and its interaction with openness and financial development.

Three factors are particularly important for our paper. We start by discussing each of these factors in isolation before turning to the interactions: i) the more active MaP is, the smaller is the volatility of GDP growth (fourth row); ii) the more financially developed the economy is, the less volatile GDP growth is (third row); iii) the more open is the economy the less volatile GDP is (fifth row). The first result is quite intuitive and reflects one of the main motives of MaP interventions, namely, financial stability considerations. The second result indicates that financial development could increase the number of available assets and thus provide better hedging opportunities, and smaller volatility.

Moving to the interactions, we have the following results: i) if an economy is more financially developed, then the MaP negative impact on volatility is reduced (sixth row); ii) if an economy is particularly open, then MaP is less effective in dampening volatility (eighth row). Both of these results could be interpreted as follows: the effectiveness of MaP is reduced when new types of unregulated financial intermediaries appear in the market (FD increases), and when openness allows firms and households to obtain financing in other (not directly regulated) jurisdictions. This result is in line with the findings of Cerutti et al. (2015).

The second stylized fact that we want to document is the interdependence of macroprudential interventions among countries. An interesting preliminary test is to verify the extent to which the activation of macroprudential policies in a country i is correlated with the use of such tools in another country j. In particular, it would be interesting to verify whether this correlation is higher if country i and country j have large trade or financial linkages. To this end, we

[10] As in Beck and Levine (2004), we used the dynamic Generalized Method of Moments (GMM) panel methodology to obtain consistent and unbiased estimates of the relationship between financial structure and economic growth. By relying on instrumental variables, the methodology reduces the endogeneity bias that may affect parameter estimates and accounts for unobservable factors affecting individual countries. Blundell and Bond (1998) argue that first differences of exogenous variables can be instrumented by themselves, while first differences in endogenous variables are instrumented by the lagged values of the variable in levels.

estimated the following model:

$$\Delta MaP_{i,t} = \alpha \Delta MaP_{j,t} + \beta \Delta MaP_{j,t} \times LINKAGES_{i,j,t} + \delta' X_{i,j,t}, + \mu_{i,j}, + \varepsilon_{i,j,t} \tag{2.2}$$

where the change in the macroprudential index in country i at time t ($\Delta MaPi, t$) is regressed on the corresponding change in the macroprudential index in country j at time t and its interaction with a linkages measure between the two countries ($\Delta MaP_{j,t} \times LINKAGES_{i,j,t}$). The model also includes a vector $X_{i,j,t}$ of macro controls for different cyclical conditions, and a complete set of country pair fixed effects ($\mu_{i,j}$) to take into account time-invariant institutional relations between the two countries. The indicator of real and financial linkages ($LINKAGES_{i,j,t}$) is given by the sum of bilateral measures: i) exports and imports; and ii) balance-sheet claims and liabilities.

Results presented in Table 2 indicate that the use of macroprudential tools among countries is positively correlated with their real and financial linkages. The positive sign on the interaction term $\Delta MaP_{j,t} \times LINKAGES_{i,j,t}$ offers preliminary evidence of the possible interdependence in the use of macroprudential tools among countries. The results remain stable to the inclusion or exclusion of different sets of controls and are also qualitatively very similar using different versions of the indicator for $LINKAGES_{i,j,t}$ (that is, including only real or financial linkages instead of their sum).

One obvious major caveat concerning our empirical analysis is that it does not identify exogenous policy innovations in one country, and how these spill over to other countries. Our analysis highlights correlations among endogenous variables. These, most likely, result from the choices of forward-looking agents, which makes causal interpretation very difficult. That said, while a richer dataset could allow for more precise inference in the future, we believe that our results provide interesting, first-pass evidence of the likely interdependence among MaP interventions and their effectiveness.

The theoretical analysis that follows is inspired and motivated by the empirically plausible idea that MaP instruments could be effective in taming finance-induced macroeconomic volatility, and that MaP decisions taken in each country might be influenced by policies chosen by financially interconnected countries. In particular, we restrict our focus to a model economy in which regulated financial intermediaries play a crucial role in the international transmission of shocks and policies. These financial intermediaries increase the investing opportunities across countries, thus adding to the ability of each economy to weather undesired economic fluctuations. At the same time, though, by operating in imperfect financial markets, they can further amplify macroeconomic fluctuations.

Table 1: Do macroprudential policies reduce output volatility?

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Total	Resilience	Cyclical	Capital based	Liquidity based	Asset side	Reserve requirement	Currency instruments
Lagged dependent variable	0.8448***	0.8344***	0.8426***	0.8442***	0.8370***	0.8425***	0.8431***	0.8491***
	(0.0233)	(0.0296)	(0.0240)	(0.0236)	(0.0262)	(0.0229)	(0.0226)	(0.0196)
Log initial income per cap.	0.0014**	0.0014***	0.0014**	0.0014**	0.0012**	0.0013**	0.0014**	0.0014***
	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)
FD	-0.0140***	-0.0109***	-0.0144***	-0.0091***	-0.0106***	-0.0108***	-0.0136***	-0.0110***
	(0.0039)	(0.0034)	(0.0037)	(0.0030)	(0.0029)	(0.0036)	(0.0033)	(0.0027)
MaP (index)	-0.0022**	-0.0031	-0.0024**	-0.0013	-0.0097**	-0.0048	-0.0025**	-0.0094***
	(0.0011)	(0.0030)	(0.0011)	(0.0034)	(0.0043)	(0.0034)	(0.0012)	(0.0017)
OPEN	-0.0023*	-0.0019*	-0.0021*	-0.0019**	-0.0015*	-0.0016*	-0.0019*	-0.0016*
	(0.0013)	(0.0010)	(0.0012)	(0.0010)	(0.0009)	(0.0010)	(0.0011)	(0.0009)
FD×MaP	0.0050**	0.0061	0.0057***	0.0028	0.0195**	0.0087	0.0065***	0.0164***
	(0.0021)	(0.0063)	(0.0021)	(0.0066)	(0.0097)	(0.0063)	(0.0024)	(0.0043)
FD×MaP×OPEN	-0.0022*	-0.0039	-0.0021*	-0.0035	-0.0087*	-0.0044	-0.0021	-0.0093***
	(0.0012)	(0.0029)	(0.0012)	(0.0033)	(0.0045)	(0.0029)	(0.0014)	(0.0027)
MaP×OPEN	0.0012*	0.0024	0.0011	0.0024	0.0046**	0.0029*	0.0010	0.0050***
	(0.0007)	(0.0016)	(0.0007)	(0.0018)	(0.0020)	(0.0016)	(0.0008)	(0.0012)
FD×OPEN	0.0035*	0.0026	0.0034*	0.0025	0.0020	0.0023	0.0030*	0.0023
	(0.0021)	(0.0017)	(0.0020)	(0.0017)	(0.0015)	(0.0018)	(0.0018)	(0.0015)
Av. schooling (in logs)	-0.0004	-0.0006	-0.0002	-0.0007	-0.0003	-0.0008	0.0003	-0.0010
	(0.0028)	(0.0027)	(0.0027)	(0.0027)	(0.0026)	(0.0026)	(0.0028)	(0.0025)
Gov. cons. (in logs)	-0.0014	-0.0017	-0.0014	-0.0015	-0.0017	-0.0014	-0.0016	-0.0017
	(0.0012)	(0.0014)	(0.0012)	(0.0013)	(0.0013)	(0.0012)	(0.0012)	(0.0012)
Inflation	0.0002	0.0003*	0.0002*	0.0003*	0.0003**	0.0003*	0.0003*	0.0003*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,471	1,471	1,471	1,471	1,471	1,471	1,471	1,471
Number of countries	63	63	63	63	63	63	63	63
Serial correlation test (1)	0.628	0.608	0.632	0.598	0.622	0.602	0.628	0.631
Hansen test (2)	0.131	0.137	0.103	0.137	0.108	0.183	0.143	0.151

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Interdependence of macroprudential tools among countries

Explanatory variables	Dependent variable: change in macroprudential tool index in country i at time t ($\Delta MP_{i,t}$)								
	Baseline			**Financial Development measure**			**Weighted OLS for GDP in country j**		
	MP aggregate index (I)	Resilience index (II)	Cyclical index (III)	MP aggregate index (IV)	Resilience index (V)	Cyclical index (VI)	MP aggregate index (VII)	Resilience index (VIII)	Cyclical index (IX)
$\Delta MP_{j,t}$	-0.0148*	-0.0142**	-0.0188**	-0.0189**	-0.0278***	-0.0220***	-0.0188**	-0.0270***	-0.0220***
	(0.0076)	(0.0072)	(0.0076)	(0.0078)	(0.0082)	(0.0078)	(0.0078)	(0.0081)	(0.0078)
$\Delta MP_{j,t} \times LINK_{i,j,t}$ (1)	0.0104***	0.0111***	0.0087***	0.0105***	0.0111***	0.0088***	0.0106***	0.0110***	0.0089***
	(0.0010)	(0.0011)	(0.0010)	(0.0010)	(0.0011)	(0.0010)	(0.0010)	(0.0011)	(0.0010)
$\Delta MP_{j,t} \times EU_{i,j,t}$ (2)	0.0247**	0.0776***	0.0278***	0.0252***	0.0786***	0.0284***	0.0239**	0.0785***	0.0275***
	(0.0096)	(0.0089)	(0.0096)	(0.0096)	(0.0089)	(0.0096)	(0.0096)	(0.0089)	(0.0095)
$\Delta MP_{j,t} \times FDD_{i,j,t}$ (3)				0.0027*	0.0127***	0.0022*	0.0029**	0.0128***	0.0023*
				(0.0014)	(0.0035)	(0.0012)	(0.0014)	(0.0035)	(0.0013)
Country pair fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Macro controls (4)	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	105,220	105,220	105,220	105,220	105,220	105,220	105,220	105,220	105,220
Number of countries i	63	63	63	63	63	63	63	63	63
R^2	0.0589	0.0357	0.0615	0.0601	0.0357	0.0629	0.0600	0.0357	0.0628

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10%, 5% and 1% level respectively. (1) The indicator of real and financial linkages is given by the sum of the following bilateral measures: exports and imports (IMF-Direction of Trade Statistics), balance sheet claims and liabilities (BIS International banking and financial statistics) and assets and liabilities (IMF-Coordinated Portfolio Investment Survey) between country i and the counterparty country j. (2) EU is a dummy that takes the value of 1 when both country i and country j belong to the European Union. (3) The Financial Development Diversity index (FDD) is the ratio between the financial development index in country j and that of country i. The financial development index is described in Rethinking Financial Deepening: Stability and Growth in Emerging Markets, IMF. The indices are normalised between 0 and 1. (4) Macro controls include the growth rates of real GDP in the two countries.

3. A model of international MaP spillovers

The focus of our analysis is the international dimension of MaP in an asymmetric world, that is, a world in which international capital markets, mainly centered in few advanced core economies (US, euro area and Japan), play a disproportionate role in financing smaller, less financially developed periphery economies, such as emerging market economies (EMEs). There are various ways in which these international links can be modeled. Our choice goes to a rather standard two-country DSGE set-up with familiar features. The core of the model consist of an international real business cycle model (IRBC). The only departure from an IRBC consists of the introduction of imperfect financial intermediation à la Gertler and Karadi (2011). In particular we modify the asymmetric open-economy model developed by Banerjee et al. (2016) (BDL) by imposing price flexibility and by abstracting from monetary policy (see Figure 2). This model features a strong, hard-wired dependency of the EME financial system on the center-country financial market, whereby EME banks can finance themselves only by borrowing abroad. While this assumption could sound extreme at first, compared to the true share of foreign borrowing by EME banks, it should be noted that in our model EME savers can finance domestic borrowers (firms) through the international financial markets. In particular we assume complete international consumption risk-sharing for households, so that EME saving opportunities are not hampered by the lack of direct deposit opportunities at home. Despite potential limitations, the assumption of "two-layers" of financial friction used by BDL offers a parsimonious way to capture two aspect of financing conditions in some EMEs: i) higher inefficiency and ii) high sensitivity to conditions in the global financial market. Absent financial frictions, the roundabout financing of EME firms has no implications for real allocations. The "two-layer" assumption emphasizes what we believe is a realistic implication of MaP, i.e. the strong international policy spillovers through regulated global banks.[11]

As we have seen in the previous section, various types of MaP have been adopted across countries over time. Some of these policies impose limits that are exogenous to individual banks (for instance, loan-to-value ratios or loan-to-income ratios) while others work through constraints that are endogenous to the choices of individual banks (for instance reserve requirements, capital charges on risk-weighted assets, large exposure limits, leverage constraints, and so on). A common feature of these policy measures is to affect the incentive to supply credit.[12]

[11] Alternatively we could have assumed some financing of EME banks by domestic households, together with more severe financial frictions in the EME banking sector.

[12] Clearly, from a social-welfare point of view a cost for an individual bank could improve aggregate welfare, e.g. if it mitigates frictions or externalities. Furthermore, through the general equilibrium effect, individual banks could eventually benefit from the policy intervention too. Nevertheless we exclude the case in which banks benefit directly from a constraint, e.g. due to bounded rationality, imperfect information etc.

As noted in the introduction we will refer to MaP instruments in a broad sense, as instruments that share the broad common features of the real-world measures, but abstract from the details that characterize each of them. From the normative point of view taken in this paper, the most direct way to capture this feature is to introduce a tax/subsidy on the return on capital accruing to banks. In our view, this is also the most natural starting point, as financial frictions engender an inefficient wedge between the return on capital and the frictionless return.

We build up our understanding of the policy problem starting from the frictionless economy, i.e. an efficient world economy that does not require public intervention. We then introduce financial frictions and show how these affect the policy problem and create international policy interdependence. The emphasis is on spillovers and trade-offs, in the tradition of the international policy cooperation literature mentioned in the introduction. We follow this literature also by limiting our analysis to (zero-) first- and second-order effects. This level of analysis allows us to discuss two key aspects of the policy problem, pertaining to macroeconomic volatility and to long run equilibrium levels, including welfare. An established result in the modern welfare analysis literature is that focusing exclusively on volatility could understate the policy trade-off, for instance when the economy is affected by long-run frictions. This is particularly true in a model like ours, in which financial frictions increase the long-run cost of capital. In this context, and abstracting from other frictions, the welfare-maximizing social planner would aim at reducing the cost of capital, for instance through lump-sum financed subsidies. This policy, on the other hand, could distort incentives and increase volatility inefficiently. The policymaker, in this case, will have to design a policy that deals with both these intertemporal dimensions. The ability to do so will crucially depend on the type of instruments that are available. In this sense, the dynamic perspective implies that the Tinbergen-Mundell instrument-target principle might not fully reveal the complexity of the policy problem faced by policymakers: a single wedge could give rise to an intertemporal trade off.[13] Our analysis sheds light on this problem through a number of quantitative examples.

We model the world as consisting of two economies, with total population normalized to have unit mass. The core country (denoted by the letter c), which stands for a large advanced economy (AE), is populated by $1 - n$ consumers. The periphery economy (denoted by the letter e), which stands for EME, has a smaller economic size, with $n < 0.5$. Both economies consist of an household sector, a production sector, banks and a government. Furthermore an international financial market exists where households can trade in assets. Variables are expressed in real terms.

[13]See Tinbergen (1952) and Mundell (1968, pp. 201-216).

3.1. The Emerging Market Economy (Periphery country)

3.1.1. Households

Households consume and work, and act as bankers as in Gertler and Karadi (2011) (more details further below).

Households maximize their intertemporal utility over consumption and labor supply given by:

$$\mathcal{W}_0^e = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{e(1-\sigma)}}{1-\sigma} - \frac{H_t^{e(1+\psi)}}{1+\psi} \right) \tag{3.1}$$

subject to their budget constraint

$$P_t^e C_t^e + E_t \Lambda_{t+1}^e B_{t+1}^e = B_t^e + W_t^e H_t^e + \Pi_t^e. \tag{3.2}$$

In particular, households purchase in the international capital market a complete set of Arrow-Debreu securities B_t^e at the state contingent price (in units of the consumption bundle) Λ_t^e (the household stochastic discount factor). They consume home and foreign goods bundled together by retail firms (C^e). Earn a wage W_t^e on their supply of working hours H_t^e and receive Π_t^e in profits earned from banks and capital producing firms net of new capital infusion into banks as well as lump-sum taxes or subsidies.

3.1.2. Retail firms

Retail firms purchase intermediate goods at price $P_{e,t}$, relative to the domestic consumption-price index P_t^e, and $RER_t P_{c,t}$, where RER_t is the price of the center-country consumption basket in terms of domestic consumption basket, and $P_{c,t}$ is the core-country producers price relative to the core-country consumption-price index P_t^c, and produce the non-tradable final good using the technology:

$$Y_t^e = \left(v_e^{\frac{1}{\eta}} Y_{e,t}^{1-\frac{1}{\eta}} + (1-v_e)^{\frac{1}{\eta}} Y_{c,t}^{1-\frac{1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{3.3}$$

where $v_e > 0$ measures the degree of home bias in domestic demand and is defined as $v_e \equiv \varpi(1-n)$, where ϖ denotes the degree of openness,[14] $-\eta < 0$ is the trade elasticity, and Y_{jt} is the country $j = \{e,\ c\}$ production of the traded intermediate good.[15]

The EME price level consistent with the CES function 3.3 is thus implicitly defined by the following CES aggregator

$$1 = \left(v_e P_{e,t}^{1-\eta} + (1-v_e) \left(RER_t P_{c,t} \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}. \tag{3.4}$$

[14] Note that $v_c \equiv 1 - \varpi n$.

[15] Equivalently, we could have used equation (3.3) to define preferences over domestic and foreign goods, eliminating the retail sector.

where, given the abstraction from nominal rigidities, we assume that $P_t^e = P_t^c = 1$, *wlog.*

3.1.3. Intermediate goods producers

We assume that the production of intermediate goods uses labor ($H_{e,t}$) and capital ($K_{e,t}$) according to a Cobb-Douglas technology:

$$Y_{e,t} = A_{e,t} \left(\xi_t K_{t-1}^e\right)^{\alpha} H_t^{e(1-\alpha)} \tag{3.5}$$

subject to the (AR(1)) total factor productivity shocks ($A_{e,t}$) and the (AR(1)) capital-quality shock (ξ_t).

In order to purchase capital the entrepreneurs operating these firms obtain funds by selling securities $Z_t^e = K_t^e$ to domestic banks. The payoff of the securities is fully indexed to the marginal return on capital which is defined as

$$r_t^e \equiv MC_t^e \alpha A_t^e H_t^{e(1-\alpha)} \frac{K_{t-1}^{e(\alpha-1)}}{\xi_t^e}, \tag{3.6}$$

where MC_t^e is the real marginal cost of production in terms of the domestic consumption-price index P_t^e.

3.1.4. Capital producing firms

A competitive set of firms produce capital by combining old capital, depreciated at rate $1 - (1-\delta)\,\xi_t$ (where $\delta \in (0,1)$) with newly purchased investment goods (I_t^e), subject to the adjustment cost function (e.g. Christiano et al., 2005),

$$I_t^e + I_t^e \zeta \left(\frac{I_t^e}{I_{t-1}^e} - 1\right)^2.$$

Capital producers buy back the old capital from banks at price Q_t^e and produce new capital from the final good in the EME economy subject to the adjustment cost function. Consequently the aggregate stock of capital evolves according to the following law of motion

$$K_t^e = I_t^e + (1-\delta)\,\xi_t K_{t-1}^e.$$

3.2. EME banks

Since the banking sector is the key sector in the analysis of MaP policies, we provide here more details compared to the other sectors.

Banks begin with some bequeathed net worth from their household, and continue their business with probability θ, and with probability $1-\theta$ revert back to their household as in Gertler and Karadi (2011). Bank i that begins with net worth N_{it} borrows an amount V_{it}^e, in units of the domestic consumption bundle, at the real rate $R_{b,t}$ from the global bank, and purchases capital so that the balance sheet is

$$Q_t^e Z_{it}^e = N_{it}^e + V_{it}^e. \tag{3.7}$$

The net worth of the EME banking system evolves according to:

$$N_t^e = \theta N_{i,t}^e + \delta_T Q_t^e K_t^e \tag{3.8}$$

where $\delta_T Q_t^e K_t^e$ is the amount transferred from households to newly established banks, while $N_{i,t}^e$ is the net-worth of the surviving banks, i.e.

$$N_{i,t}^e = R_{k,t}^e Q_{t-1}^e Z_{i,t-1}^e - R_{b,t-1} V_{i,t-1}^e. \tag{3.9}$$

where $R_{k,t}^e$ is the gross return on capital defined as

$$R_{k,t}^e \equiv \xi_t \frac{\left(1 - \tau_{k,t}^e\right) r_t^e + (1-\delta) Q_t^e}{Q_{t-1}^e} \tag{3.10}$$

where $\tau_{k,t}^e$ is a tax (subsidy) used for MaP purposes as discussed further below.

Contracts between savers and banks are subject to limited enforceability. Banks could abscond with part of their assets and leave only a fraction κ^e of them to cover for their debt. The incentive compatibility constraint, therefore, requires that the franchising value of the bank be at least as large as the value of the assets. If this is not the case, bankers would prefer to "default". Bankers maximize the franchising value of the bank that they are expected to pay to the household when the time to leave their activity comes (i.e. with probability $1-\theta$). The problem of the (s-) banker can thus be expressed as

$$J^e\left(N_t^{e,s}\right) = E_t \max_{N_t, Z_t^e, V_{st}^e} (1-\theta) \sum_{i=0}^{\infty} \Lambda_{t+1+i}^e \left[\theta^i N_{s,t+1+i}^e\right] \tag{3.11}$$

subject to the net-worth accumulation law (3.9) and the incentive compatibility constraint (ICC)

$$J_{s,t}^e \geq \kappa^e Q_t^e Z_{s,t}^e \tag{3.12}$$

where $J_{s,t}^e$ is the value of bank s, and Λ_t^e is the household discount factor.

First Order Conditions

The first order conditions (FOCs) of the banker's problem are

$$Z_t: \; E_t \Omega_{t+1|t} \left(R_{k,t+1}^e - R_{b,t}\right) = \gamma_t^e \kappa^e \tag{3.13a}$$

the envelope condition,

$$N^e_{s,t}:\ J^{e\prime}\left(N^{e,s}_t\right)(1-\gamma^e_t) = E_t\Omega_{t+1|t}R_{b,t}, \tag{3.13b}$$

and the complementary slackness condition

$$\gamma^e_t\left(J^e_t - \kappa^e_Z Q^e_t Z^e_{t+1}\right) = 0, \tag{3.13c}$$

where γ^e_t is the Lagrange multiplier on the ICC and $\Omega_{t+1|t} \equiv \Lambda^e_{t+1}\left[1-\theta+\theta J^{e\prime}_{t+1}\right]$ is the effective pricing kernel of the bank.

In the FOCs we have omitted the bank-specific index as the banker problem is invariant to scale and we can thus refer to a representative bank. The only useful distinction remains between $N^e_{s,t}$ and N^e_t for obvious reasons.

Equation (3.13a) shows that up to first order of accuracy (under certainty equivalence) there is a wedge between the marginal return accruing to banks and the marginal cost of funds as long as banks are constrained at present ($\gamma^e_t > 0$). Nevertheless, to higher order of accuracy a "risk-premium" would emerge even if currently banks were unconstrained, as long as $\Omega_{t+1|t}$ is not permanently equal to zero, i.e. if the constraint is expected to be binding under certain states of the world.

There is therefore a tight relationship between the financial channel and the relative cost of capital. In a first best economy, the expected return on capital should be equal to the riskless interest rate adjusted for a possible risk-premium. Denoting the former by R^e_t, the efficient allocation would command the following credit spread

$$\chi^e_t \equiv E_t\Lambda^e_{t+1}\left(R^e_{k,t+1} - R^e_t\right) = 0. \tag{3.13d}$$

The inefficiency under financial frictions stems from generating $\chi^e_t > 0$.

3.3. The Advanced Economy (Core country)

The core country household and production sectors are identical to those of the EMEs, except for i) the possibility of households to purchase deposits from the center-country banks and ii) the country size (and thus effective home bias). For the sake of conciseness therefore we omit the description of these sectors and move straight to the banking sector.

3.3.1. Core country banks (global banks)

The global bank j has a balance sheet constraint given by

$$RER_t^{-1}V^e_{jt} + Q^c_t Z^c_{j,t} = N^c_{jt} + B^c_t$$

where V^e_{jt} is claims on the EME bank, and $Q_{c,t}Z^c_{j,t}$ is claims on the core country capital stock. N^e_{jt} is the bank's net worth, and B^c_t are deposits received from households.

The return on investment in the domestic (core country) capital stock is:

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

The global bank's value function can then be written as:

$$J^c_{jt}\left(N^c_{j,t}\right) = E_t \max_{N^c_{j,t}, Z^c_{j,t}, V^e_{jt}, B^c_t} \Lambda^c_{t+1}\left[(1-\theta)(R^c_{kt+1}Q^c_t Z^c_{j,t} + RER^{-1}_{t+1}R_{b,t}V^e_{jt} - R^c_t B^c_t) + \theta J^c_{jt+1}\left(N^c_{j,t+1}\right)\right]$$

The bank faces the incentive compatibility constraint:

$$J_{jt} \geq \kappa^c_V RER^{-1}_t V^e_{jt} + \kappa^c Q_{c,t} Z^c_{j,t};\ \kappa^c_V, \kappa^c > 0$$

where we allow for the possibility that the ICC is affected asymmetrically by the different types of assets (e.g. Gertler et al., 2010).

First order conditions

The FOCs of the core country bank problem are:

$$Z_{j,t}:\ E_t\Omega^c_{t+1|t}\left(R^c_{kt+1} - R^c_t\right) = \kappa^c\gamma^c_t \tag{3.14}$$

$$V^e_{j,t}:\ E_t\Omega^c_{t+1|t}\left(R_{b,t}\frac{RER_t}{RER_{t+1}} - R^c_t\right) = \kappa^c_V\gamma^c_t \tag{3.15}$$

and the envelope condition

$$J^{c\prime}_j\left(N^{c,s}_t\right)(1-\gamma^c_t) - E_t\Omega^c_{t+1|t}R^c_t = 0 \tag{3.16}$$

3.4. Macroprudential policy

As argued earlier a number of MaP measures have the ultimate effect of influencing portfolio decisions of banks by altering the costs and benefits of intermediation. As in this paper we abstract from the details concerning the implementation of particular measures, it suffices to discuss the implication of choosing a tax/subsidy on the return to capital. Doing so has the advantage of working directly with the source of the financial inefficiency: the wedge between the return on capital and the deposit rate. Abstracting from other frictions, the inefficiency wedge consists exclusively of credit spreads. In the efficient economy, these spreads should be zero all the time, and financial intermediation should reduce to an immaterial "veil" on the real economy. This outcome is not necessarily always feasible in a decentralized economy. We thus use as our welfare benchmark the constrained efficient allocation. This reflects the fact that the agency problem affecting the banking sector cannot be eliminated *ex-machina*. For the sake of realism, furthermore we avoid the assumption that policy interventions are costless. This could be done by imposing some *ad hoc* costs of intervention (see for instance Gertler and Karadi, 2011 or Dedola et al., 2013). As an alternative approach, we assume that either changes in the capital tax/subsidy must be met by changes in the distortionary labor tax/subsidy, or that they must be met with a combination of changes in public debt and changes in distortionary labor taxes and lump-sum taxes, so as to ensure the stationarity of public debt.

We study policies under commitment. The global benevolent policymaker chooses the constrained efficient allocation in order to maximize the expected present value of the population-weighted sum of household utilities (see equation (3.1) and the core-country counterpart), in the cooperative case, or the domestic households' utility in the non-cooperative (Nash) equilibrium. The policymaker discounts the future at the same rate as households.

The policymaker has to deal with two dimensions of the financial distortion: the long run dimension (mean distortion) and the short run dimension (volatility). We approach this problem in the following way. We compute the long-run taxation as the one that solves the non-stochastic steady-state of the Ramsey cooperative problem and of the non-cooperative problem. Then, depending on how we compute the time-varying optimal taxation, we use either measure of long run taxation.

Concerning the time-varying taxation, we study the Ramsey cooperative policy and the open-loop Nash optimal policies. This approach was also followed by Coenen et al. (2009) and Banerjee et al. (2016).[16] Fudenberg and Levine (1988) discuss the game-theoretic foundations of this concept as opposed to the closed-loop equilibrium. In the game-theory literature, these equilibria differ in terms of the information set available to players. Open-loop equilibria are typically defined as equilibria of games in which players know only the initial value of state variables, and on the basis of this define the whole sequence of actions, which are then played "by the clock" (see for instance Cellini and Lambertini, 2004 and Başar and Olsder, 1998). This equilibrium concept is typically preferred on computational grounds, which motivate our choice too. Closed-loop equilibria refer to a larger set of games in which actions are state dependent, although the information set can contain different portions of the sequence of states, or of observables. In our policy game the sequence of actions is state contingent. Yet the sequence of actions taken by the other policymaker is not observed. This is clearly a limitation of the open-

[16]See Coenen et al. (2009) for a discussion of this equilibrium in a DSGE modeling context.

loop equilibrium, as policymakers in our model never learn about (or take advantage of) the link between state variables and policy actions of the other policymakers.[17] Contrary to monetary policy games, in which the choice of policy rates as "instruments" would lead to non saddle-path equilibria (for reasons akin to the lack of saddle-path equilibrium under pegged nominal rates, see for instance Sargent and Wallace, 1975), in the case of taxes/subsidies this problem does not emerge. This allows us to make the rather appealing assumption that each policymaker takes the whole future path of the other country MaP instrument as given. Importantly, each policymaker takes into account the global effects of their choice on all the other endogenous variables.

3.4.1. Sovereign budget constraint

The first specification of public finances that we consider imposes a balanced budget period by period. This assumption implies that

$$\alpha \tau_{k,t}^{j} + (1-\alpha)\, \tau_{l,t}^{j} = 0;\ j = \{e, c\} \tag{3.17}$$

While this assumption is more parsimonious and transparent, it implies a larger cost of intervention. As a way to control this cost, we consider a second, more convoluted specification. This alternative specification allows for sovereign debt dynamics. In this case the policymaker can issue sovereign debt (S_t) and optimally choose the level of deficit necessary to conduct MaP. Debt is purchased entirely by domestic households, and thus pays the same return as deposits. We assume that the public sector cannot hold a long run positive net-asset position. This implies that, in the long-run, if banks are subsidized, the necessary revenue has to come from other taxes. In particular, the public budget constraint under these assumptions is

$$S_t^j + \tau_{l,t}^j W_t H_t^j + \tau_{k,t}^j r_{k,t}^j K_{t-1}^j + T_t^j = R_{t-1}^j S_{t-1}^j;\ j = \{e, c\} \tag{3.18}$$

where T_t^j is a lump-sum tax.

For a stationary equilibrium to exist, in the presence of public debt dynamics, assumptions must be made concerning the cyclical behavior of taxes. Given the focus of this paper we assume that capital taxes are chosen optimally, while labor taxes and the lump-sum tax are set (*ad hoc*) to ensure stationarity. While *ad hoc*, this assumption is not particularly restrictive, as we allow for different assumptions concerning the speed of mean-reversion of public debt. In particular

[17]The Ramsey optimal policy as well as the Nash open loop is implemented using Dynare (Juillard, 1996) together with the Dynare-compatible toolbox (OPDSGE) used for example by Coenen et al. (2009) and Banerjee et al. (2016). The code is available at `https://sites.google.com/site/giovannilombardohomepage/`. See also Bodenstein et al. (2014) who recently developed a toolbox with similar features.

we assume that

$$\widehat{\tau}^{j}_{l,t} = (1-\ell)\,\kappa^{j}_{SD}\left(\widehat{S}^{j}_{t}\right);\ j = \{e, c\} \tag{3.19}$$

and

$$\widehat{T}^{j}_{t} = \ell\kappa^{j}_{SD}\left(\widehat{S}^{j}_{t}\right);\ j = \{e, c\}. \tag{3.20}$$

where $\ell \in (0,1)$. In the limit case of $\ell \to 1$ this set-up is equivalent to allowing for lump-sum taxes: due to Ricardian equivalence, public debt would have no material implications.[18] If $\kappa^{j}_{SD} \to \infty$, we are back to the assumption of balanced budget period by period. Allowing for public debt, thus, gives us a way to control the social cost of MaP interventions.[19]

3.5. Cooperative and non-cooperative equilibria

Formally, we can define the two equilibria as follows.

Definition 1 (Cooperative policy problem). *Under the cooperative policy (CP) problem both policymakers choose the vector of all endogenous variables Θ_t, and the policy instruments $\tau^{e}_{k,t}$ and $\tau^{c}_{k,t}$ in order to solve the following problem*

$$\mathcal{W}_{CP,0} \equiv \max_{\Theta_t, \tau^{e}_{k,t}, \tau^{c}_{k,t}} \left[n\mathcal{W}^{c}_{0} + (1-n)\,\mathcal{W}^{e}_{0}\right] \tag{3.21}$$

subject to

$$E_t F\left(\Theta_{t+1}, \Theta_t, \Theta_{t-1}, \tau^{e}_{k,t+1}, \tau^{c}_{k,t+1}, \tau^{e}_{k,t}, \tau^{c}_{k,t}, \tau^{e}_{k,t-1}, \tau^{c}_{k,t-1}, \Phi_{t+1}, \Phi_t, \Phi_{t-1}; \varphi\right) = 0 \tag{3.22}$$

where Φ_t, is the vector of all exogenous shocks, φ is the parameter measuring the importance (loading) of the exogenous shocks in the model ($\varphi = 0$ implies that the model is deterministic) and $F(\cdot)$ is the set of equations representing all the private sector resource constraints, the public-sector constraints and budget rules, and all first-order conditions solving the private sector optimization problems.

Furthermore, the policymaker is subject to the "timeless-perspective" constraint, which defines the $t = 0$ range of possible policy interventions (see Benigno and Woodford, 2011).

The first order conditions of this problem can be defined as

$$E_t \mathcal{P}\left(\Theta_{t+1}, \Theta_t, \Theta_{t-1}, \tau^{e}_{k,t+1}, \tau^{c}_{k,t+1}, \tau^{e}_{k,t}, \tau^{c}_{k,t}, \tau^{e}_{k,t-1}, \tau^{c}_{k,t-1}, \Phi_{t+1}, \Phi_t, \Phi_{t-1}, \Gamma_{t+1}, \Gamma_t, \Gamma_{t-1}; \varphi\right) = 0 \tag{3.23}$$

[18] Recall that households, who invest in sovereign debt, have access to the "risk-free" rate, i.e. the return on sovereign debt.

[19] Ideally we should not constrain labor and lump-sum taxes to follow a particular rule. For numerical tractability reasons, and to ensure local stationarity, we have to resort to this mildly-restrictive assumption.

where Γ_t is a vector of Lagrange multipliers related to the constrained maximization problem of the policymaker.

Definition 2 (Cooperative Equilibrium)**.** *The cooperative equilibrium is the set of endogenous variables (quantities and relative prices) and policy instruments, such that given any exogenous process for Φ_t equations* (3.22) *and* (3.23) *are jointly satisfied $\forall t$.*

Definition 3 (Non-cooperative policy problem)**.** *Under the non-cooperative policy (NP) problem , each policymaker chooses independently all endogenous variables and her own instrument in order to solve the following problem*

$$\mathcal{W}^{j}_{NP,0} \equiv \max_{\Theta_t, \tau^{j}_{k,t}} \mathcal{W}^{j}_{0} : \; j = \{e, c\} \tag{3.24}$$

subject to

$$E_t F\left(\Theta_{t+1}, \Theta_t, \Theta_{t-1}, \tau^{e}_{k,t+1}, \tau^{c}_{k,t+1}, \tau^{e}_{k,t}, \tau^{c}_{k,t}, \tau^{e}_{k,t-1}, \tau^{c}_{k,t-1}, \Phi_{t+1}, \Phi_t, \Phi_{t-1}; \varphi\right) = 0 \tag{3.25}$$

Furthermore, the policymaker is subject to the "timeless-perspective" constraint, which defines the $t = 0$ range of possible policy interventions.

The first order conditions of this problem can be defined as

$$E_t \mathcal{P}^{j}\left(\Theta_{t+1}, \Theta_t, \Theta_{t-1}, \tau^{e}_{k,t+1}, \tau^{c}_{k,t+1}, \tau^{e}_{k,t}, \tau^{c}_{k,t}, \tau^{e}_{k,t-1}, \tau^{c}_{k,t-1}, \Phi_{t+1}, \Phi_t, \Phi_{t-1}, \Gamma^{j}_{t+1}, \Gamma^{j}_{t}, \Gamma^{j}_{t-1}; \varphi\right) = 0 \tag{3.26}$$

where Γ^{j}_{t} is a vector of Lagrange multipliers related to the constrained maximization problem of the j policymaker, where $j = \{e, c\}$.

Definition 4 (Nash Equilibrium)**.** *The non-cooperative (Nash) equilibrium is the set of endogenous variables (quantities and relative prices) and policy instruments, such that, for any exogenous process for Φ_t, equations* (3.22) *and* (3.26)*, both for $j = e$ and $j = c$, are jointly satisfied $\forall t$.*

3.6. Second order approximation of the welfare gains

We solve the model using perturbation methods, to first order of accuracy for the evaluation of the impulse response functions, and to second order of accuracy for the evaluation of welfare.[20]

Definition 5 (Exact welfare gain)**.** *We define the welfare gain from cooperation as*

$$Gain \equiv \mathcal{W}_{CP,0} - \left(n\mathcal{W}^{e}_{NP,0} + (1-n)\,\mathcal{W}^{c}_{NP,0}\right) \tag{3.27}$$

[20] For the definition and application of perturbation methods see Judd (1998), Holmes (1995), Schmitt-Grohé and Uribe (2004), Lombardo and Sutherland (2007) and Lombardo and Uhlig (2014).

From this definition, it follows that taking the second-order Taylor expansion of equation (3.27) around the point $\varphi = 0$, i.e. around the deterministic steady state, leads to the following

Definition 6 (Second-order accurate welfare gain)**.** *The second-order accurate gain deviates from the exact gain by a term of order three or larger:*

$$\widetilde{Gain} \equiv Gain - \mathcal{O}\left(\varphi^3\right) \tag{3.28}$$

From this definition, and from the asymptotic property of the Taylor expansion (Holmes, 1995), it is clear that our measure of the gains from cooperation can be arbitrarily accurate as $\varphi \to 0$.

Note in particular that if $\varphi = 0$ the two economies (under Nash and cooperative equilibria) are at their long-run equilibrium (and our solution is exact). This equilibria do not coincide with the maximum steady state welfare, but rather with the steady state of the maximum welfare that the policymakers can achieve. This distinction is important and is analogous to the principle of the "modified golden rule" in the neo-classical growth model (King and Wolman, 1999). In this respect our approximation point differs from that of Clarida et al. (2002).

4. Results

4.1. Parametrization and empirical fit

The main objective of our parametrization is rather minimalist, consisting of generating second moments that are not "too far" from the empirical counterparts, in the spirit of calibration exercises. By fulfilling this weak criterion we can still hope that impulse-responses and welfare outcomes be commensurate to what could be observed in reality. We believe that setting an empirical higher bar would be asking too much to our relatively simple model. This said, the quantitative results should be interpreted only as suggestive of the order of magnitude of MaP effects. Our parametrization strategy is twofold: on the one hand we aim at choosing parameter values that are within the ballpark offered by the current related literature; on the other hand we aim at generating moments that are not too far from those empirically observed.

The outcome of our parameter selection is presented in Table 3. Under this parametrization, and assuming that no MaP intervention takes place, Tables 4 and 5 display the fit of the model relative to the data. As for the long run (Table 4) We target the share of investment in GDP: a key variable in our model where financial frictions affect capital accumulation directly. The other two key variables in the financial channel are credit spreads and leverage. In both cases our model delivers measures that are well within historical data. As for the volatility of key variables of our model (Table 5) our relatively simple set-up is able to deliver standard deviations that

Table 3: Parameter values used in the simulations

Definition	Label	Value	Definition	Label	Value
EME size	n	0.15	Adjustment cost of investment	ψ	2
Time preference factor	β	0.9926	ICC parameter	$\kappa^c = \kappa^c_V = \kappa^e_V$	0.3
Demand elasticity	σ_p	6	Tax rule parameter	$\kappa^e_{Htx} = \kappa^c_{Htx}$	0.2
Exit rate of bankers	$\theta_e = \theta_c$	0.9	Share of lump-sum tax	ℓ	0.5
Capital share	α	0.3	Shock persistence	$\rho_{A,e} = \rho_{A,c} = \rho_{\xi,e} = \rho_{\xi,c}$	0.85
Home bias EME	v_e	0.83	Standard dev. TFP shocks	$\sigma_{Ae} = \sigma_{Ac}$	0.007
Home bias AE	v_c	0.97	Standard dev. capital quality shocks	$\sigma_{\xi_c} = \sigma_{\xi_e}$	0.005
Capital depreciation	δ	0.025	Household risk aversion	σ	1
Transfer rate to new bankers	$\delta_{T,e} = \delta_{T,c}$	0.01			
Trade elasticity	η_p	1.5			

Table 4: Steady state ratios

	Model	Data
Spread AE (annual bp)	306	221–660†
Spread EME (annual bp)	548	400–748††
Leverage AE	5.83	6.14 – 12.02♩
Leverage EME	5.56	4.46 – 7.94♩
$\frac{Investment}{GDP}$ AE	24%	24%♩♩
$\frac{Investment}{GDP}$ EME	25%	24%♩♩

Sources: † BofA Merrill Lynch US Corporate BBB Option-Adjusted Spread vs. High Yield (from FRED, Federal Reserve Bank of St. Louis), period: 1999.01 – 2016.10; †† Bank of America, Merrill Lynch Emerging Markets Corporate Plus Index Option-Adjusted Spread vs. High Yield (from FRED, Federal Reserve Bank of St. Louis), period: 1999.01 – 2016.10;♩ World Bank, one-stdev confidence interval of total bank-assets over bank-equity minus 1; ♩♩ World Bank, cross country averages; Period:1980 – 2014. Emerging economies: Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Czech Republic, Estonia, Greece, Hong Kong SAR, China, Hungary, India, Indonesia, Kuwait, Latvia, Lebanon, Lithuania, Malaysia, Mexico, Nigeria, Peru, Philippines, Romania, Russian Federation, Saudi Arabia, Serbia, South Africa, Thailand, Turkey, Ukraine, United Arab Emirates, Uruguay, Vietnam. Advanced economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States.

are remarkably close to the empirical counterparts. In light of the relatively good fit our model (albeit along a minimalist set of criteria) we can take the numerical results of our experiments as suggestive of the possible quantitative implications of alternative MaP strategies.

Table 5: Standard deviations (no MaP)

Variable	Model	Data:♩ average (stdev)
Growth GDP EME	0.87	1.17 (0.57)
Growth GDP AE	0.74	0.74 (0.35)
Growth Investment EME	3.7	7.48 (21.48) [median = 3.39]
Growth Investment AE	2.6	2.61 (1.20)
Spread EME	510	202 − 391
Spread AE	91	110 − 275
Real Exchange Rate †	2.4	EME: 7.07 (4.84); AE: 3.72 (1.89)

♩ Sources: World Bank and BIS.
† The empirical counterpart is the real effective exchange rate.

4.2. The frictionless economy

In this section we describe the response of the economy to TFP shocks as well as capital quality shocks in the absence of frictions. In particular i) prices are flexible and markets are competitive, ii) banks are redundant as the ICC never binds and the return on capital is identical to the "risk-free" rate. Results are shown in Figures 3 and 4, dashed line.

The response of the economy to these shocks is rather standard. A positive TFP shock in the EME has expansionary effects domestically and abroad, with a stronger local effects. The real interest rate falls, following the path of household saving (consumption). Accordingly with the asset-pricing equations, the return on capital, which unexpected response on impact is positive, turns negative and approaches its long run equilibrium from below. The positive impact response is sufficiently large to generate an increase in asset prices, which in turn drives up investment. The real exchange rate of the country experiencing the TFP increase depreciates, reflecting the path of the difference between EME and AE real interest rates. The same is true for EME banks debt, which in absence of frictions is immaterial for real allocations and shown only for comparison reasons. It's dynamics reflect the amount of saving that need to be channeled to EME investors, whereas the net foreign-asset position (NFA) reflects the total international distribution of global savings. As for the latter, after a positive impact implying a net accumulation of assets by the EME, a protracted decumulation of assets ensues. TFP shocks in the AE generate large spillovers to the EME. The most interesting effect of this shock, compared to the one taking place in the EME, is that now investment co-moves positively, while in the former case arbitrage by center-country bank generates a fall in center-country investment (matched by an increase in loans to the EME).

The capital quality shock has properties that are between a TFP shock (both enter the production function) and an investment shock (the capital quality shock amounts to a change in depreciation of capital). The latter dimension explains the dynamics of investment upon a positive capital quality shock. As effective capital becomes more abundant, less capital accumulation is necessary: domestic investment falls. Despite this reduction in demand, GDP tends to increase (decreases slightly on impact), as the existing resources become more productive. Since the expected return on capital is equalized across countries by arbitrage, the different dynamics of asset-prices is due to the different path of the capital quality shock (constant in the country not hit by the shock). The country experiencing the shock goes through a contraction in asset prices and investment, while the opposite is true for the other country. This notwithstanding output in the two countries is strongly positively correlated.

Against this background of responses of the frictionless world the next sections discuss the response of the economies to shocks under financial frictions.

4.3. Introducing financial frictions

We now introduce financial frictions assuming that the ICC constraint is always binding, although the degree to which this constitutes a burden for banks varies endogenously in response to shocks. In particular we assume that $\kappa^c = \kappa^c_V = \kappa^e = 0.3$. Results are shown in Figures 3 and 4, solid line.

Introducing financial frictions has strong implications for the response of the economy to shocks. The most notable effect is the strong cross country spillover, already discussed by Dedola and Lombardo (2012) (DL). The rationale for the heightened spillovers rests on the cross-country arbitrage of returns by financially constrained intermediaries. In the frictionless environment discussed above, arbitrage ensured the equalization of returns on capital: the expected return on capital is equalized across countries by frictionless banks, while the real rate (adjusted for the real exchange rate) is equalized by households.[21] Without financial frictions, though, the spillovers on asset prices and returns is milder than under financial frictions. With financial frictions two further factors are at play. First, the country hit by the shock experiences a variation in credit spreads that generally induces an amplification of the responses. This channel implies a stronger spillover due to the amplified reaction of endogenous variables to shocks. Second, financial intermediation generates a direct channel through which domestic lending rates are affected. In our set-up, contrary to DL, each bank invests directly in it's own capital. Nevertheless, the center-country bank can arbitrage differences in the return on it's

[21] This would be the case also under incomplete markets. Complete markets equalize the ex-post real return.

own capital and the lending rate offered to EME banks. These in turn relate the return on their own capital to the cost of funds. So, for example, an increase in the credit spread in the core country induces an increase in the cost of borrowing for EME banks. This reduces their franchising value, forcing them to seek higher returns domestically. Eventually credit spreads increase in the EME, even keeping other factors like trade or households saving fixed. As pointed out by DL, not all shocks generate positive co-movements when financial frictions are present. In our model, financial frictions tend to magnify the international spillovers, in particular strengthening the co-movement of GDP, as Figures 3 and 4 shows. Interestingly, openness and financial frictions have little bearing on the response of domestic GDP to domestic TFP shocks (solid line), compared to the frictionless case (dashed line).

Much more marked is instead the domestic effect of capital quality shocks, in particular for the EME. Spillovers from the AE to the EME can be so strong to induce larger responses in the latter than in the former, i.e. the source of the disturbance, as the set of responses to capital-quality shock in AE demonstrate. As discussed by Gertler and Karadi (2011), the capital quality shock has marked financial-shock features, as it affects directly the asset side and profitability of the banking sector. This explains why this shock, coupled with financial frictions, can generate responses that differ more markedly from the frictionless case.

Having confirmed that financial frictions can generate large international spillovers in our core-periphery model of financial integration, it is now time to study whether public intervention can mitigate the adverse consequences of the agency problem affecting the financial sector. In particular we look for policies that can reduce the excess volatility generated by financial frictions as well as boost capital formation, hindered by the higher cost of capital.

4.4. The effect of optimal cooperative Ramsey MaP

We start by considering the simplest fiscal scenario in this and the next sections. Under this scenario the public budget must be balanced period by period. In particular, in this section we study the best (constrained) equilibrium, i.e. the one where perfect cooperation across countries is feasible by appropriately setting the path of the (stylized) MaP policy instruments. This scenario is tantamount to a world where a global Ramsey policymaker can choose all policy instruments in order to maximize global welfare, and thus redistribute the gains to make all agents equally better off.

The policymaker tries to affect both the long-run cost of capital as well as its response to shocks. The long run dimension of policy is computed as the "MaP Modified Golden Rule" (MaPMoGR), i.e. the policy that satisfies the first-order conditions of the dynamic policy problem in the long run. This perspective is identical to that discussed by Khan et al. (2000), King and Wolman (1999), and Woodford (2003) for optimal monetary policy. Importantly, the long run level of welfare is not the same as that obtained by choosing the optimal policy in the non-stochastic steady state of our model. The optimal MaPMoGR implies significant long-run subsidies, as shown in Table 6. We postpone the discussion of the whole table to the next section.

Figure 5 and 6 compares the response of the economy to our four shocks with and without MaP policy (solid and dashed lines respectively). The panels show that the tax policy can effectively dampen the response of the economy to shocks, although it cannot fully eliminate the effect of financial frictions. Particularly notable though is the mitigation of the cross-country spillovers. This is especially evident for investment and for the core country. For the EME economy though, the tax policy is not as effective, due to the double layer of financial frictions.

The cooperative policymaker appears to be more concerned with cross-country financial spillovers than with the effect of the financial multiplier on domestic shocks. In particular, under TFP shocks the spread-channel of cross-country spillovers appears fundamentally altered if not totally severed. Since the agency problem cannot be fully circumvented by the Ramsey policymaker, under the assumed set of instruments, the optimal response does not coincide with frictionless response to shocks seen in Figures 3 and 4.

In order to implement the optimal allocation, the policymaker has to engineer an adjustment of taxes and subsidies (recall that to first order the labor tax is just the opposite of the capital tax). Figures 5 and 6 shows that a positive TFP shock in EME calls for a sudden increase in the subsidy on capital (and thus an increase of the tax on labor) followed by a persistent reduction in subsidies (the tax variable is in level deviation from it's steady-state value). Since investment decisions are driven by forward looking agents, the expected reduction in subsidies dampens the expansionary effect of TFP. For example, EME investment response is now closer to the first-best seen in Figures 3 and 4. The core country, on the other hand, tries to mitigate the contraction in investment by further increasing the capital subsidies (at the cost of higher labor taxes). The spread in the core country increases by less.

A TFP shock in the core country does not produce a response of taxes exactly symmetric to the previous case, reflecting the fact that this shock has a stronger positive spillovers to the EME. Thus, in this case, in order to reduce the expansionary spillover, the EME tax rate, after the initial period, needs to increase by more, dampening the contraction in EME spreads. The tax rate in the AE follows the pattern seen above for the EME country: an initial increase in subsidies followed by a protracted decrease.

Upon a capital quality shock in the EME, capital tax rates in both economies mimic basically the response of GDP: an initial increase in taxes is immediately followed by a reverse adjustment. The expected path of taxes lies behind the behavior of spreads (which are forward looking variables). When the capital quality shock hits the AE, the response of taxes ceases to be symmetric, at least on impact: a protracted increase in subsidies takes place in both economies, while only the AE experiences a short run increase in taxes, consistent with the short-run increase in GDP. The expected path of the subsidies induces a dramatic dampening of spreads.

4.5. The effect of open-loop optimal Nash MaP

We have seen that a global MaP policymaker could engineer movements in the effective return on capital that mitigate the undesired effects of cross-country spillovers in the presence of financial frictions. An obvious related question is to which extent the optimal allocation can be reproduced by self-oriented policymakers. In the monetary economics literature there is a long tradition of assessing the gains from monetary policy cooperation, as discussed in the introduction. The typical result is that self-oriented monetary policies can come very close to the cooperative equilibrium. This result has been confirmed by Banerjee et al. (2016) on the basis of the same model used here. The main message of that paper was that the gains from cooperation are small, at least to the extent that policymakers do take into account financial dimensions. In this section we conduct a similar analysis but from the point of view of MaP policies.

The first difference between the Nash equilibrium and the cooperative equilibrium concerns the non-stochastic steady state optimal subsidies. As Table 6 shows, lack of cooperation forces the EME policymaker to subsidize much more heavily their firms, despite the relatively unchanged subsidy in the core country. The main driver of the different constellation of subsidies under Nash appears to be independent of financial frictions. To gain intuition, Table 6 compares also the long-run subsidies under cooperation and non-cooperation without financial frictions (IRBC). In the latter case subsidies are computed under two alternative assumptions concerning the size of the two economies: symmetric and asymmetric (as in the baseline model). By comparing these cases we can conclude that the bulk of the difference between cooperative and non-cooperative long-run subsidies can be ascribed to differences in country size, whereas the overall level is explained by financial frictions.

Figures 7 and 8 compare the response of the economy under the Nash equilibrium (solid line) the cooperative equilibrium (dashed line) and the no-intervention case (dot-dashed line). The differences between the responses is striking compared to the negligible differences obtained by Banerjee et al. (2016) for the monetary policy equilibrium. In particular the Nash policies

Table 6: Long-run subsidies, with and without financial frictions

τ_k (MaP)†				
	Cooperative		Nash	
	EME	AE	EME	AE
No public debt	-45.3%	-21.52%	-62.74%	-24.88%
With public debt††	-49.8%	-23.2%	-63.2%	-26.4%
		Size-Symmetric IRBC		
No public debt	0	0	-9.5%	-9.5%
		Size-asymmetric IRBC		
No public debt	0	0	-22.4%	-2.2%

†These values are obtained solving the dynamic Ramsey model in the non-stochastic steady state, as opposed to choosing optimal subsidies in the static version of the economy. See the discussion in Woodford (2003) for the monetary-equilibrium counterpart. Starting from an equilibrium without MaP in which the incentive compatibility constraint is binding, the latter is still binding under the large subsidies.
†† Lump-sum taxes only in the short run as discussed in the text.

fall short of delivering to the EME the same degree of insulation from foreign spillovers. This is particularly evident for EME GDP under AE shocks and for AE investment under EME shocks.

These results are brought about by tax dynamics that are markedly different between the two types of equilibria (cooperative and non-cooperative). For example, upon an expansionary TFP shock in the AE, the EME does not reduce subsidies under Nash by as much as under cooperation. On the contrary, the AE is forced to reduce subsidies by much more. Importantly, while these differences are not particularly material for spreads, they are reflected in the response of EME GDP (in particular). By not reducing subsidies as much, labor taxes have to remain relatively higher, which hinders the expansion of EME GDP. Another example of how the different tax dynamics implied by the two different equilibria affect responses is given by the case of a capital quality shock in the EME. Optimal cooperative investment in the AE expands, while it contracts under the Nash equilibrium. This behavior is driven by spreads. Under the Nash equilibrium they follow more closely the no-intervention case, and thus increase in the AE. Under cooperation they decrease boosting the demand for capital.

4.6. Reducing the cost of MaP intervention

In this section we analyze the cooperative and non-cooperative responses of policymakers to shocks under the assumption that MaP authorities can issue debt securities. In particular we assume that $\kappa^e_{SD} = \kappa^c_{SD} = 10\%$.

Figures 9 and 10 are obtained assuming that in the short run 50% of the adjustment in the deficit necessary to bring debt back to its steady-state value is born by lump-sum taxes. Even in this case Nash and cooperative policies generate different adjustment patterns. These figures show also that the resource constraints faced by the MaP authority are important in determining the adjustment path of the economy. This admittedly rather obvious fact raises an important caveat in translating our theoretical results to the real world, where feasibility and implementability constraints are likely to drive even larger gaps among alternative policy schemes.

4.7. Welfare gains from cooperation

The previous three sections have shown the response of the economy to shocks under both the cooperative and non-cooperative (open-loop) equilibria. The sizable differences in the impulse responses under the two policies are reflected in the welfare gains from cooperation, as Table 7 shows. The table displays the welfare gains of cooperation relative to the non-cooperative policy, both globally and for each country, for two relative sizes of the EME. Gains are expressed in percentages of permanent consumption (see the footnote to the table for details).

We first consider global welfare. The second column of Table 7 shows that the gains are large under our baseline parametrization, and in particular under either assumption concerning the financing sources of the intervention. The quantitative effects depend, to different extents, on all the parameters of the model. For the sake of conciseness, though, we focus on only two key parameters: country size and relative credit spreads. In the baseline case ($n = 0.15$), global consumption can be increased by about 1.12% quarterly, if sovereign debt can be issued, while the gains are somewhat smaller when MaP intervention must be financed with distortionary labor taxes (0.99%). Under the baseline relative credit spreads, increasing the size of the EME changes the overall size of the gains, as well as the ordering of the gains, across the fiscal options.

Comparing the global gains with their distribution across countries (third and fourth columns) we observe a large degree of heterogeneity. While the emerging economy always greatly gains from cooperation, the larger center country either gains only marginally or loses out. In the latter case, the cooperative equilibrium would generate a Pareto improvement only with transfers of gains from the periphery to the center. The large gains from cooperation accruing to the peripheral economy are due to the strong financial dependence of the smaller economy on the financial intermediation of foreign banks. Inefficient fluctuations in foreign credit spreads spill over to the emerging economy via the domestic, inefficient financial sector. The core country can help the smaller economy by reducing the spillover, though with little gain for itself, consistently with the impulse-response analysis. Indeed, when these interventions are costly, doing so harms consumers in the core country. In this case, a self-oriented policy would be preferable in the absence of transfers.

If the core country were confronted with a larger financially dependent economy ($n = 0.45$),[22] its incentive to act cooperatively would decrease, as relatively larger interventions would be needed. The gains would be comparatively smaller for the emerging market too. A self-oriented, large EME is more effective in dealing with the spillovers.

Finally, we perturb the parameter of the incentive-compatibility constraints of the banks, keeping the other parameters at their baseline value. In particular we make the agency problem worse for all banks by increasing κ^e and κ^c to 0.35 from the baseline value of 0.3. We then gradually reduce the value of κ^e to the baseline level and compute for each step the welfare gains from cooperation. The results are shown in Table 8. The relative degree of inefficiency (measured by the credit spread) of the EME is a further factor affecting the gains from cooperation. Recall that the small, peripheral economy faces a larger inefficiency wedge between the cost of capital and the deposit rate, as it reflects both the domestic as well as the foreign financial inefficiency. By assuming that the determinant of the EME credit spread is increasingly the core country inefficiency we can generate an EME that is closer to the core country spread.[23] The closer is the EME spread to the AE one, the larger are the gains from cooperation. Although the EME country gains relatively less, the AE loses out less by cooperating too: managing its own spread goes closer to managing the dominant source of global inefficiency. The AE MaP intervention has a stronger positive spillover on the EME when the EME cost of capital is increasingly driven by the core country inefficiency. The latter effect dominates.

5. Conclusion

The Global Financial Crisis has generated renewed interest in MaP policies and their international coordination. Based on a core-periphery model that emphasizes the role of international financial centers, we study the effects of coordinated and non-coordinated MaP policies when financial intermediation is hampered. We find that even when the only frictions in the economy consist of financial frictions and financial dependency, the policy prescriptions in a coordinated world can differ quite markedly from those emerging from self-oriented policy decisions. Optimal MaP policies call for a long-run perspective, whereby financial inefficiencies and the associated

[22]The existence of equilibria in this model depends on combinations of parameters, governing in particular size and financial frictions. For the exactly size-symmetric case ($n = 0.5$) an equilibrium does not exist keeping the other parameters unchanged. For this reason we show a slightly size-asymmetric case, rather than searching over different constellations of parameter values.

[23]The gains are produced starting from a higher inefficiency in order to avoid going too close to the case of non-binding constraint for the EME economy, where numerical problems emerge. The gains appear to be increasingly larger as we approach that limit in the case of public debt issuance, i.e. low intervention costs.

Table 7: Gains from cooperation in percentage of permanent consumption (quarterly values) †

MaP funding	Global Welfare	EME Welfare	AE Welfare
	Baseline country size ($n = 0.15$)		
With public debt	1.12	7.87	0.187
Without public debt	0.99	12.8	-0.68
	Larger EME ($n = 0.45$)		
With public debt	0.49	2.17	-0.50
Without public debt	0.75	3.87	-1.13

†The percentage deviations are computed as follows. Percentage welfare changes in consumption units (relative to steady state) are computed for cooperative and non cooperative policies. Welfare is computed assuming that the initial conditions coincide with the unconditional mean of the state variables under the given policy (i.e. either cooperative or non-cooperative). Changes of consumption in level are then computed using steady-state consumption for each policy. Finally percentages are computed as (one minus) consumption under Nash divided by consumption under cooperation times hundred. These percentages coincide with the permanent compensation (fee if positive) paid to (levied from) consumers in the Nash equilibrium, to make them indifferent between living under non-cooperative or cooperative MaP policies. Global consumption gains are equal to the sum of individual-country consumption gains, weighted by size and consumption shares.

Table 8: Gains from cooperation in percentage of permanent consumption (quarterly values) for different relative EME spread

	With public debt			Without public debt		
EME relative spread†	Global	EME	AE	Global	EME	AE
0.72	0.7709	9.576	-0.3919	1.088	15.19	-0.81
0.7	0.7814	9.454	-0.3656	1.093	15.18	-0.8066
0.67	0.8008	9.337	-0.3297	1.101	15.18	-0.8003
0.64	0.8344	9.229	-0.2788	1.112	15.18	-0.7901
0.61	0.8914	9.138	-0.2038	1.127	15.17	-0.7747
0.58	0.9905	9.085	-0.08596	1.149	15.17	-0.7518

†The relative spread is modified by changing κ^e from $\kappa^e = \kappa^c = 0.35$ to $\kappa^e = 0.30$, in equal steps. Note that the baseline calibration has $\kappa^e = \kappa^c = 0.30$.

higher cost of capital are addressed, as well as for cyclical adjustment of policy instruments, to mitigate the adverse consequences of financial frictions.

We deal with long-run inefficiency by allowing for optimal subsidies to banks in the non-stochastic steady state. These subsidies differ depending on the equilibrium. Cooperative long-run subsidies are smaller for all countries, but particularly so for EMEs. The non-cooperative subsidies are influenced considerably by terms-of-trade incentives, which induce policymakers to manipulate the MaP instrument so to extract more value from the other economy.

The stabilization properties of MaP adjustments in response to shocks show that the cooperative policy aims, in particular, at mitigating cross-country spillovers induced by financial integration. Each economy is markedly more insulated from foreign shocks under cooperative policy. We find that changes in the real exchange rate are a powerful channel through which policy operates. This suggests that extending the analysis to monetary policy could generate a strong interaction between the different types of instruments, a perspective we leave to future research.

In terms of welfare, we find that MaP policy coordination generates sizable gains in our asymmetric model of the world economy. This result contrasts with the literature on monetary policy coordination. We also find that the magnitude of the gains could be strongly asymmetric across countries, and in some cases negative for the larger, financially dominant economies. This asymmetry points to potential political-economy obstacles to the achievement of cooperative outcomes.

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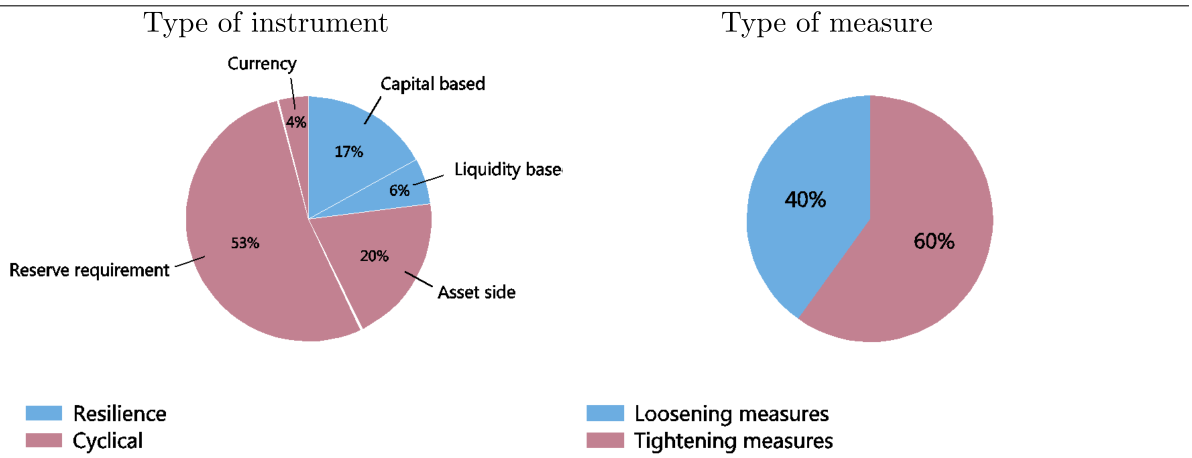
Figure 1: Use of macroprudential instruments. Different kinds of policies



Note: Resilience macroprudential tools include: a) capital based instruments (countercyclical capital requirements, leverage restrictions, general or dynamic provisioning) and b) the establishment of liquidity requirements. Cyclical macroprudential tools consider: c) asset side instruments (credit growth limits, maximum debt service-to-income ratio, limits to banks exposures to the housing sector as maximum loan to value ratio); d) changes in reserve requirements; e) currency instruments (variations in limits on foreign currency exchange mismatches and net open positions). Source: Altunbas et al. (2017).

Figure 2: The world economy

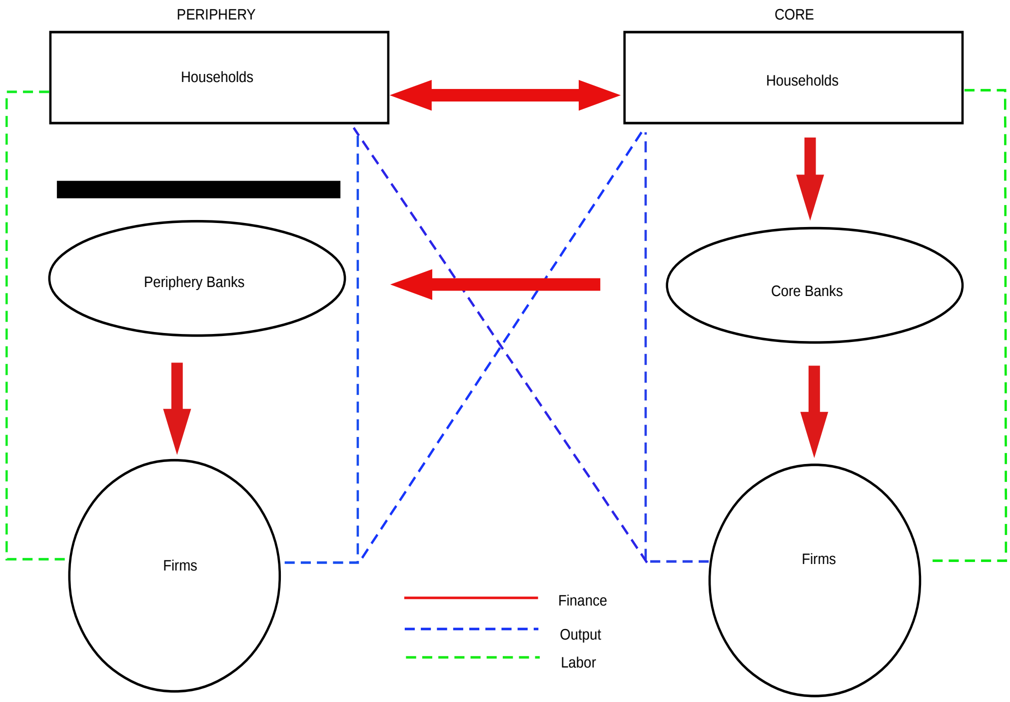
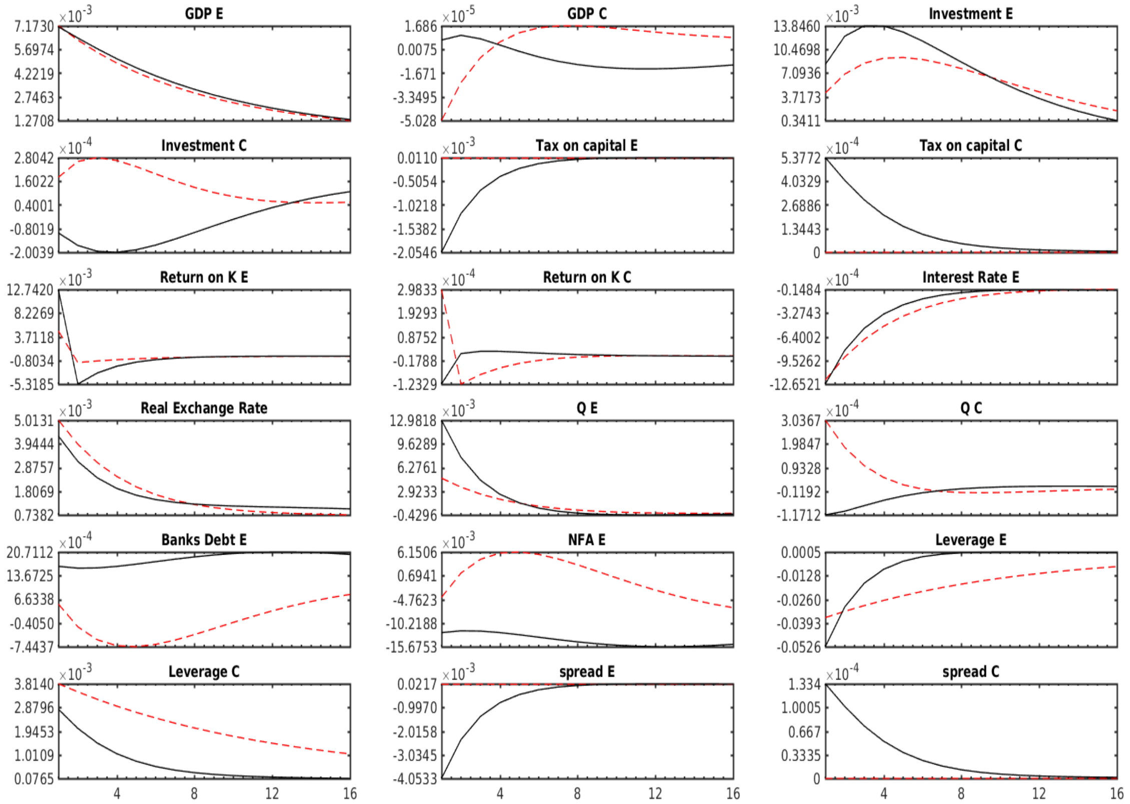


Figure 3: Financial frictions (solid line) vs frictionless economy (dashed line)

TFP shock in EME



TFP shock in AE

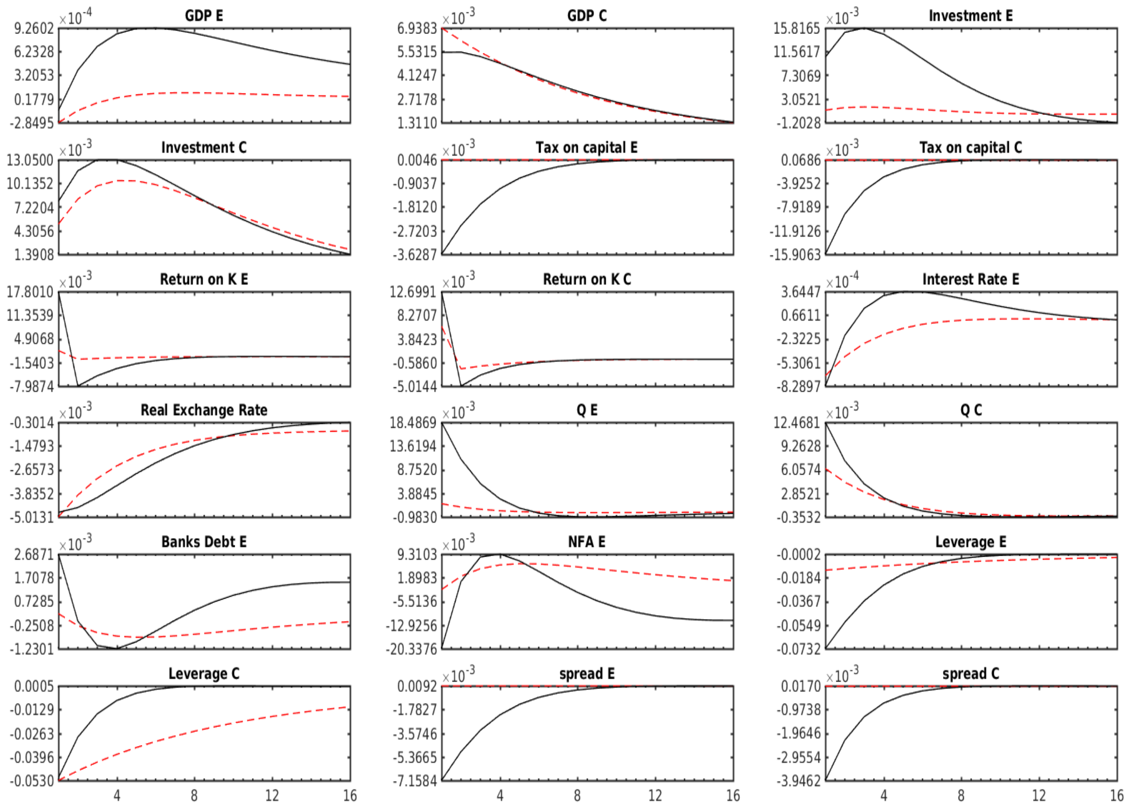
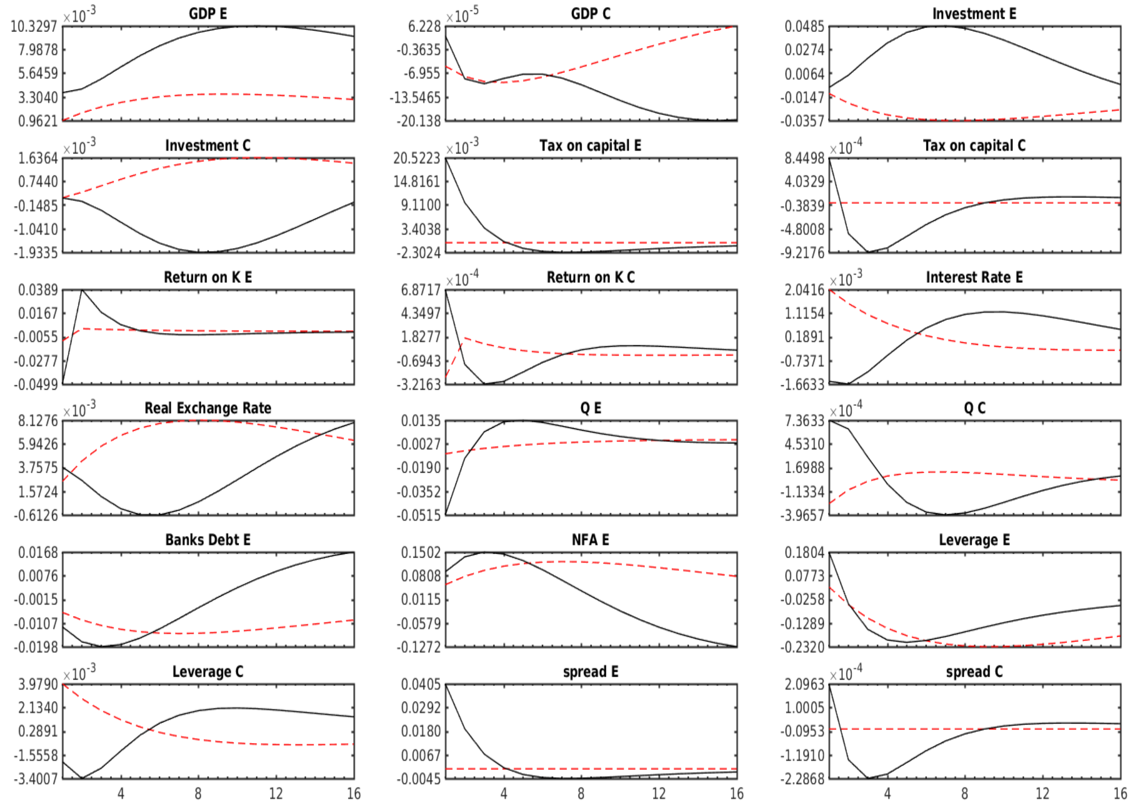


Figure 4: IRFs to capital quality shocks: Financial frictions (solid line) vs frictionless economy (dashed line)

Capital quality shock in EME



Capital quality shock in AE

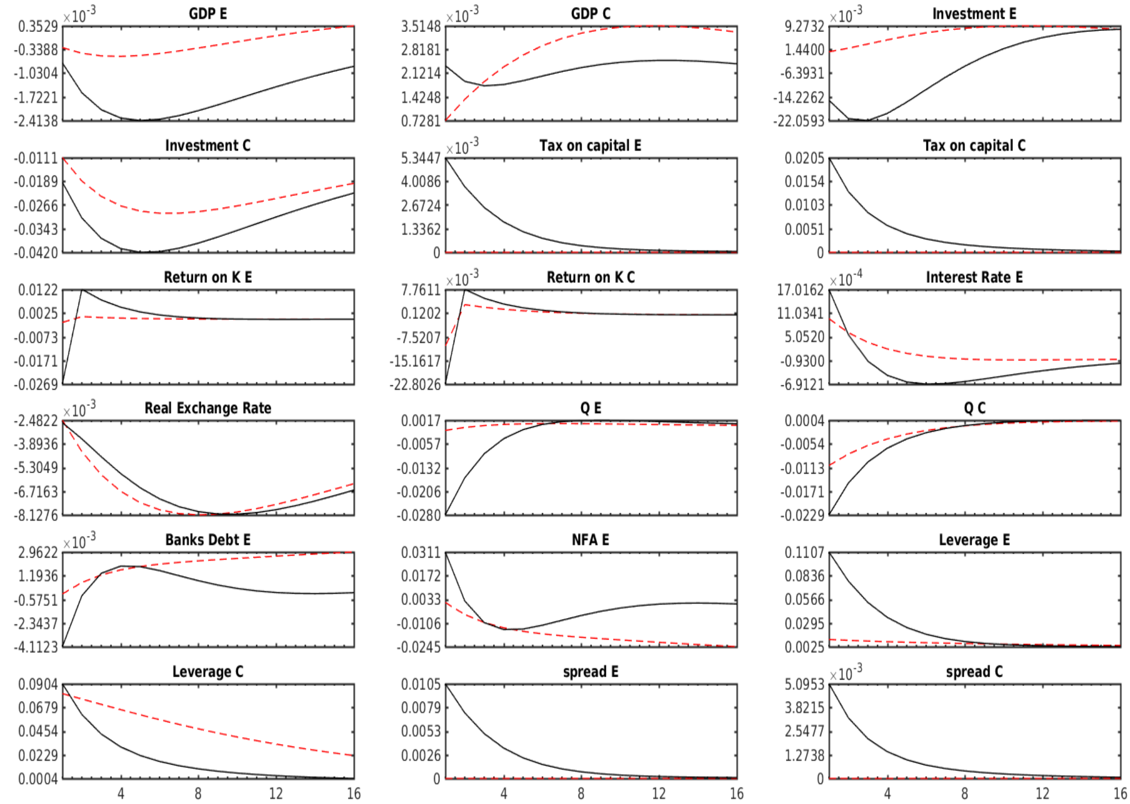
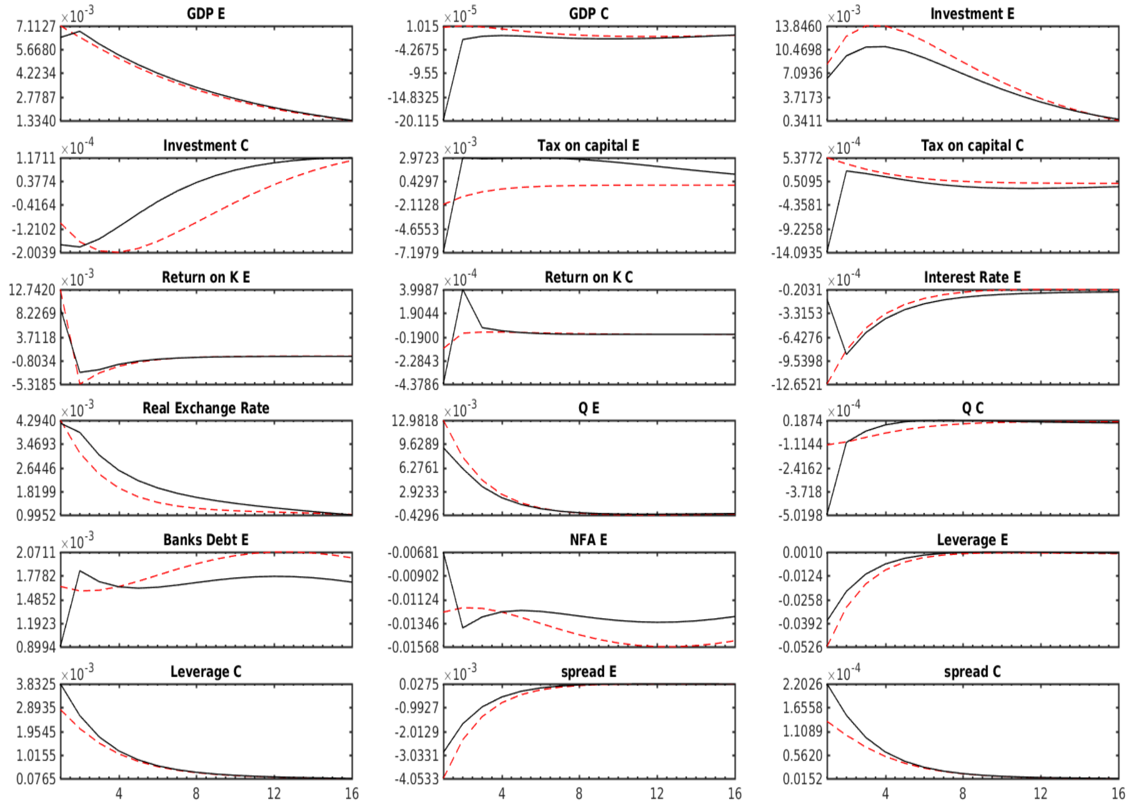


Figure 5: TFP shocks: Financial frictions : Ramsey MaP (solid line) vs no intervention (dashed line)

TFP shock in EME



TFP shock in AE

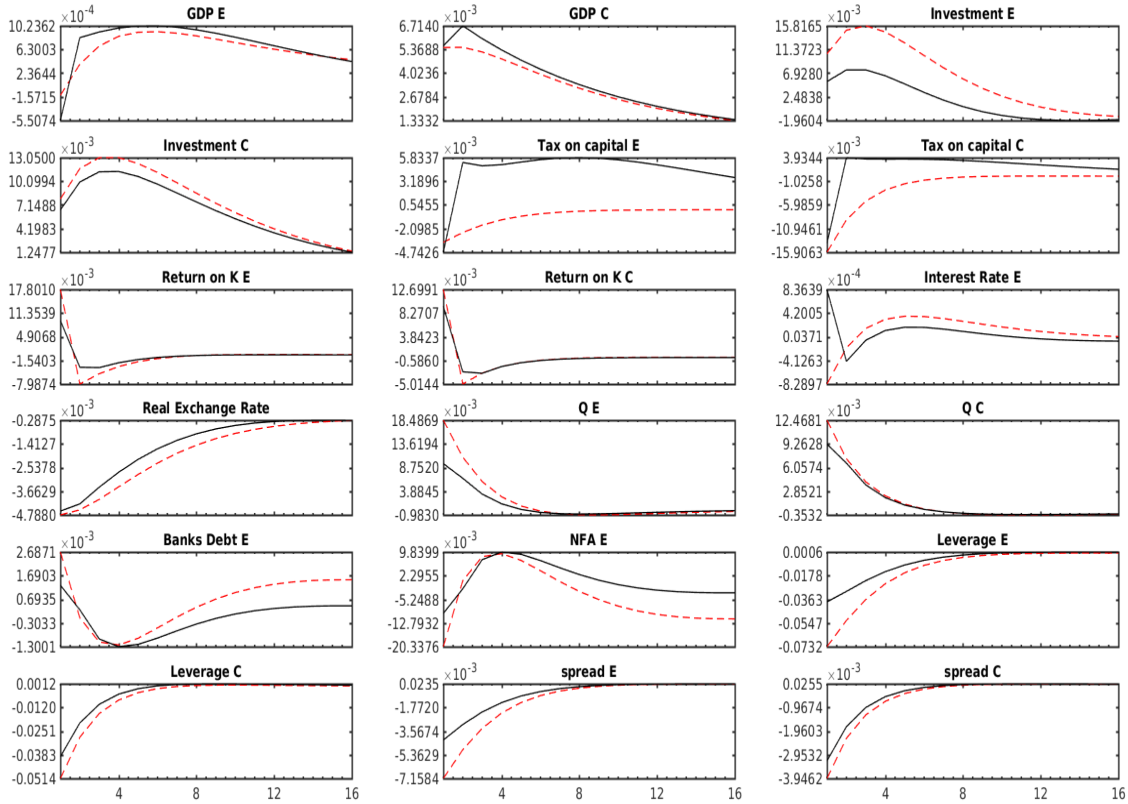


Figure 6: Capital quality shocks: Financial frictions : Ramsey MaP (solid line) vs no intervention (dashed line)

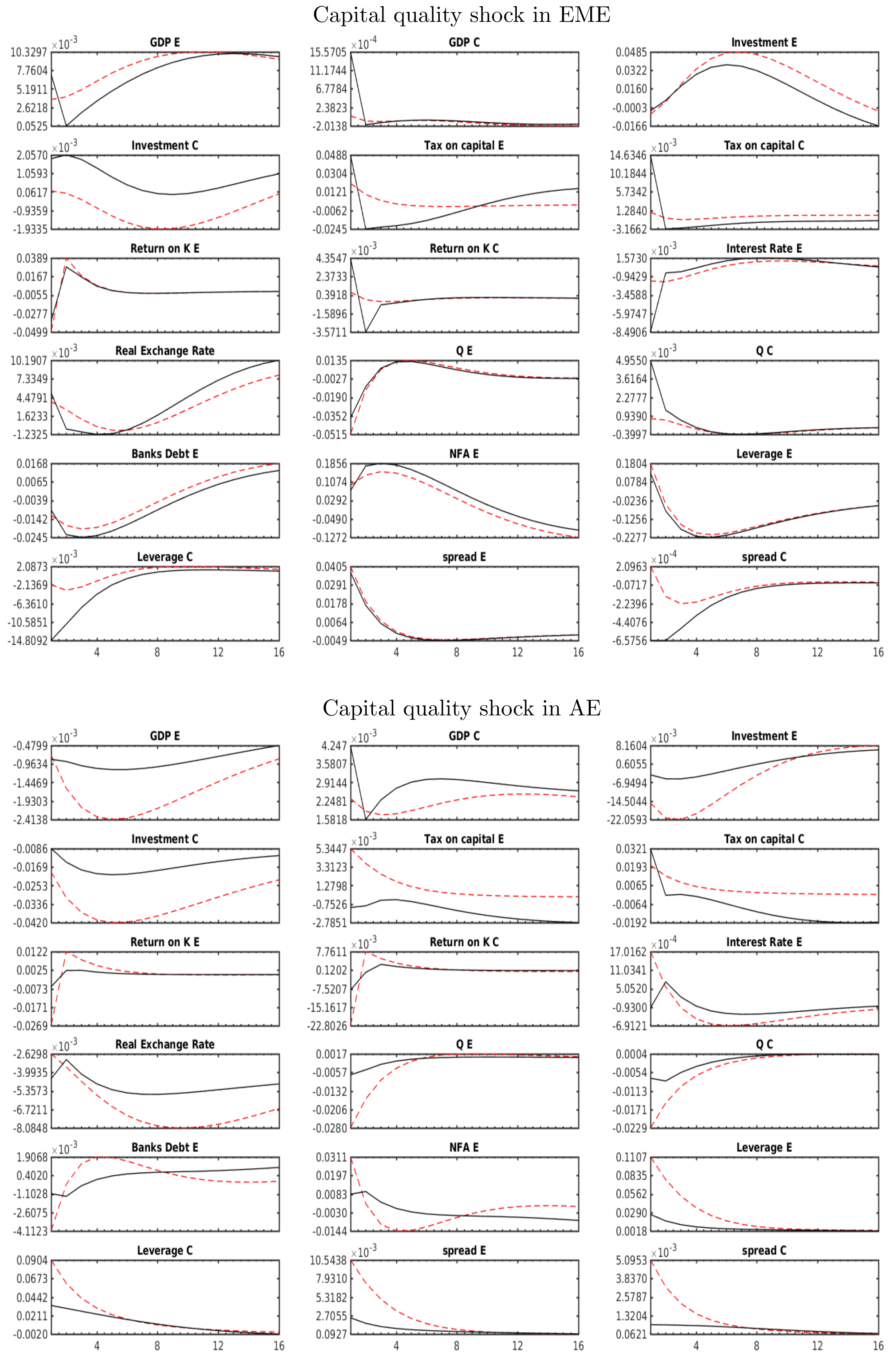
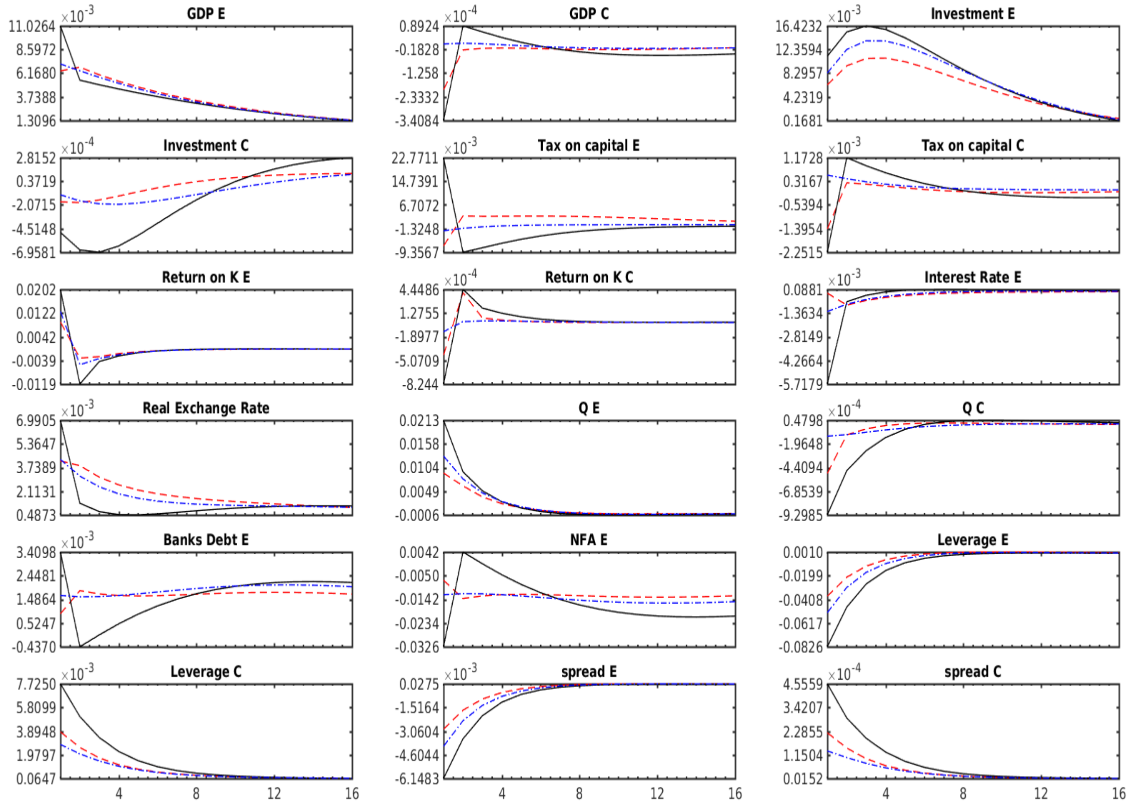


Figure 7: TFP shock and financial frictions: Nash MaP (solid line) vs Ramsey MaP (dashed line) and no intervention (dot-dashed line)

TFP shock in EME



TFP shock in AE

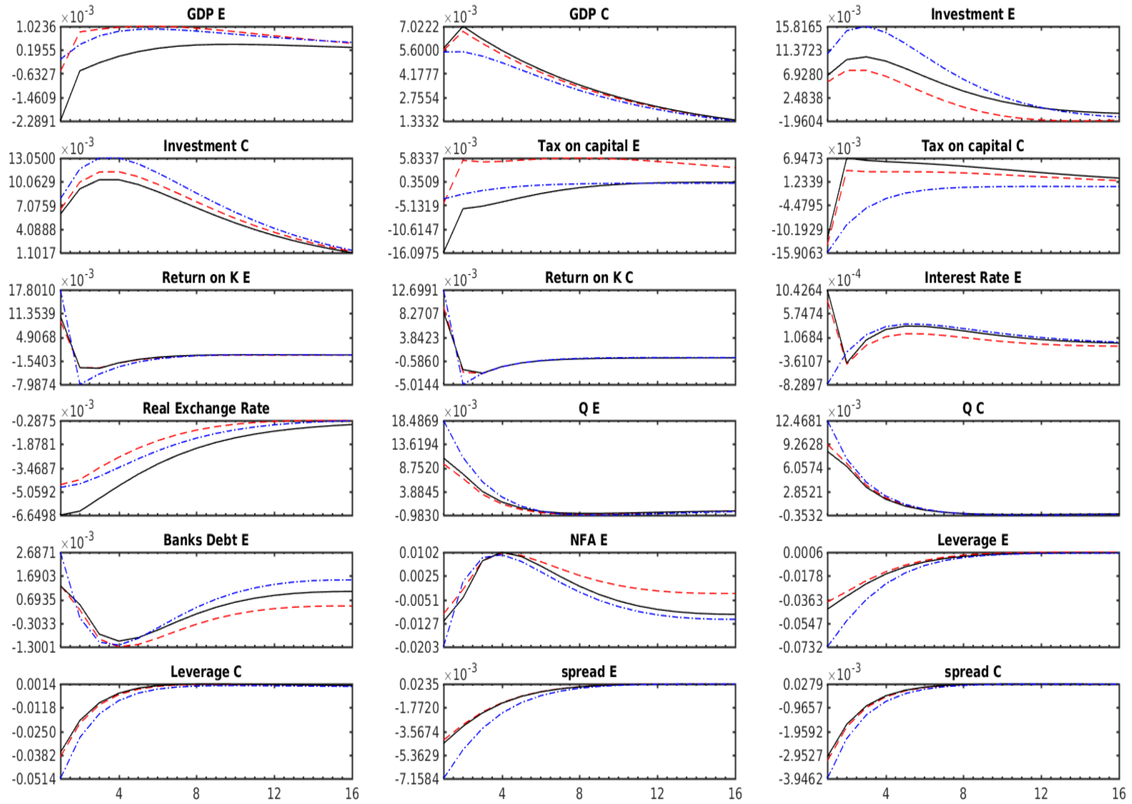


Figure 8: Capital quality shock and financial frictions : Nash MaP (solid line) vs Ramsey MaP (dashed line) and no intervention (dot-dashed line)

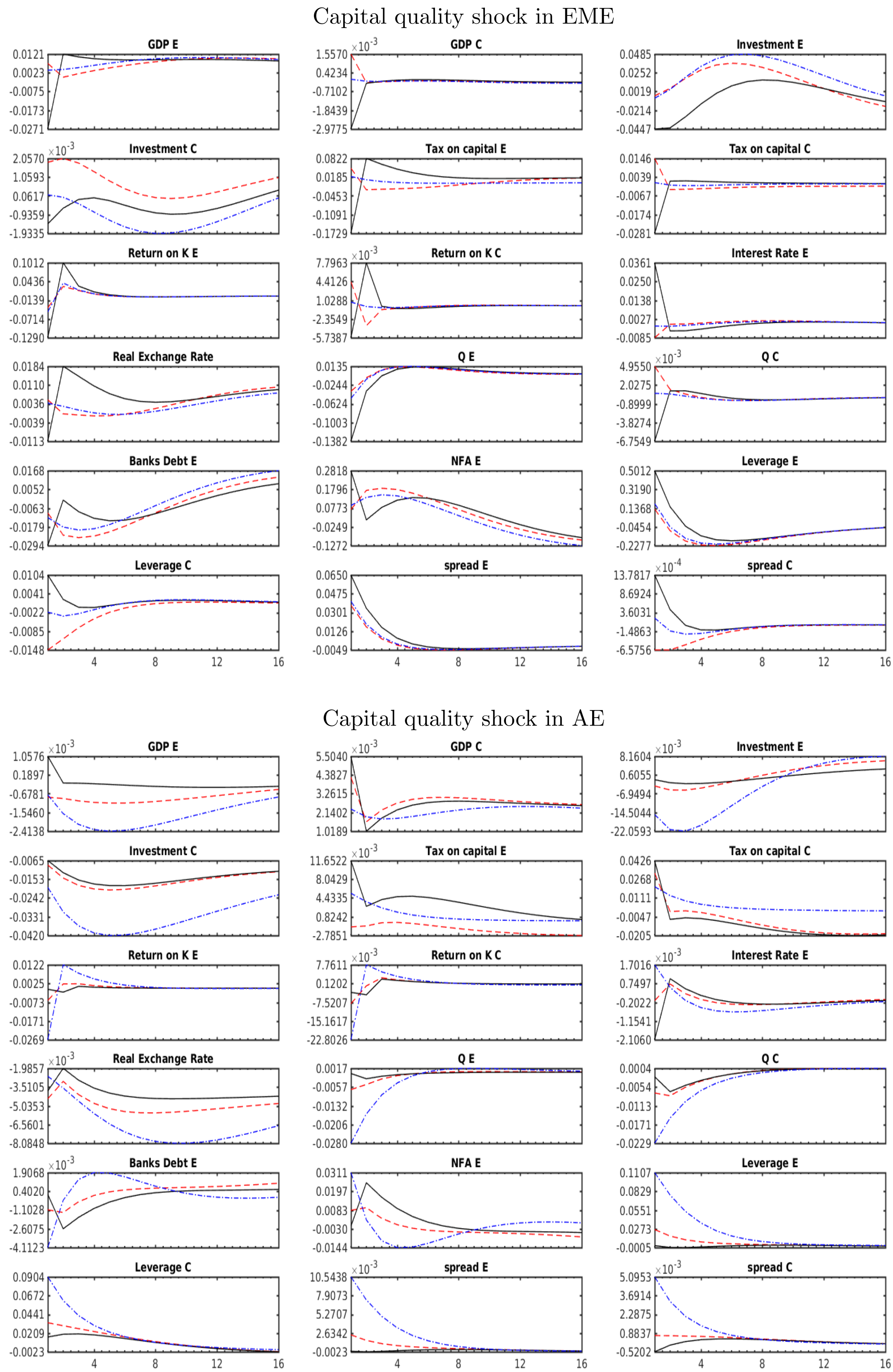
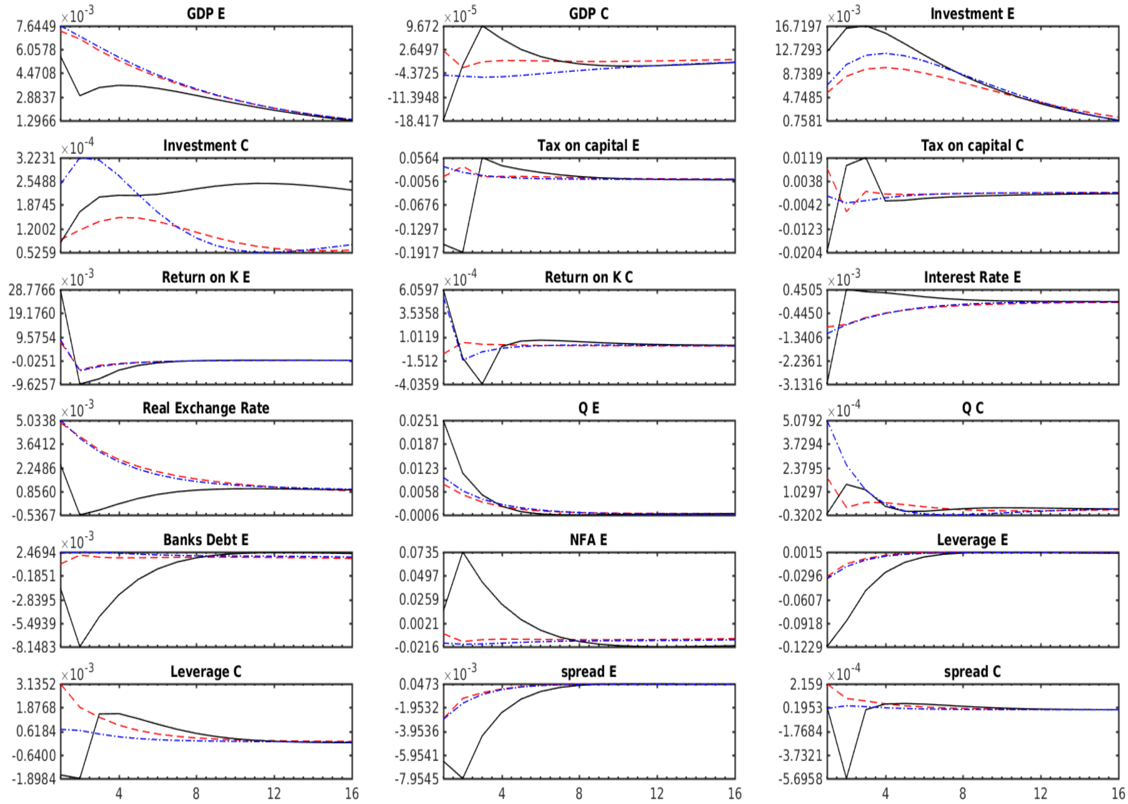


Figure 9: TFP shock with sovereign debt issuance and lump-sum taxes: Nash MaP (solid line) vs Ramsey MaP (dashed line) and no intervention (dot-dashed line)

TFP shock in EME



TFP shock in AE

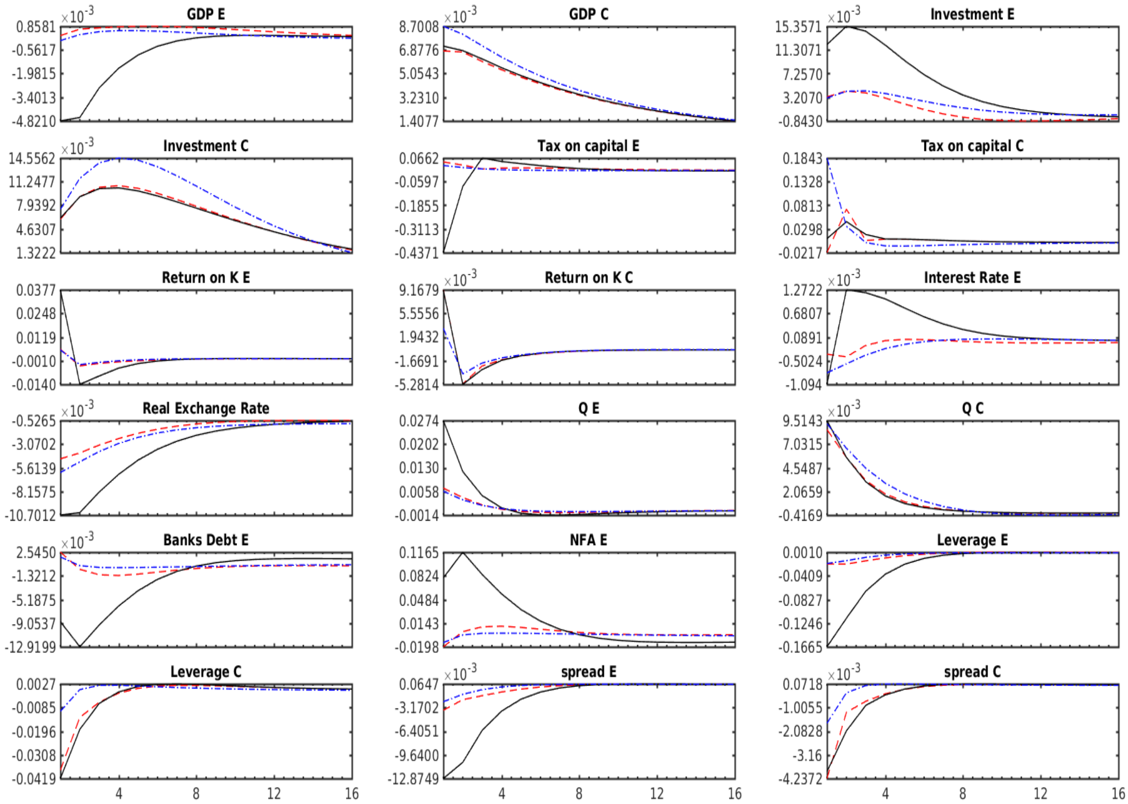
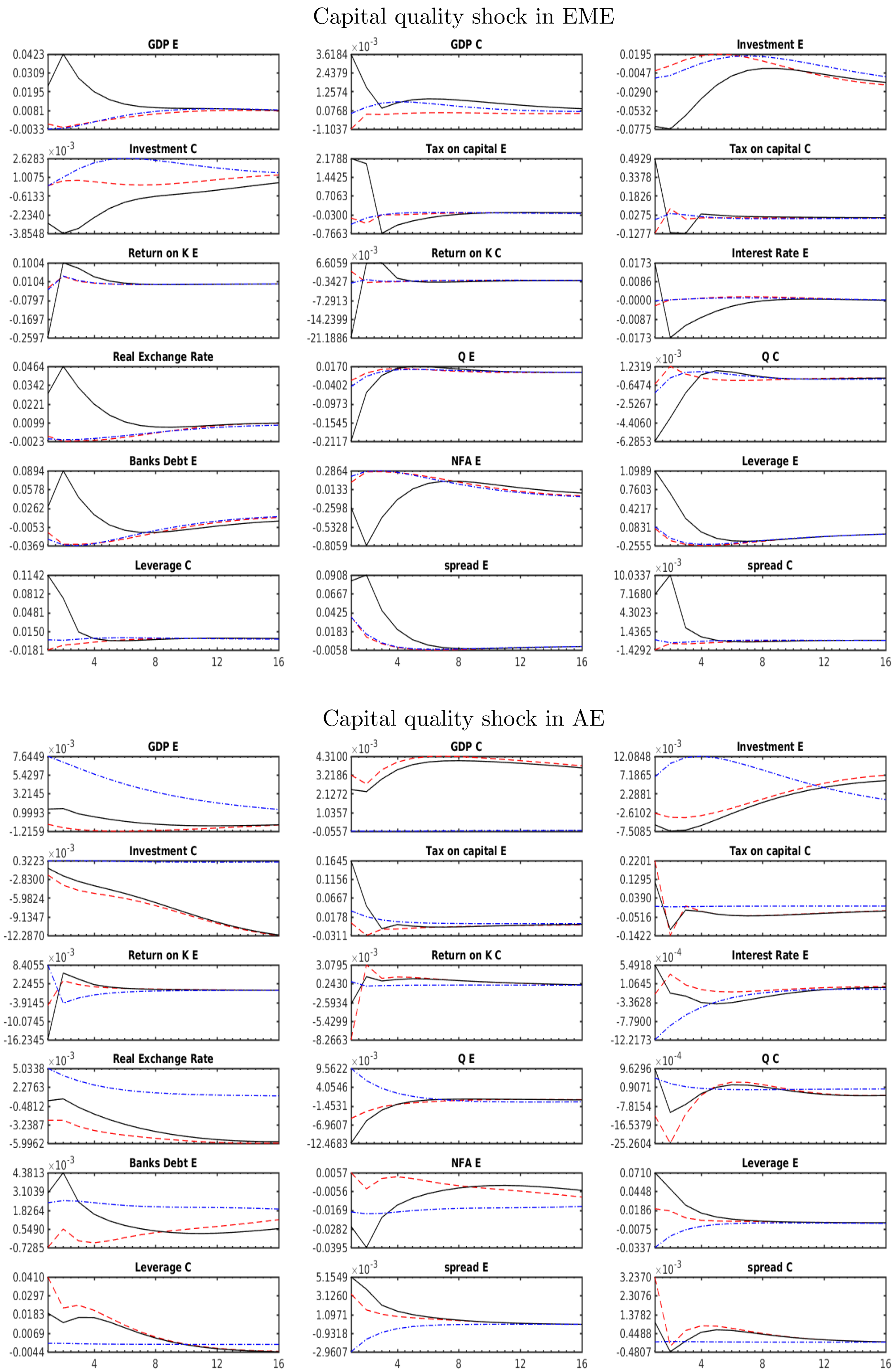


Figure 10: Capital quality shock with sovereign debt issuance and lump-sum taxes : Nash MaP (solid line) vs Ramsey MaP (dashed line) and no intervention (dot-dashed line)



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