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External Shocks, Banks and Monetary Policy in an Open Economy: Loss Function Approach

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External Shocks, Banks and Monetary Policy in an Open Economy: Loss Function Approach*

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Abstract

We systematically document that the 2007-09 financial crisis exposed emerging market economies (EMEs) to an adverse feedback loop of capital outflows, depreciating exchange rates, deteriorating balance sheets, rising credit spreads and falling real economic activity. Using a medium-scale New Keynesian DSGE model of a small open economy augmented with a banking sector that has access to both domestic and foreign funds, we explore the quantitative performances of alternative augmented IT rules in terms of macroeconomic and financial stabilization. In response to external financial shocks, credit-augmented IT rules are found to outperform output and exchange rate augmented rules in achieving policy mandates that target financial and external stability. A countercyclical reserve requirement policy that positively responds to the noncore liabilities share is found effective especially in coordination with monetary policy in reducing the procyclicality of the financial system.

Keywords: External shocks, banks, foreign debt, reserve requirements.
JEL Classification: E44, G21, G28

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1 Introduction

The 2007-09 global financial crisis exposed emerging market economies (EMEs) to an adverse feedback loop of capital outflows, depreciating exchange rates, deteriorating balance sheets, rising credit spreads and falling economic activity. Although the crisis originated in advanced economies, EMEs experienced the severe contractionary effects induced by the crisis as Figure 1 clearly illustrates for 20 EMEs around the 2007-09 episode.[1] The country borrowing premium, as measured by the EMBI Global spread, rose roughly by 400 basis points, leading to declines in GDP and consumption of around 4% and in investment by 8% compared to an HP trend level. Lending spreads over the costs of domestic and foreign funds increased by 200 basis points. Finally, the cyclical components of the real effective exchange rate and current account-to-GDP ratios displayed reversals of about 10% and 2%, respectively.[2]

In order to mitigate the adverse macroeconomic and financial impact of the external shock, EME central banks deployed monetary and macroprudential policy tools, particularly short-term policy rate and reserve requirements. As displayed in the bottom panel of Figure 1, policy rates were increased when capital outflows emerged in the run up to the crisis before displaying a gradual easing (of about 4 percentage points in 6 quarters) in response to the accommodative policy stance of advanced economies during the crisis. Reserve requirements on the other hand, complemented conventional monetary policy at the onset of the crisis and appear to substitute short-term policy rates when there was a sharp upward reversal in capital flows in the aftermath, and displayed an abrupt decline (about 4 percentage points in a single quarter), pointing out to a more discretionary use. In particular, Colombia and Peru reduced their reserve requirement ratios by 16 and 9 percentage points, respectively, from 2009:Q4 to 2010:Q1.

These adverse developments revitalized the previously active debate on the view that the central bank should pay no attention to financial variables over and above their effects on inflation. The "*leaning-against-the-wind*" (hereafter LATW) policies -defined as augmented Taylor type monetary policy rules that respond to financial variables beyond inflation- are now central to the discussions in both academic and policy circles.[3] It is now also widely agreed that price stability, the ultimate mandate for monetary policy before the global financial crisis, does not guarantee financial stability. Consequently, conventional interest rate policy by itself might be of limited use in achieving these multiple objectives. In the case of EMEs, the situation is even harder as exchange rate developments have a significant impact on inflation dynamics. Hence, additional policy instruments beyond the short-term

[1] The countries included in the analysis are Brazil, Chile, China, Colombia, Czech Republic, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Poland, Russia, Singapore, South Africa, Thailand, and Turkey. Variables regarding the real economic activity and the external side are depicted by cross-country simple means of deviations from HP trends. Using medians of deviations produce similar patterns.

[2] Table 1 also displays the peak-to-trough changes in macroeconomic and financial variables in 2007:Q1 to 2011:Q3 episode for each emerging economy in our sample. The table indicates that there is a substantial heterogeneity among emerging markets in terms of realized severity of the financial crisis. It also confirms the financial amplification effects created by the external shocks.

[3] See the discussion in Angelini et al. (2011) and Gambacorta and Signoretti (2014).

policy rate such as macroprudential tools are required and should be effectively combined with monetary policy to maintain these multiple goals.

In the light of these events and discussions, this paper aims to answer three main questions. First, we investigate the macroeconomic and financial effects (transmission channels) of external shocks on EMEs. We consider three types of external shocks relevant for EMEs: a shock to country borrowing premium arguably caused by the collapse of Lehman Brothers in September 2008 and taper tantrum in May 2013, a shock to the U.S. interest rate reflecting the FED's policy normalization expected in late 2015 and a shock to export demand caused by the fall in the income of the rest of the world. These shocks, calibrated to match the empirical observations in EMEs, enable us to capture both the macroeconomic and financial collapse observed during the crisis and potential repercussions that are likely to emerge when the FED starts to normalize its monetary policy.

Second, we ask whether monetary policy should respond to financial and external variables over and above their effect on inflation in an open economy. In particular, we compare the quantitative performances of three alternative augmented IT rules: (i) the conventional Taylor rule that responds to inflation and output gaps, (ii) an augmented IT rule that responds to the credit growth in addition to the inflation, and (iii) another augmented IT rule that responds to change in real exchange rate (RER) in addition to the inflation gap. We assess the performances of these rules based on three possible policy mandates of a central bank: (i) macroeconomic stability that cares about inflation and output volatility, (ii) domestic financial stability that cares about credit market volatility in addition to macroeconomic stability, and (iii) external financial stability that cares about RER volatility in addition to macroeconomic stability. We construct optimized monetary policy rules based on these different policy mandates using the loss function approach.

Finally, we are interested in whether reserve requirements can effectively complement interest rate policy in leaning against the wind. Specifically, we consider a countercyclical reserve requirement rule that responds to the deviations of banks' noncore liabilities share from its steady-state value and examine whether the policy mix of this macroprudential rule with a conventional Taylor rule improves upon only employing the latter. Shin (2013) and Chung et al.(2014) have recently emphasized the usefulness of liability-based macroprudential policy tools. Shin (2013) argues that as global financial conditions ease, banks utilize international markets more to increase funding since their lending increases faster than the growth of core liabilities such as retail deposits. Therefore, he suggests that a levy on noncore liabilities can act as an automatic stabilizer. In our framework, reserve requirement policy that responds to the deviations of banks' noncore liabilities share from its long-run value acts as the same, mitigating the adverse effects of capital outflows and the related bank deleveraging. Moreover, the Central Bank of Turkey has recently employed a remuneration policy on domestic currency required reserves that depends on the share of noncore liabilities in banks' balance sheets.[4] As the share of noncore liabilities increases, the rate of remuneration gets lower compared to the policy rate, encouraging banks to hold

[4]For details, please refer to http://www.tcmb.gov.tr/wps/wcm/connect/8c95234f-5c81-4bc6-8c20-89c3f9f8c1dc/Details2.pdf?MOD=AJPERES.

more core liabilities, strengthening their balance sheet. We analyse these three questions using a medium-scale New Keynesian DSGE model of a small open economy augmented with a banking sector that has access to both domestic and foreign debt.

Our main departure from using an otherwise standard New Keynesian small open economy model is that we introduce an active banking sector with financial frictions into our model as in Gertler and Kiyotaki (2011). In this class of models, financial frictions necessitate that banks collect funds from external sources and their ability to borrow is limited due to an endogenous leverage constraint introduced by a costly enforcement problem. This departure generates the financial accelerator mechanism in which balance sheet fluctuations of banks exacerbate real fluctuations. Our model differs from that of Gertler and Kiyotaki (2011) by replacing interbank borrowing in their framework with foreign debt in an open economy setup. That is, in addition to collecting domestic deposits, banks in our model are solely responsible for the foreign borrowing of the small open economy.

The lending relationship between international creditors and domestic banks is also subject to financial frictions described above. However, we assume that frictions between banks and their domestic versus foreign creditors are asymmetric. Specifically, we assume that domestic depositors are more efficient than international investors in recovering diverted assets from banks in case of a run. This makes foreign debt risky and depresses the magnitude of intermediated foreign funds more compared to domestic funds. Consequently, loan-deposit spreads over foreign debt becomes higher than that of domestic debt as empirically observed in EMEs.[5] This key ingredient gives us the ability to empirically match the liability structure of domestic banks, which is defined as the ratio of foreign funds to the total liabilities, and analyse changes in this measure in response to external shocks.

Finally, our model incorporates various real rigidities generally considered in medium-scale DSGE models such as those studied by Christiano et al. (2005) and Smets and Wouters (2007). In particular, the model features habit formation in consumption, variable capacity utilization and investment adjustment costs, which improve its empirical fit.

In our model, adverse risk premium shocks (modelled similar to that in Gertler et al. (2007)) increase the cost foreign borrowing and triggers capital outflows. Accordingly, the economy experiences a depreciation in the exchange rate and a reversal in the current account deficit. Banks respond to the funding cost change by switching their liability structure towards domestic deposits, yet the increase in domestic deposits falls short of the decline in foreign debt, which shrinks the magnitude of total external finance for the bank. The restraint in bank lending results in a tightening in credit conditions (as measured by a rise in loan-deposit spreads) and a collapse in the price of physical capital which is only accessible to nonfinancial firms via bank credit. The decline in asset prices in turn feeds back into the endogenous leverage constraint of banks and suppresses their balance sheet even more (via the financial accelerator). As a result, real economic activity declines and inflation

[5] We illustrate in the bottom-left panel of Figure 1 that, with the exception of the period 2010:Q2-2011:Q3, credit spreads over cost of foreign debt are larger than that of domestic deposits. This implies that domestic deposit rates are higher than cost of foreign debt. This regularity dates back to 2002:Q4 for the average of emerging economies in our sample.

increases via exchange rate pass through and the negative supply side transmission of the credit channel. Our results show that the uncertainty regarding the timing of the FED's policy normalization may create an amplification in the adverse feedback loop in EMEs.

Our findings support the view that LATW type monetary policy rules, in particular credit-augmented IT rules, outperform conventional and RER augmented interest rate rules under mandates that favor financial or external stability. Furthermore, credit augmented rules are found to perform better in response to external financial shocks rather than domestic real shocks. Under the conventional Taylor rule, the central bank raises the policy rate aggressively in order to mitigate inflationary pressures originating from nominal depreciation. However, under the credit-augmented IT rule, the policy rate rise by the central bank is muted compared to the Taylor rule as it also takes into account the procyclical and more volatile credit market developments particularly driven by external financial shocks. The milder increase in the policy rate causes real deposit rates to increase less since prices are sticky. Consequently, central bank eases the borrowing conditions for banks, which results in much less decline in credit, asset prices and real economic activity via the credit channel. These supply side gains (brought by lower domestic funding terms on banks) outweigh the inflationary pressures that originate from stronger exchange rate pass through, and inflation increases less compared to the economy under the conventional Taylor rule. Therefore, LATW policies dominate conventional interest rate rules in terms of financial and external stability objectives.

Our analysis strikingly suggests that augmenting a conventional IT rule with a RER stabilization objective does not contribute to macroeconomic stabilization. This is because central bank raises the policy rate quite aggressively to combat the exchange rate depreciation in response to the negative external shock, which is detrimental on the domestic aggregate demand via the hindered credit channel. Indeed, loss values that depend on volatilities of key macroeconomic and financial variables emerge larger (than those implied by the other rules) since the suppression of domestic demand (under higher domestic interest rates) outweighs gains from containing the depreciation in the exchange rate.

Finally, we report that countercyclical reserve requirements that positively respond to the noncore liabilities share can improve upon a standard Taylor rule in producing less macroeconomic and financial volatility. This is because central bank reduces reserve requirements (which is effectively a tax on banks) in response to the decline in the share of foreign debt followed by the adverse external shock. This partly mitigates the funding stress on domestic banks and achieves a much weaker deterioration in their balance sheet. Accordingly, central bank raises the short-term policy rates by less since the adverse supply side impact of the shock is partly contained. The prudential role of the reserve requirement rule is even more evident in capital inflow episodes. When external shocks are favorable, policy rates decline following the exchange rate appreciation and banks tend to fuel risky borrowing by tweaking liability structure towards foreign debt. By increasing reserve requirement ratios in those episodes, central bank curbs excessive risky borrowing that exacerbates the impact of the financial accelerator.[6] We find that jointly optimizing over a standard Taylor rule and a

[6] As illustrated in the bottom panel of Figure 1, the period that follows the trough point of the recent

countercyclical required reserves rule achieves much smaller losses compared to both lack of cooperation and the absence of the reserve requirement tool.

Related literature

This paper is closely related to the work of Gertler et al. (2007) and Glocker and Towbin (2012) with regards to the modelling of financial crisis in emerging markets through balance sheet effects and to the role of monetary and macroprudential policy tools in containing the adverse financial amplification effects, respectively. Both studies consider a New Keynesian small open economy model of the financial accelerator that works through nonfinancial firms' balance sheets in which these firms engage in polar funding relationships. Our work differs from these studies mainly because the financial accelerator mechanism in our model works through the balance sheet of banks that engage in domestic and foreign borrowing simultaneously. Furthermore, while the former study explores the connection between the exchange rate regime and financial crisis in emerging economies, we explore macroprudential policies and optimize over alternative IT augmenting monetary policy rules. The latter study, on the other hand, investigates the interaction of alternative monetary policy rules and reserve requirements in a setup that incorporates lending and depositing units into that of Gertler et al. (2007). The co-existence of domestic and foreign debt in our setup allows us to capture the use of reserve requirements in containing risks that build up via increasing noncore borrowing as emphasized by Shin (2013) and Chung et al (2014), as opposed to containing domestic credit growth or responding to inflation as considered by Glocker and Towbin (2012).

Our paper is also related to and complements a growing recent strand of the literature that analyses LATW type monetary and/or macroprudential policy measures by taking into account financial frictions. Faia and Monacelli (2007) reports that it is welfare improving to respond to asset prices with a Taylor-type interest rate rule when response to inflation is not strong. Angelini et al. (2011) show that macroprudential policy instruments such as capital requirements and loan-to-value ratios are effective in response to financial shocks. Mimir et al. (2013) illustrate that countercyclical reserve requirements that respond to credit growth have desirable stabilization properties as opposed to constant required reserves ratios. Gambacorta and Signoretti (2014) considers bank balance sheet and bank lending channels simultaneously and show that Taylor-type interest rate rules that respond to financial variables have the potential to LATW even in response to supply side shocks. Our study mainly differs from these studies by investigating an open economy framework in which financial shocks are related to the international borrowing conditions of the emerging economy. Finally, Medina and Roldos (2014) focuses on the effects of alternative parameterized monetary and macroprudential policy rules in an open economy setting with a different modelling of the financial sector than ours, and find that LATW capabilities of conventional monetary policy might be limited.

This paper contributes to and complements the existing literature through five main

crisis might be thought of as exemplifying such a policy mix of policy rates and reserve requirements.

dimensions. First, we investigate the joint role of LATW and macroprudential policies in containing the adverse financial amplification effects *in an open economy framework*. Adopting an open economy framework gives us the ability to consider external shocks relevant for EMEs leading to capital outflows. In addition, it enables us to study exchange rate developments, its transmission to inflation dynamics and whether monetary policy should respond to changes in RER over and above its effect on inflation and output. Second, we analyze the monetary transmission of external shocks *in the presence of an active banking sector with financial frictions*. Third, we study the role of a banking sector that can *borrow both domestic and foreign funds simultaneously* in the transmission of LATW and macroprudential policies in an open economy setting. Finally, we investigate the interactions of the most empirically relevant LATW and macroprudential policies in mitigating the adverse effects of external shocks. In particular, we consider alternative *augmented* Taylor-type interest rate rules that *respond to output, credit growth and RER stability* on top of inflation stability and one of the most frequently used macroprudential instruments in EMEs, *reserve requirement policies*.

The rest of the paper is structured as follows: In Section 2, we describe the theoretical framework. Section 3 presents the model parametrization and calibration together with the quantitative analysis. In section 4, we conduct sensitivity analysis. Section 5 concludes.

2 Model economy

The analytical framework is a medium-scale New Keynesian small open economy model inhabited by households, banks, nonfinancial firms, capital producers, and a government. Financial frictions define bankers as a key agent in the economy. The modelling of the banking sector follows Gertler and Kiyotaki (2011), with the modification that bankers make external financing from both domestic depositors and international investors, potentially bearing currency risk. They then combine debt with their own net worth and extend credit to nonfinancial firms, who issue securities against their physical capital demand. The consolidated government makes an exogeneous stream of spending and determines monetary as well as macroprudential policy. The benchmark monetary policy regime is a Taylor rule that aims to stabilize inflation and output. In order to understand the effectiveness of alternative monetary policy rules, we augment the baseline policy framework with credit and exchange rate stabilization targets, consecutively. In addition, we analyze the macroprudential use of reserve requirements in regulating noncore borrowing made by banks. Unless otherwise stated, variables denoted by upper (lower) case characters represent nominal (real) values in domestic currency.

2.1 Households

There is a large number of infinitely-lived identical households, who derive utility from consumption c_t, leisure $(1 - h_t)$, and real money balances $\frac{M_t}{P_t}$. The consumption good is a

constant-elasticity-of-substitution (CES) aggregate of domestically produced and imported tradable goods as in Galí and Monacelli (2005) and Gertler et al. (2007),

$$c_t = \left[\omega^{\frac{1}{\gamma}}(c_t^H)^{\frac{\gamma-1}{\gamma}} + (1-\omega)^{\frac{1}{\gamma}}(c_t^F)^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}, \tag{1}$$

where $\gamma > 0$ is the elasticity of substitution between *home* and *foreign* goods, and $0 < \omega < 1$ is the relative weight of home goods in the consumption basket, capturing the degree of home bias in household preferences. Let P_t^H and P_t^F represent domestic currency denominated prices of home and foreign goods, respectively. If home and foreign goods are aggregated according to (1), then the expenditure minimization problem of households

$$\min_{c_t^H, c_t^F} P_t c_t - P_t^H c_t^H - P_t^F c_t^F$$

yields the demand curves $c_t^H = \omega\left(\frac{P_t^H}{P_t}\right)^{-\gamma} c_t$ and $c_t^F = (1-\omega)\left(\frac{P_t^F}{P_t}\right)^{-\gamma} c_t$, for home and foreign goods, respectively. These demand curves and the consumption aggregator in turn imply that the domestic consumer price index (CPI) of this economy is

$$P_t = \left[\omega(P_t^H)^{1-\gamma} + (1-\omega)(P_t^F)^{1-\gamma}\right]^{\frac{1}{1-\gamma}}. \tag{2}$$

The final demand for home consumption good c_t^H, is an aggregate of a continuum of varieties of intermediate home goods along the [0,1] interval. That is, $c_t^H = \left[\int_0^1 (c_{it}^H)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}$, where each variety is indexed by i, and ϵ is the elasticity of substitution between these varieties. For any given level of demand for the composite home good c_t^H, the demand for each variety i solves the problem of minimizing total home goods expenditures, $\int_0^1 P_{it}^H c_{it}^H di$ subject to the aggregation constraint, where P_{it}^H is the nominal price of variety i. The solution to this problem yields the optimal demand for c_{it}^H, which satisfies

$$c_{it}^H = \left(\frac{P_{it}^H}{P_t^H}\right)^{-\epsilon} c_t^H, \tag{3}$$

with the aggregate home good price index P_t^H being

$$P_t^H = \left[\int_0^1 (P_{it}^H)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}. \tag{4}$$

We assume that each household is composed of a worker and a banker who perfectly insure each other. Workers consume the consumption bundle and supply labor (h_t). They also save in local currency assets which are *deposited* within financial intermediaries owned by the banker members of *other* households.[7] The balance of these deposits is denoted by B_{t+1}, which promises to pay a net nominal risk-free rate r_{nt} in the next period. There are no interbank frictions, hence r_{nt} coincides with the policy rate of the central bank. Furthermore, the borrowing contract is *real* in the sense that the risk-free rate is determined based on the

[7] This assumption is useful in making the agency problem that we introduce in Section 2.2 more realistic.

expected inflation. By assumption, households cannot directly save in productive capital, and only banker members of households are able to borrow in foreign currency.

Preferences of households over consumption, leisure, and real balances are represented by the lifetime utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t, h_t, \frac{M_t}{P_t}\right), \tag{5}$$

where U is a CRRA type period utility function given by

$$U\left(c_t, h_t, \frac{M_t}{P_t}\right) = \left[\frac{(c_t - h_c c_{t-1})^{1-\sigma} - 1}{1-\sigma} - \frac{\chi}{1+\xi} h_t^{1+\xi} + \upsilon \log\left(\frac{M_t}{P_t}\right)\right]. \tag{6}$$

E_t is the mathematical expectation operator conditional on the information set available at t, $\beta \in (0,1)$ is the subjective discount rate, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, $h_c \in [0,1)$ governs the degree of habit formation, χ is the utility weight of labor, and $\xi > 0$ determines the Frisch elasticity of labor supply. We also assume that the natural logarithm of real money balances provides utility in an additively separable fashion with the utility weight υ.[8]

Households face the flow budget constraint,

$$c_t + \frac{B_{t+1}}{P_t} + \frac{M_t}{P_t} = \frac{W_t}{P_t} h_t + \frac{(1+r_{nt-1})B_t}{P_t} + \frac{M_{t-1}}{P_t} + \Pi_t - \frac{T_t}{P_t}. \tag{7}$$

On the right hand side are the real wage income $\frac{W_t}{P_t} h_t$, real balances of the domestic currency interest bearing assets at the beginning of period t $\frac{B_t}{P_t}$, and real money balances at the beginning of period t $\frac{M_{t-1}}{P_t}$. Π_t denotes real profits remitted from firms owned by the households (banks, intermediate home goods producers, and capital goods producers). T_t represents nominal lump-sum taxes collected by the government. On the left hand side are the outlays for consumption expenditures and asset demands.

Households choose c_t, h_t, B_{t+1}, and M_t to maximize preferences in (6) subject to (7) and standard transversality conditions imposed on asset demands, B_{t+1}, and M_t. The first order conditions of the utility maximization problem of the households are given by

$$\varphi_t = (c_t - h_c c_{t-1})^{-\sigma} - \beta h_c E_t (c_{t+1} - h_c c_t)^{-\sigma}, \tag{8}$$

$$\frac{W_t}{P_t} = \frac{\chi h_t^{\xi}}{\varphi_t}, \tag{9}$$

$$\varphi_t = \beta E_t \left[\varphi_{t+1}(1+r_{nt}) \frac{P_t}{P_{t+1}}\right], \tag{10}$$

[8]The logarithmic utility used for real money balances does not matter for real allocations as it enters into the utility function in an additively separable fashion and money does not appear in any optimality conditions except the consumption-money optimality condition.

$$\frac{\upsilon}{M_t/P_t} = \beta E_t \left[\varphi_{t+1} r_{nt} \frac{P_t}{P_{t+1}} \right]. \tag{11}$$

Equation (8) defines the Lagrange multiplier, φ_t as the marginal utility of consuming an additional unit of income. Equation (9) equates marginal disutility of labor to real wages. Finally, equations (10) and (11) represent the Euler equations for bonds, the consumption-savings margin, and money demand, respectively.

Combining equations (8) and (10) yields the consumption-savings optimality condition,

$$\left(c_t - h_c c_{t-1} - \frac{\chi}{1+\xi} h_t^{1+\xi} \right)^{-\sigma} - \beta h_c E_t \left(c_{t+1} - h_c c_t - \frac{\chi}{1+\xi} h_{t+1}^{1+\xi} \right)^{-\sigma}$$

$$= \beta E_t \left[\left\{ \left(c_{t+1} - h_c c_t - \frac{\chi}{1+\xi} h_{t+1}^{1+\xi} \right)^{-\sigma} - \beta h_c \left(c_{t+2} - h_c c_{t+1} - \frac{\chi}{1+\xi} h_{t+2}^{1+\xi} \right)^{-\sigma} \right\} \frac{(1+r_{nt+1})P_t}{P_{t+1}} \right].$$

Combining equations (10) and (11) implies the consumption-money optimality condition,

$$\frac{\upsilon/m_t}{\varphi_t} = \frac{r_{nt}}{1+r_{nt}}. \tag{12}$$

with m_t denoting real balances held by consumers.

The CES aggregator for c_t and the price index of final consumption goods imply that the optimal demand frontier for home and foreign goods are determined by the condition,

$$\frac{c_t^H}{c_t^F} = \frac{\omega}{1-\omega} \left(\frac{P_t^H}{P_t^F} \right)^{-\gamma}. \tag{13}$$

The nominal exchange rate of the foreign currency in domestic currency units is denoted by S_t. Therefore, the real exchange rate of the foreign currency in terms of real home goods becomes $s_t = \frac{S_t P_t^*}{P_t}$, where foreign currency denominated CPI P_t^*, is taken exogenously.

We assume that foreign goods are produced in a symmetric setup as in home goods. That is, there is a continuum of foreign intermediate goods that are bundled into a composite foreign good, whose consumption by the home country is denoted by c_t^F. We assume that the law of one price holds for the import prices of intermediate goods, that is, $MC_t^F = S_t P_t^{F*}$, where MC_t^F is the marginal cost for intermediate good importers and P_t^{F*} is the foreign currency denominated price of such goods. Foreign intermediate goods producers put a markup over the marginal cost MC_t^F while setting the domestic currency denominated price of foreign goods. The small open economy also takes P_t^{F*} as given. In Section 2.4, we elaborate further on the determination of the domestic currency denominated prices of home and foreign goods, P_t^H and P_t^F.

2.2 Banks

The modeling of banks closely follows Gertler and Kiyotaki (2011) except that banks in our paper borrow in local currency from domestic households and in foreign currency from international lenders. They combine these funds with their net worth, and finance capital expenditures of home based tradable goods producers. For tractability, we assume that banks only lend to home based production units.

The main financial friction in this economy originates in the form of a moral hazard problem between bankers and their funders and leads to an endogenous borrowing constraint on the former. The agency problem is such that depositors (both domestic and foreign) believe that bankers might divert certain fraction of their assets for their own benefit. Additionally, we formulate the diversion assumption in a particular way to ensure that in equilibrium, an endogeneous positive spread between the costs of domestic and foreign borrowing emerges, as in the data. Ultimately, in equilibrium, the diversion friction restrains funds raised by bankers and limit the credit extended to nonfinancial firms, leading up to credit spreads.

Banks are also subject to symmetric reserve requirements on domestic and foreign deposits, i.e., they are obliged to hold a certain fraction of domestic and foreign deposits rr_t, at the central bank. We retain this assumption to facilitate the investigation of reserve requirements as a policy tool used by the monetary authority.

2.2.1 Balance sheet

We now proceed to the bankers' problem. For ease of notation, we denote nominal (real) variables in the balance sheet of banks in capital (lower case) letters. Variables that are denominated in foreign currency or related to the rest of the world are indicated by an asterisk.

The period-t balance sheet of a banker j denominated in domestic currency units is,

$$Q_t l_{jt} = B_{jt+1}(1 - rr_t) + S_t B^*_{jt+1}(1 - rr_t) + N_{jt}, \tag{14}$$

where B_{jt+1} and B^*_{jt+1} denote domestic deposits and foreign debt (in nominal foreign currency units), respectively, N_{jt} denotes banker's net worth, Q_{jt} is the nominal price of claims purchased from nonfinancial firms and l_{jt} is the quantity of such claims. rr_t is the required reserves ratio on domestic and foreign deposits. It is useful to divide equation (14) by the aggregate price index P_t, and re-arrange terms to obtain banker j's balance sheet in real terms. Those manipulations imply

$$q_t l_{jt} = b_{jt+1}(1 - rr_t) + b^*_{jt+1}(1 - rr_t) + n_{jt}, \tag{15}$$

where q_t is the relative price of the security claims purchased by bankers and $b^*_{jt+1} = \frac{S_t B^*_{jt+1}}{P_t}$ is the foreign borrowing in real domestic units. Notice that if the exogenous foreign price index P^*_t is assumed to be equal to 1 at all times, then b^*_{jt+1} incorporates the impact of the real exchange rate, $s_t = \frac{S_t}{P_t}$ on the balance sheet.

Next period's real net worth n_{jt+1}, is determined by the difference between the return earned on assets (i.e., loans and reserves) and the cost of borrowing. Therefore we have,

$$n_{jt+1} = R_{kt+1} q_t l_{jt} + rr_t (b_{jt+1} + b^*_{jt+1}) - R_{t+1} b_{jt+1} - R^*_{t+1} b^*_{jt+1}, \tag{16}$$

where R_{kt+1} denotes the state-contingent real returns earned on the claims against the securities issued by domestic final goods producers. R_{t+1} is the real risk-free deposit rate offered to domestic workers, and R^*_{t+1} is the country borrowing rate of foreign debt, denominated in real domestic currency units. R_t and R^*_t both satisfy Fisher equations,

$$R_t = E_t \left\{ (1 + r_{nt}) \frac{P_t}{P_{t+1}} \right\}$$

$$R^*_t = E_t \left\{ \Psi_t (1 + r^*_{nt}) \frac{S_{t+1}}{S_t} \frac{P_t}{P_{t+1}} \right\} \quad \forall t, \tag{17}$$

where r_n denotes the net nominal deposit rate as in equation (7) and r^*_n denotes the net nominal international borrowing rate. Bankers face a premium over this rate while borrowing from abroad. Specifically, the premium is an increasing function of foreign-debt-to GDP ratio; $\Psi_t = F\left(\frac{b^*_{t+1}}{y_t}\right)\psi_t$ with $F'(.) > 0$, where b^*_{t+1} represents the aggregate foreign borrowing of bankers from international capital markets, y_t represents GDP, and ψ_t is a random disturbance to this premium.[9] Particularly, we assume ψ_t follows,

$$\log(\psi_{t+1}) = \rho^{\psi} \log(\psi_t) + \epsilon^{\psi}_{t+1} \tag{18}$$

with zero mean and constant variance innovations ϵ^{Ψ}_{t+1}. Introducing ψ_t enables us to study the domestic business cycle responses to exogenous cycles in global capital flows. In order to capture the impact of monetary policy normalization on emerging economies, we assume that exogenous world interest rates follow an autoregressive process of the form,

$$r^*_{nt+1} = \rho^{r^*_n} r^*_{nt} + \epsilon^{r^*_n}_{t+1}, \tag{19}$$

in which the innovations $\epsilon^{r^*_n}_{t+1}$ are normally distributed with zero mean.

Solving for b_{jt+1} in equation (15) and substituting it in equation (16), and re-arranging terms imply that bank's net worth evolves as,

$$n_{jt+1} = \left[R_{kt+1} - \frac{R_{t+1} - rr_t}{1 - rr_t} \right] q_t l_{jt} + \left[R_{t+1} - R^*_{t+1} \right] b^*_{jt+1} + \frac{R_{t+1} - rr_t}{1 - rr_t} n_{jt}. \tag{20}$$

Note that $\frac{R_{t+1} - rr_t}{1 - rr_t}$ can be thought as reserves adjusted domestic deposit rate. Denoting this term by $\hat{R}_{t+1}$, equation (20) can be re-written as

[9] By assuming that the cost of borrowing from international capital markets increases in the net foreign indebtedness of the aggregate economy, we ensure the stationarity of the foreign asset dynamics as in Schmitt-Grohe and Uribe (2003).

$$n_{jt+1} = \left[R_{kt+1} - \hat{R}_{t+1}\right] q_t l_{jt} + \left[R_{t+1} - R^*_{t+1}\right] b^*_{jt+1} + \hat{R}_{t+1} n_{jt}. \tag{21}$$

This equation illustrates that individual bankers' net worth depends positively on the premium of the return earned on assets over the reserves adjusted cost of borrowing, $R_{kt+1} - \hat{R}_{t+1}$. The second term on the right-hand side shows the benefit of raising foreign debt as opposed to domestic debt. Finally, the last term highlights the contribution of internal funds, that are multiplied by $\hat{R}_{t+1}$, the opportunity cost of raising one unit of external funds via domestic borrowing.

Banks would lend to nonfinancial firms only if

$$E_t \left\{ \Lambda_{t,t+i+1} \left[R_{kt+i+1} - \hat{R}_{t+i+1}\right] \right\} \geq 0 \quad \forall t, \tag{22}$$

where $\Lambda_{t,t+i+1} = \beta E_t \left[\frac{U_c(t+i+1)}{U_c(t)}\right]$ denotes the $i+1$ periods-ahead stochastic discount factor of households, whose banker members operate as financial intermediaries. This condition ensures that bankers find it profitable to purchase securities issued by nonfinancial firms. Financial intermediation becomes a veil in the absence of financial frictions, that is R_k reduces due to an abundance of intermediated funds, which in turn eliminates the premium. In the following, we also establish that

$$E_t \left\{ \Lambda_{t,t+i+1} \left[R_{t+i+1} - R^*_{t+i+1}\right] \right\} > 0 \quad \forall t, \tag{23}$$

so that the cost of domestic debt entails a positive premium over the cost of foreign debt at all times.

In order to rule out any possibility of complete self-financing, we assume that bankers have a finite life and survive to the next period only with probability $0 < \theta < 1$. At the end of each period, $1 - \theta$ measure of new bankers are born and are remitted $\frac{\epsilon}{1-\theta}$ fraction of the loans owned by exiting bankers in the form of start-up funds.

2.2.2 Net worth maximization

Bankers maximize expected discounted value of the terminal net worth of their financial firm V_{jt}, by choosing the amount of security claims purchased l_{jt}, and the amount of foreign debt b^*_{jt+1}. For a given level of net worth, the optimal amount of domestic deposits can be solved for by using the balance sheet.

Bankers solve the following value maximization problem,

$$\begin{aligned} V_{jt} &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \\ &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i} \Big(\left[R_{kt+1+i} - \hat{R}_{t+1+i}\right] q_{t+i} l_{jt+i} \\ &\quad + \left[R_{t+1+i} - R^*_{t+1+i}\right] b^*_{jt+1+i} + \hat{R}_{t+1+i} n_{jt+i} \Big). \end{aligned} \tag{24}$$

For a nonnegative premium on credit, the solution to the value maximization problem of banks would lead to an unbounded magnitude of assets. In order to rule out such a scenario, we follow Gertler and Kiyotaki (2011) and introduce an agency problem between depositors and bankers. Specifically, lenders believe that banks might divert λ fraction of their total divertable assets, where divertable assets constitute total assets minus a fraction ω_l, of domestic deposits. When lenders become aware of the potential confiscation of assets, they would initiate a bank run and lead to the liquidation of the bank altogether. In order to rule out bank runs in equilibrium, in any state of nature, bankers' optimal choice of l_{jt} should be incentive compatible. Therefore, the following constraint is imposed on bankers,

$$V_{jt} \geq \lambda\Big(q_t l_{jt} - \omega_l b_{jt+1}\Big), \tag{25}$$

where λ and ω_l are constants between zero and one. This inequality suggests that the liquidation cost of bankers from diverting funds V_{jt}, should be greater than or equal to the diverted portion of assets. When this constraint binds, bankers would never choose to divert funds and lenders adjust their position and restrain their lending to bankers accordingly.

We introduce asymmetry in financial frictions by excluding ω_l fraction of domestic deposits from diverted assets. This is due to the idea that domestic depositors would arguably have a comparative advantage over foreign depositors in recovering assets in case of a bankruptcy. Furthermore, they would also be better equipped than international lenders in monitoring domestic bankers.[10]

Given this setup, it is useful to represent the value function of bankers in recursive form. Since,

$$\begin{aligned} V_{jt} &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \\ &= \max_{l_{jt+i}, b^*_{jt+1+i}} E_t \left[(1-\theta)\Lambda_{t,t+1} n_{jt+1} + \sum_{i=1}^{\infty} (1-\theta)\theta^i \Lambda_{t,t+1+i}\ n_{jt+1+i} \right], \end{aligned} \tag{26}$$

we have

$$V_{jt} = \max_{l_{jt}, b^*_{jt+1}} E_t \Big\{ \Lambda_{t,t+1} [(1-\theta) n_{jt+1} + \theta V_{jt+1}] \Big\}. \tag{27}$$

Now we conjecture the optimal value of financial intermediaries to be a linear function of bank loans, foreign debt, and bank capital, that is,

$$V_{jt} = \nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt}, \tag{28}$$

where ν^l_t is the marginal value of assets, ν^*_t is the excess value of borrowing from abroad, and ν_t is the marginal value of bank capital at the end of period t. The Lagrangian which solves the bankers' profit maximization problem reads,

[10] See Section 2.8 for a detailed discussion of the asymmetry in financial frictions.

$$\max_{l_{jt}, b^*_{jt+1}} L = \nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} \tag{29}$$

$$+\mu_t \left[\nu^l_t q_t l_{jt} + \nu^*_t b^*_{jt+1} + \nu_t n_{jt} - \lambda \left(q_t l_{jt} - \omega_l \left[\frac{q_t l_{jt} - n_{jt}}{1 - rr_t} - b^*_{jt+1} \right] \right) \right],$$

where the term in square brackets represents the incentive compatibility constraint, (25) combined with the balance sheet, (15), to eliminate b_{jt+1}. The first-order conditions for l_{jt}, b^*_{jt+1}, and the Lagrange multiplier μ_t are:

$$\nu^l_t(1 + \mu_t) = \lambda \mu_t \Big(1 - \frac{\omega_l}{1 - rr_t}\Big), \tag{30}$$

$$\nu^*_t(1 + \mu_t) = \lambda \mu_t \omega_l \tag{31}$$

and

$$\nu^l_t q_t l_{jt} + \nu^*_t \left[\frac{q_t l_{jt} - n_{jt}}{1 - rr_t} - b_{jt+1} \right] + \nu_t n_{jt} - \lambda(q_t l_{jt} - \omega_l b_{jt+1}) \geq 0, \tag{32}$$

respectively. We are interested in cases in which the incentive constraint of banks is always binding, which implies that $\mu_t > 0$ and (32) holds with equality.[11] This is the case in which the loss of bankers in the event of liquidation is just equal to the amount of loans that they can divert.

An upper bound for ω_l is determined by the necessary condition for a positive value of making loans, $\nu^l_t > 0$, implying $\omega_l < 1 - rr_t$. Therefore, the fraction of nondiverted domestic deposits has to be smaller than one minus the reserve requirement ratio, as implied by (30).

Combining (30) and (31) yields,

$$\frac{\frac{\nu^*_t}{1-rr_t}}{\nu^l_t + \frac{\nu^*_t}{1-rr_t}} = \frac{\omega_l}{1 - rr_t}. \tag{33}$$

Re-arranging the binding version of (32) implies,

$$q_t l_{jt} - \omega_l b_{jt+1} = \frac{\nu_t - \frac{\nu^*_t}{1-rr_t}}{\lambda - \zeta_t} n_{jt} = \kappa_{jt} n_{jt}, \tag{34}$$

where $\zeta_t = \nu^l_t + \frac{\nu^*_t}{1-rr_t}$. This endogenous constraint, which emerges from the costly enforcement problem described above, ensures that banks' leverage of risky assets is always equal to κ_{jt} and is decreasing with the fraction of divertable funds λ.

We replace V_{jt+1} in equation (27) by imposing our linear conjecture in equation (28) and the borrowing constraint (34) to obtain,

[11] Our methodological approach is to linearly approximate the stochastic equilibrium around the deterministic steady state.

$$\tilde{V}_{jt} = E_t\Big\{\Xi_{t,t+1} n_{jt+1}\Big\}, \tag{35}$$

where $\tilde{V}_{jt}$ stands for the optimized value and $\Xi_{t,t+1} = \Lambda_{t,t+1}\Big[1-\theta+\theta\Big(\zeta_{t+1}\kappa_{t+1}+\nu_{t+1}-\frac{\nu^*_{t+1}}{1-rr_{t+1}}\Big)\Big]$ is the augmented stochastic discount factor of bankers, which is a weighted average over the likelihood of survival.

Replacing the left-hand side to verify our linear conjecture on bankers' value (28) and using equation (21), we find that ν^l_t, ν_t, and ν^*_t should consecutively satisfy,

$$\nu^l_t = E_t\Big\{\Xi_{t,t+1}\Big[R_{kt+1} - \hat{R}_{t+1}\Big]\Big\}, \tag{36}$$

$$\nu_t = E_t\Big\{\Xi_{t,t+1}\hat{R}_{t+1}\Big\}, \tag{37}$$

$$\nu^*_t = E_t\Big\{\Xi_{t,t+1}\Big[R_{t+1} - R^*_{t+1}\Big]\Big\}. \tag{38}$$

Equation (36) suggests that bankers' marginal valuation of total assets is the premium between the expected discounted total return to loans and the benchmark cost of domestic funds. Equation (37) shows that marginal value of net worth should be equal to the expected discounted opportunity cost of domestic funds, and lastly, equation (38) demonstrates that the excess value of raising foreign debt is equal to the expected discounted value of the premium in the cost of raising domestic debt over the cost of raising foreign debt. One can show that this spread is indeed positive, that is, $\nu^*_t > 0$ by studying first order condition (31) and observing that $\lambda, \mu, \omega_l > 0$, and $rr_t < 1$.

The definition of the augmented pricing kernel of bankers is useful in understanding why banks shall be a veil absent financial frictions. Specifically, the augmented discount factor of bankers can be re-written as $\Xi_{t,t+1} = \Lambda_{t,t+1}\Big[1-\theta+\theta\lambda\kappa_{t+1}\Big]$ by using the leverage constraint. Financial frictions would vanish when non of the assets are diverted, i.e. $\lambda = 0$ and bankers never have to exit, i.e. $\theta = 1$. Consequently, $\Xi_{t,t+1}$ simply collapses to the pricing kernel of households $\Lambda_{t,t+1}$. This case would also imply efficient intermediation of funds driving the arbitrage between the lending and deposit rates down to zero. The uncovered interest parity on the other hand, is directly affected by the asymmetry in financial frictions. That is, as implied by equation (38), the uncovered interest parity obtains when $\nu^*_t = 0$.

2.2.3 Aggregation

We confine our interest to equilibria in which all households behave symmetrically, so that we can aggregate equation (34) over j and obtain the following aggregate relationship:

$$q_t l_t - \omega_l b_{t+1} = \kappa_t n_t, \tag{39}$$

where $q_t l_t$, b_{t+1}, and n_t represent aggregate levels of bank assets, domestic deposits, and net worth, respectively. Equation (39) shows that aggregate credit net of nondivertable domestic deposits can only be up to an endogenous multiple of aggregate bank capital. Furthermore,

fluctuations in asset prices q_t, would feed back into fluctuations in bank capital via this relationship. This would be the source of the financial accelerator mechanism in our model.

The evolution of the aggregate net worth depends on that of the surviving bankers n_{et+1} and the start-up funds of the new entrants n_{nt+1}. Surviving bankers' net worth might be obtained by substituting the aggregate bank capital constraint (39) into the net worth evolution equation (21),

$$n_{et+1} = \theta \left(\left[R_{kt+1} - \hat{R}_{t+1} + \frac{R_{t+1} - R^*_{t+1}}{1 - rr_t} \right] \kappa_t - \left[\frac{R_{t+1} - R^*_{t+1}}{1 - rr_t} \right] + \hat{R}_{t+1} \right) n_t$$

$$+ \left(\left[R_{kt+1} - \hat{R}_{t+1} + \frac{R_{t+1} - R^*_{t+1}}{1 - rr_t} \right] \omega_l - \left[\frac{R_{t+1} - R^*_{t+1}}{1 - rr_t} \right] \right) b_{t+1}. \tag{40}$$

The start-up funds for new entrants, on the other hand, are equal to $\frac{\epsilon^b}{1-\theta}$ fraction of exiting banks' loans $(1-\theta)q_t l_t$. Therefore,

$$n_{nt+1} = \epsilon^b q_t l_t. \tag{41}$$

As result, the transition for the aggregate bank capital becomes,

$$n_{t+1} = n_{et+1} + n_{nt+1}. \tag{42}$$

2.3 Capital producers

Capital producers play a profound role in the model since variations in the price of capital drives the financial accelerator. We assume that capital producers operate in a perfectly competitive market, purchase investment goods and transform them into new capital. They also repair the depreciated capital that they buy from the intermediate goods producing firms. At the end of period t, they sell both newly produced and repaired capital to the intermediate goods firms at the unit price of q_t. Intermediate goods firms use this new capital for production at time $t+1$. Capital producers are owned by households and return any earned profits to their owners. We also assume that they incur investment adjustment costs while producing new capital, given by the following quadratic function of the investment growth

$$\Phi\left(\frac{i_t}{i_{t-1}}\right) = \frac{\Psi}{2}\left[\frac{i_t}{i_{t-1}} - 1\right]^2. \tag{43}$$

Capital producers use an investment good that is composed of home and foreign final goods in order to repair the depreciated capital and to produce new capital goods

$$i_t = \left[\omega_i^{\frac{1}{\gamma_i}} (i_t^H)^{\frac{\gamma_i - 1}{\gamma_i}} + (1-\omega_i)^{\frac{1}{\gamma_i}} (i_t^F)^{\frac{\gamma_i - 1}{\gamma_i}}\right]^{\frac{\gamma_i}{\gamma_i - 1}}, \tag{44}$$

where ω_i governs the relative weight of home input in the investment composite good and γ_i

measures the elasticity of substitution between home and foreign inputs. Capital producers choose the optimal mix of home and foreign inputs according to the intratemporal first order condition

$$\frac{i_t^H}{i_t^F} = \frac{\omega_i}{1-\omega_i}\left(\frac{P_t^H}{P_t^F}\right)^{-\gamma_i}. \tag{45}$$

The resulting aggregate investment price index P_t^I, is given by

$$P_t^I = \left[\omega_i (P_t^H)^{1-\gamma_i} + (1-\omega_i)(P_t^F)^{1-\gamma_i}\right]^{\frac{1}{1-\gamma_i}}. \tag{46}$$

Capital producers require i_t units of investment good at a unit price of $\frac{P_t^I}{P_t}$ and incur investment adjustment costs $\Phi\left(\frac{i_t}{i_{t-1}}\right)$ per unit of investment to produce new capital goods i_t and repair the depreciated capital, which will be sold at the price q_t. Therefore, a capital producer makes an investment decision to maximize its discounted profits represented by

$$\max_{i_t} \sum_{t=0}^{\infty} E_0 \left[\Lambda_{t,t+1}\left(q_t i_t - \Phi\left(\frac{i_t}{i_{t-1}}\right) q_t i_t - \frac{P_t^I}{P_t} i_t\right)\right]. \tag{47}$$

The optimality condition with respect to i_t produces the following Q-investment relation for capital goods

$$\frac{P_t^I}{P_t} = q_t\left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + E_t\left[\Lambda_{t,t+1} q_{t+1} \Phi'\left(\frac{i_{t+1}}{i_t}\right)\frac{i_{t+1}}{i_t}\right]. \tag{48}$$

Finally, the aggregate physical capital stock of the economy evolves according to

$$k_{t+1} = (1-\delta_t)k_t + \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t, \tag{49}$$

with δ_t being the endogenous depreciation rate of capital determined by the utilization choice of intermediate goods producers.

2.4 Firms

Final and intermediate goods are produced by a representative final good producer and a continuum of intermediate goods producers that are indexed by $i \in [0,1]$, respectively. Among these, the former repackages the differentiated varieties produced by the latter and sell in the domestic market. The latter on the other hand, acquire capital and labor and operate in a monopolistically competitive market. In order to assume rigidity in price setting, we assume that intermediate goods firms face menu costs.

2.4.1 Final goods producers

Finished goods producers combine different varieties $y_t(i)$, that sell at the monopolistically determined price $P_t^H(i)$, into a final good that sell at the competitive price P_t^H, according to the constant returns-to-scale technology,

$$y_t^H = \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}}. \tag{50}$$

The profit maximization problem,

$$\max_{y_t^H(i)} \quad P_t^H \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\epsilon}} di\right]^{\frac{1}{1-\frac{1}{\epsilon}}} - \left[\int_0^1 P_t^H(i) y_t^H(i) di\right] \tag{51}$$

combined with the zero profit condition implies that the optimal variety demand is,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H, \tag{52}$$

with, $P_t^H(i)$ and P_t^H satisfying,

$$P_t^H = \left[\int_0^1 P_t^H(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}. \tag{53}$$

We assume that imported intermediate good varieties are repackaged via a similar technology with the same elasticity of substitution between varieties as in domestic final good production. Therefore, $y_t^F(i) = \left(\frac{P_t^F(i)}{P_t^F}\right)^{-\epsilon} y_t^F$ and $P_t^F = \left[\int_0^1 P_t^F(i)^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$ hold for imported intermediate goods.

2.4.2 Intermediate goods producers

There is a large number of intermediate goods producers indexed by i, who produce variety $y_t(i)$ using the constant returns-to-scale production technology,

$$y_t(i) = A_t\Big(u_t(i)k_t(i)\Big)^{\alpha} h_t(i)^{1-\alpha}. \tag{54}$$

As shown in the production function, firms choose the level of capital and labor used in production, as well as the utilization rate of the capital stock. A_t represents the aggregate productivity level and follows an autoregressive process given by

$$\ln(A_{t+1}) = \rho^A \ln(A_t) + \epsilon_{t+1}^A, \tag{55}$$

with zero mean and constant variance innovations ϵ_{t+1}^A.

Part of $y_t(i)$ is sold in the domestic market, as $y_t^H(i)$, in which the producer i operates as a monopolistically competitor. Accordingly, the nominal sales price $P_t^H(i)$ is chosen by the firm to meet the aggregate domestic demand for its variety,

$$y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H, \tag{56}$$

which depends on the the aggregate home output y_t^H. Apart from incurring nominal marginal costs of production MC_t, these firms additionally face Rotemberg (1982)-type quadratic menu costs of price adjustment, in the form of

$$P_t \frac{\varphi^H}{2}\left[\frac{P_t^H(i)}{P_{t-1}^H(i)} - 1\right]^2. \tag{57}$$

These costs are denoted in nominal terms with φ^H capturing the intensity of the price rigidity.

Domestic intermediate goods producers choose their nominal price level to maximize the present discounted real profits

$$\max_{P_t^H(i)} E_t \sum_{j=0}^{\infty} \Lambda_{t,t+j}\left[\frac{D_{t+j}^H(i)}{P_{t+j}}\right] \tag{58}$$

subject to the nominal profit function

$$D_{t+j}^H(i) = P_{t+j}^H(i) y_{t+j}^H(i) + S_{t+j} P_{t+j}^{H*} c_{t+j}^{H*}(i) - MC_{t+j} y_{t+j}(i) - P_{t+j}\frac{\varphi^H}{2}\left[\frac{P_{t+j}^H(i)}{P_{t+j-1}^H(i)} - 1\right]^2, \tag{59}$$

and the demand function $y_t^H(i) = \left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon} y_t^H$. Since households own these firms, any profits are remitted to consumers and future streams of real profits are discounted by the stochastic discount factor of consumers, accordingly. Notice that the sequences of the nominal exchange rate and export prices in foreign currency $\{S_{t+j}, P_{t+j}^{H*}\}_{j=0}^{\infty}$ are taken exogenously by the firm, since it acts as a price taker in the export market. The first-order condition to this problem becomes

$$(\epsilon - 1)\left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon}\frac{y_t^H}{P_t} = \epsilon\left(\frac{P_t^H(i)}{P_t^H}\right)^{-\epsilon-1} MC_t \frac{y_t^H}{P_t P_t^H} - \varphi^H\left[\frac{P_t^H(i)}{P_{t-1}^H(i)} - 1\right]\frac{1}{P_{t-1}^H(i)} \tag{60}$$

$$+\varphi^H E_t\left\{\Lambda_{t,t+1}\left[\frac{P_{t+1}^H(i)}{P_t^H(i)} - 1\right]\frac{P_{t+1}^H(i)}{P_t^H(i)^2}\right\}. \tag{61}$$

We confine our interest to symmetric equilibrium, in which all intermediate producers choose the same price level, that is $P_t^H(i) = P_t^H \quad \forall i$. Imposing this condition to (61) and using the definitions $rmc_t = \frac{MC_t}{P_t}$, $\pi_t^H = \frac{P_t^H}{P_{t-1}^H}$, and $p_t^H = \frac{P_t^H}{P_t}$, yield

$$p_t^H = \frac{\epsilon}{\epsilon - 1} rmc_t - \frac{\varphi^H}{\epsilon - 1} \frac{\pi_t^H(\pi_t^H - 1)}{y_t^H} + \frac{\varphi^H}{\epsilon - 1} E_t \left\{ \Lambda_{t,t+1} \frac{\pi_{t+1}^H(\pi_{t+1}^H - 1)}{y_t^H} \right\}. \tag{62}$$

Notice that even if prices are flexible, that is $\varphi^H = 0$, the monopolistic nature of the intermediate goods market implies that the optimal sales price reflects a markup over the marginal cost, that is $P_t^H = \frac{\epsilon}{\epsilon-1} MC_t$.

The remaining part of the intermediate goods is exported as $c_t^{H*}(i)$ in the foreign market, where the producer is a price taker. To capture the foreign demand, we follow Gertler et al. (2007) and impose an autoregressive exogenous export demand function in the form of

$$c_t^{H*} = \left[\left(\frac{P_t^{H*}}{P_t^*} \right)^{-\Gamma} y_t^* \right]^{\nu^H} (c_{t-1}^{H*})^{1-\nu^H}, \tag{63}$$

which positively depends on foreign output, which follows and autoregressive exogeneous process hit by export demand shocks as zero mean and constant innovations. That is,

$$\ln(y_{t+1}^*) = \rho^{y^*} \ln(y_t^*) + \epsilon_{t+1}^{y^*}. \tag{64}$$

For tractability, we further assume that the small open economy takes $P_t^{H*} = P_t^* = 1$ as given. We also want to note that the model allows for the export of only consumption goods, but not investment goods. We think that this model feature is realistic for Turkey and other EMEs in general considering the observed export structure of these economies.

Imported intermediate goods are purchased by a continuum of producers that are analogous to the domestic producers except that these firms face exogenous import prices as their marginal cost. In other words, the law of one price holds for the import prices, so that $MC_t^F = S_t P_t^{F*}$. Since these firms also face quadratic price adjustment costs, the domestic price of imported intermediate goods is determined as,

$$p_t^F = \frac{\epsilon}{\epsilon - 1} s_t - \frac{\varphi^F}{\epsilon - 1} \frac{\pi_t^F(\pi_t^F - 1)}{y_t^F} + \frac{\varphi^F}{\epsilon - 1} E_t \left\{ \Lambda_{t,t+1} \frac{\pi_{t+1}^F(\pi_{t+1}^F - 1)}{y_t^F} \right\}, \tag{65}$$

with $p_t^F = \frac{P_t^F}{P_t}$, $s_t = \frac{S_t P_t^{F*}}{P_t}$, and $P_t^{F*} = 1 \; \forall t$ is taken exogenously by the small open economy.

For a given sales price, optimal factor demands and utilization of capital are determined by the solution to a symmetric cost minimization problem, where the cost function shall reflect the capital gains from market valuation of firm capital and resources that are devoted to the repair of the worn out part of it. Consequently, firms minimize

$$\min_{u_t, k_t, h_t} q_{t-1} r_{kt} k_t - (q_t - q_{t-1}) k_t + p_t^I \delta(u_t) k_t + w_t h_t + rmc_t \Big[y_t - A_t \Big(u_t k_t \Big)^{\alpha} h_t^{1-\alpha} \Big] \tag{66}$$

subject to the endogeneous depreciation rate function,

$$\delta(u_t) = \delta + \frac{d}{1+\varrho} u_t^{1+\varrho}, \tag{67}$$

with $\delta, d, \varrho > 0$. The first order conditions to this problem govern factor demands and the optimal utilization choice as,

$$p_t^I \delta'(u_t) k_t = \alpha \Big(\frac{y_t}{u_t}\Big) rmc_t, \tag{68}$$

$$R_{kt} = \frac{\alpha\Big(\frac{y_t}{k_t}\Big) rmc_t - p_t^I \delta(u_t) + q_t}{q_{t-1}}, \tag{69}$$

and

$$w_t = (1-\alpha)\Big(\frac{y_t}{h_t}\Big) rmc_t. \tag{70}$$

2.5 Monetary authority and the government

The monetary authority sets the short-term nominal interest rate via a simple (and implementable) monetary policy rule that includes only a few observable macroeconomic variables and ensures a unique rational expectations equilibrium.[12] Given home goods inflation and relative prices, the definition of the CPI in equation (2) determines the evolution of aggregate inflation in the model economy

$$(1+\pi_t)^{1-\gamma} = \omega(1+\pi_t^H)^{1-\gamma}(p_t^H)^{1-\gamma} + (1-\omega)(1+\pi_t)^{1-\gamma}(s_t)^{1-\gamma}. \tag{71}$$

We consider three different types of Taylor rules. The first rule, that we call as T1, is the conventional Taylor rule that reacts to inflation and output gap, which is given by

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n} \log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_y \log\left(\frac{y_t^H}{\overline{y}}\right)\right].$$

The second rule, that we name as T2, is an augmented Taylor rule that responds to the growth of domestic credit in addition to inflation gap, which is given by

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n} \log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_l \log\left(\frac{q_t l_t}{q_{t-1} l_{t-1}}\right)\right].$$

Finally, third rule, that we call as T3, is an augmented Taylor rule that responds to the depreciation in the real exchange rate in addition to the inflation gap, which is given by

$$\log\left(\frac{1+r_{nt}}{1+\overline{r_n}}\right) = \rho_{r_n} \log\left(\frac{1+r_{nt-1}}{1+\overline{r_n}}\right) + (1-\rho_{r_n})\left[\varphi_\pi E_t \log\left(\frac{1+\pi_{t+1}}{1+\overline{\pi}}\right) + \varphi_s \log\left(\frac{s_t}{s_{t-1}}\right)\right],$$

[12] For further discussion on simple and implementable rules, see Schmitt-Grohe and Uribe (2007).

where variables with bars denote respective steady-state values that are targeted by the central bank.

In the benchmark specification, we assume that the required reserves ratio is fixed at $rr_t = \overline{rr}\ \forall t$, with $\overline{rr}$ denoting a steady state level. In section 3.4 we investigate whether reserve requirements can play a macroprudential role in inducing banks to prudential borrowing. In particular, we assume that required reserve ratios for both domestic and foreign deposits respond positively to the deviation of the noncore liabilities share from its steady-state value, that is,

$$\log(1+rr_t) = (1-\rho_{rr})\log(1+\overline{rr}) + \rho_{rr}\left[\log(1+rr_{t-1}) + \varphi_{rr}\left(\frac{b^*_{t+1}}{b_{t+1}+b^*_{t+1}} - \overline{\frac{b^*}{b+b^*}}\right)\right] + \epsilon^{rr}_t$$

with $0 < \rho_{rr} < 1$, $\varphi_{rr} > 0$, and ϵ^{rr}_t is a normally distributed disturbance to rr_t with zero mean and constant standard deviation σ^{rr}. Notice that this specification both involves inertia and nests the analysis of discretionary changes in the reserve requirements for $\varphi_{rr} = 0$, and $\sigma^{rr} \neq 0$. Recall that as denoted by the constraint (25), noncore liabilities are fully diverted so that financial frictions intensify as the liability structure favors foreign debt more. Therefore, the central bank can lean against the wind by increasing reserve requirements when the share of risky borrowing increases.[13]

Money supply in this economy will be demand determined and it compensates for the cash demand of workers and the required reserves demand of bankers. Consequently, the money market clearing condition is given by

$$M_{0t} = M_t + rr_t B_{t+1}, \tag{72}$$

where M_{0t} denotes the supply of monetary base at period t.

We also assume that the monetary authority might have three alternative policy mandates. The first policy mandate targets macroeconomic stability by trying to minimize the loss function, $\sigma^2_\pi + \sigma^2_y$, where both inflation and output volatilities have equal weights. The second policy mandate targets domestic financial stability in addition to macroeconomic stability by trying to minimize the loss function, $\sigma^2_\pi + \sigma^2_y + \sigma^2_{credit}$, where inflation, output and bank credit volatilities have equal weights. Finally, the third policy mandate targets external financial stability in addition to macroeconomic stability by trying to minimize the loss function, $\sigma^2_\pi + \sigma^2_y + \sigma^2_{RER}$, where inflation, output and real exchange rate volatilities have equal weights.

Government consumes a time-varying fraction of home goods g^H_t that follows the exogenous process

$$\ln(g^H_{t+1}) = (1-\rho^{g^H})\bar{g^H} + \rho^{g^H}\ln(g^H_t) + \epsilon^{g^H}_{t+1}, \tag{73}$$

where $\epsilon^{g^H}_{t+1}$ is a Gaussian process with zero mean and constant variance. We introduce this shock to capture disturbances in domestic aggregate demand that create a trade off for the

[13]See Glocker and Towbin (2012) and Mimir et al. (2013) for similar reserve requirement specifications.

monetary policy in responding to inflation or output.

The fiscal and monetary policy arrangements lead to the consolidated government budget constraint,

$$p_t^H g_t^H y_t^H = \frac{M_t - M_{t-1}}{P_t} + \frac{rr_t B_{t+1} - rr_{t-1} B_t}{P_t} + \frac{T_t}{P_t}. \tag{74}$$

Lump sum taxes $\tau_t = \frac{T_t}{P_t}$ are determined endogenously to satisfy the consolidated government budget constraint at any date t.

2.6 Resource constraints

The resource constraint for home goods equates domestic production to the sum of domestic and external demand for home goods and the real domestic price adjustment costs, so that

$$y_t^H = c_t^H + c_t^{H*} + i_t^H + g_t^H y_t^H + \left(p_t^H\right)^{-\gamma} \frac{\varphi^H}{2} \left(\pi_t \frac{p_t^H}{p_{t-1}^H} - 1\right)^2. \tag{75}$$

A similar market clearing condition holds for the domestic consumption of the imported goods, that is,

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-\gamma} \frac{\varphi^F}{2} \left(\pi_t \frac{p_t^F}{p_{t-1}^F} - 1\right)^2. \tag{76}$$

The balance of payments vis-à-vis the rest of the world defines the trade balance as a function of net foreign assets

$$R_t^* b_t^* - b_{t+1}^* = c_t^{H*} - y_t^F. \tag{77}$$

Finally, the national income identity that reflects investment adjustment costs built in capital accumulation condition (49) would read,

$$y_t = y_t^H - y_t^F. \tag{78}$$

2.7 Competitive equilibrium

A competitive equilibrium is defined by sequences of prices $\left\{p_t^H, p_t^F, p_t^I, \pi_t, w_t, q_t, s_t, R_{kt+1}, R_{t+1}, R_{t+1}^*\right\}_{t=0}^{\infty}$, government policies $\{r_{nt}, rr_t, M_{0t}, T_t\}_{t=0}^{\infty}$, allocations $\left\{c_t^H, c_t^F, c_t, h_t, m_t, b_{t+1}, b_{t+1}^*, \varphi_t, l_t, n_t, \kappa_t, \nu_t^l, \nu_t^*, \nu_t, i_t, i_t^H, i_t^F, k_{t+1}, y_t^H, y_t^F, y_t, u_t, rmc_t, c_t^{H*}, D_t^H, \Pi_t, \delta_t\right\}_{t=0}^{\infty}$, initial conditions, b_0, b_0^*, k_0, m_-, n_0 and exogenous processes $\left\{A_t, g_t^H, \psi_t, r_{nt}^*, y_t^*, \sigma_t^{r_n^*}\right\}_{t=0}^{\infty}$ such that;

i) Given exogenous processes, initial conditions, government policy, and prices; the allocations solve the utility maximization problem of households (6)-(7), the net worth maximization problem of bankers (24)-(25), and the profit maximization problems of capital producers (47), final goods producers (51), and intermediate goods producers (58)-(59) and (66)-(67).

ii) Home and foreign goods, physical capital, investment, security claims, domestic deposits, money, and labor markets clear. The balance of payments and GDP identities (77) and (78) hold.

2.8 Asymmetric financial frictions breaking uncovered interest parity (UIP)

The general idea regarding the violation of the UIP condition is that domestic financial markets could be repressed and gain of access to international debt markets might entail various costs, pushing up domestic interest rates above country borrowing rates.[14] We establish this result analytically by observing that when $\lambda, \mu, \omega_l > 0$, and $rr_t < 1$, equation (31) yields $\nu_t^* > 0$. Therefore, the excess value of borrowing from abroad should be positive and in equilibrium, domestic depositors are expected to charge more compared to international lenders. From the perspective of global financial markets efficiency, this finding also suggests that UIP does not hold due to asymmetry in financial frictions.

Figure 2 illustrates how financial frictions are modified when ω_l is introduced into the problem. We plot the external funds market on the left panel of the figure, in which absent financial frictions, there is a perfectly elastic supply curve, and a downward sloped demand curve for foreign funds. Indeed, the slope of the supply curve is slightly positive since the country risk premium increases with the foreign debt-to-GDP ratio. When $\lambda > 0$, the incentive constraint binds and the supply curve for external funds become vertical at the equilibrium level of foreign debt b_ω^*. The panel on the right displays the domestic funds market and covers three cases regarding the asymmetry of financial frictions. Notice that as opposed to the chart on the left, the supply curve in this market is upward sloped and is implied by the consumption-savings margin of households.

When $\omega_l = 0$, financial frictions are symmetric in both markets and the supply curve makes a kink at the equilibrium domestic debt level $b_{\omega=0}$, and becomes vertical. This case corresponds to the UIP condition so that there is no arbitrage between the two sources of external finance, yielding $R_k > R = R^*$. When ω_l takes an intermediate value between 0 and 1, the kink on the supply curve shifts to the right (the dotted-dashed curve). Since $R_k > R$, the demand curve of bankers shifts to the right until the value of relaxing the incentive constraint becomes equal to the excessive cost of domestic deposits on the margin, resulting in $R_k > R > R^*$. Lastly, when $\omega_l = 1$, the domestic deposit markets become frictionless and the supply curve becomes continuous rendering banks a veil from the perspective of households. In this case, $R_k = R > R^*$, implying that depositing at a financial intermediary is no different than directly investing in physical capital for households. This shifts the equilibrium level of domestic debt further to the right to $b_{\omega=1}$. Therefore, the existence of asymmetry in external financing is instrumental in the determination of the liability structure of bankers.

For simplicity, we did not plot the impact of changes in ω_l on the amount of foreign debt. Indeed, one shall expect that the share foreign debt increases with ω_l despite the increase

[14] See Munro (2014) on the conditions regarding the measurement of the deviation from the UIP condition.

in domestic deposits. This is because ω_l levers up bankers, that is, it facilitates smaller amounts of domestic borrowing to bring enough relaxation of the financial constraint (25) in matching the excess cost of domestic debt. In Section 3.3, we explore the impact of changing ω_l on the amplification of shocks.[15]

3 Quantitative analysis

This section analyzes the quantitative predictions of the model by studying the results of numerical simulations of an economy calibrated to the broad features of an emerging market such as Turkey, for which financial frictions in the banking sector and monetary policy tools analyzed here are particularly relevant. To investigate the dynamics of the model, we compute a first-order approximation to the equilibrium conditions.[16]

3.1 Model parametrization and calibration

Table 2 lists the parameter values used for the quantitative analysis of the model economy. The preference and production parameters are standard in the business cycle literature. Starting with the former, we fix the quarterly discount factor, β, at 0.9821, to match the 7.48% average annualized real deposit rate observed in Turkey. The relative risk aversion, σ is taken as 2. We pick the relative utility weight of labor, χ, to fix hours worked in the steady state at one third of the available time. The Frisch elasticity of labor supply parameter, ξ, is taken as 5 to limit the response of hours worked to wages, helping the model to capture the fall in hours after an interest rate shocks. We set the habit persistence parameter, h_c, to 0.7, as commonly used in the literature. The relative utility weight of money, υ, is chosen as 0.35 to match the M2-GDP ratio. Following Gertler et al. (2007), we take the intra-temporal elasticity of substitution for the consumption composite, γ, as 1 and the intra-temporal elasticity of substitution for the investment composite good, γ_i, as 0.25. We set the share of domestic goods in the consumption composite, ω, to 0.4 to match the average share of consumption in GDP in Turkey over the period 2002-2014. We pick the elasticity of export demand with respect to prices as 1, the share parameter, ν^F, as 0.25, the foreign output, Y_t^* as 0.16 to match the average share of exports in GDP.

We calibrate the financial sector parameters, the fraction of the revenues that can be diverted, λ, the proportional transfer to newly entering bankers, ϵ^b, the fraction of domestic deposits that cannot be diverted, ω_l, and the survival probability of bankers, θ simultaneously to match the following four targets: an average lending spread from domestic funds

[15] The asymmetry as modelled by better monitoring ability of domestic depositors might be thought as the result of an implicit partial deposit insurance provided to households, who are awarded by higher deposit rates compared to foreigners. Full deposit insurance would correspond to the case in which $\omega_l = 1$ so that domestic deposits are fully nondiverted.

[16] We also conduct a second-order approximation to the equilibrium conditions of the model. The main results of the paper including impulse responses and business cycles statistics remained unchanged. All computations are conducted using Dynare.

of 34 basis points, which is the historical average of the difference between the quarterly commercial loan rate and the quarterly domestic deposit rate from 2002 to 2014, an average lending spread from foreign funds of 152 basis points, which is the historical average of the difference between the quarterly commercial loan rate and the quarterly foreign rate in domestic currency terms from 2002 to 2014, an average bank leverage of 7.95, which is the historical average of Turkish commercial banks' leverage for the same period, and the share of foreign funds in total bank liabilities, which is 0.4083 for Turkish commercial banks. The resulting values for λ, ω_l, θ, and ϵ are 0.65, 0.81, 0.925 and 0.00195, respectively.[17]

Regarding the technology parameters, the share of capital in the production function, α is set to 0.4 to match the labor share of income in Turkey. We pick the share of domestic goods in the investment composite, ω_i, as 0.87 to match the average share of investment in GDP in Turkey over the period 2002-2014. The steady-state utilization rate is normalized at 1 and the quarterly depreciation rate of capital is taken as 3.5% to match the average annual investment to capital ratio. The elasticity of marginal depreciation with respect to the utilization rate, ϱ, is set to 1 as in Gertler et al. (2007). The investment adjustment cost parameter, ψ, is taken as 4 to match the elasticity of the price of capital with respect to the investment-capital ratio. We set the elasticity of substitution between varieties in final output, ϵ, to 11, to have a steady-state mark-up value of 1.1. We choose Rotemberg price adjustment cost parameters in domestic and foreign intermediate goods production, φ_H and φ_F, as 120 to have a probability of the price not adjusting of 0.75 in both sectors.

We take the inertia parameter, ρ_{r_n}, as 0.85 in all of Taylor rule specifications. Regarding the response coefficients on CPI inflation, output, credit growth and changes in RER, we use the optimized values which minimized the loss function. These values are reported in Table 4 for each different rule under different policy mandates. Moreover, we assume that the required reserve ratios for domestic and foreign currency denominated deposits are symmetric and we take them as 0.09 to match the average reserve requirement ratio in Turkey for the period 1996-2015. We choose the persistence parameter of reserve requirement ratio ρ_{rr}, as 0.5 to reflect the relatively discretionary use of reserve requirements in EMEs including Turkey.[18] We set the steady state government expenditure to GDP ratio to 0.10 to match the average share of government spending in GDP in Turkey over the period 2002-2014.

Finally, we estimate three independent AR(1) processes for the share of public demand for home goods, g_t^H, country risk premium, Ψ_{t+1}, and the US interest rate, $R^*_{nt+1}$where $\epsilon^{g^H}_{t+1}$, ϵ^{Ψ}_{t+1}, and $\epsilon^{R^*_n}_{t+1}$ are i.i.d. shocks. The resulting estimated persistence parameters are $\rho_{g^H} = 0.457$, $\rho_{\Psi} = 0.963$, and $\rho_{R^*_n} = 0.977$. The estimated standard deviations are $\sigma_{g^H} = 0.04$, $\sigma_{\Psi} = 0.0032$, and $\sigma_{R^*_n} = 0.001$. Parameters underlying the TFP shock are taken from Bahadir and Gumus (2014). They estimate an AR(1) process for the Solow residuals coming from tradable output in Turkey. The persistence parameter, ρ_A, is equal to 0.662 and the standard deviation, σ_A is equal to 0.0283. Finally, we calibrate the export demand shock

[17]The proportional transfer to newly entering bankers is small (less than 0.2% of total bank assets), hence it does not have significant impact on the model results.

[18]Model dynamics are not sensitive to this parameter.

process under all shocks to match both the persistence and the volatility of Euro area GDP, which are 0.31 and 0.48%, respectively. The resulting persistence, ρ_{y^*}, and the standard deviation, σ_{y^*}, parameters are 0.425 and 0.0048, respectively.

3.2 Dynamics of the model economy

In this section, we first explore the importance and relevance of external shocks (excluding the policy uncertainty shock) that emerging economies face compared to more conventional shocks by conducting variance decomposition analysis. We run this analysis under a conventional Taylor rule responding to inflation and output gap. We then search for optimal Taylor type monetary policy rules which minimize losses under different policy mandates by conducting a discrete grid search for response coefficients. In this analysis, we consider three monetary policy rules under three different policy mandates that care about macroeconomic stability (inflation and output volatility), domestic financial stability (inflation, output and credit volatility) and external financial stability (inflation, output and RER volatility).

Under these optimized monetary policy rules, we investigate the dynamics of the model presented in Section 2 in response to external shocks that are more relevant for emerging economies in the period since the global financial crisis. The first shock that we study introduces an annualized 127 basis points hike in the country borrowing premium of the model economy, as emerging economies faced during the taper tantrum period around May 2013. We then consider an exit/normalization scenario, in which a one time increase of 39 basis points per annum in the US policy rate occurs. This estimated volatility magnitude of the hike in the US policy rate is also in line with magnitudes discussed in policy debates the initial rise in the FED funds rate is expected to be moderate when the policy normalization starts.

After studying the shock to the level of the world interest rates, we also explore the repercussions of policy uncertainty regarding the normalization calendar of the U.S. policy rate hike. We aim to capture this phenomenon by first feeding a trajectory of an increase of 350 basis points over 12 quarters into our model simulations (in line with the FOMC projections of the Fed illustrated in the July, 2015 Monetary Policy Report) and then reducing the rate hike horizon to 6 quarters.[19]. We accompany these financial shocks with conventional TFP, government spending and export demand shocks in the overall analysis which might be important in understanding different policy trade-offs that the emerging economies might face.

Finally, we introduce reserve requirements as a countercyclical policy tool, which aims to induce banks to favor core liabilities in the determination of their funding structure. With this formulation, we try to capture the idea that central banks or supervisory authorities deploy policy tools to encourage banks to have and less vulnerable balance sheets. We choose the response coefficient of this policy rule by first optimizing it simultaneously with a standard Taylor rule and second optimizing it separately to minimize a loss function that target price and output stability. Joint versus separate optimization of the reserves rule

[19]The projections can be obtained at the link http://www.federalreserve.gov/monetarypolicy

elaborates on the policy coordination dilemma that authorities face.

3.2.1 Variance decomposition

Table 3 reports the unconditional variance decomposition of main model variables under TFP, government spending and external shocks operating simultaneously.[20] The results illustrate that country risk premium shocks explain most of the variation in financial and external variables as well as consumption and inflation rate. Regarding the financial and external variables, country risk premium shocks explain more than half of the volatilities, particularly 86.67% of the fluctuations in the real exchange rate. The latter result indicates the importance of risk premium shocks in explaining the real exchange rate movements. When we look at the nominal variables, we observe that these shocks contributes to explaining 54% of the variation in CPI inflation and 34% of the variation in the policy rate. These results underscore the relevance of external conditions in driving inflation dynamics and the extent to which the policy rate decisions are affected by the external conditions.

The table also shows that the U.S. interest rate shocks explain more or less 8% of the variation in almost all variables, which is consistent with the empirical findings by Uribe and Yue (2006). TFP shocks explain 87% of the volatility in output, 93% of the volatility in investment, and 58% of the variation in policy rate while they contribute about tenth of a percent of the variation in real exchange rate, and about one-third of the variation in credit and lending spreads. Export demand shocks derive a negligible amount of volatility in almost all variables. Overall, these findings motivate us to focus mainly on external shocks and specifically on country risk premium shocks that directly impact the cost of foreign borrowing faced by an emerging economy.

3.2.2 Optimized monetary policy rules

Table 4 reports the optimized coefficients as well as the implied losses for the three monetary policy rules described in section 2.5. The top, middle, and bottom panel of the table report loss values for each rule under; (i) a standard mandate that cares about inflation and output volatility, (ii) a financial stability mandate, which augments credit volatility to the standard mandate, and (iii) an external stability mandate that augments real exchange rate volatility to the standard mandate, respectively. Within each mandate, rows report the loss values implied by the optimized coefficients under a particular shock. The second and third columns of each vertical panel report the optimized coefficients searched over a discrete grid. We search inflation response coefficients over [1.001,3] and the other coefficients over [0,3]. Both grids have 15 elements. The loss values typed in bold denote the minimum loss across alternative rules.

There are two main results that emanate from Table 4. First, in this model, there is no motive for the short term interest policy in responding to the real exchange rate depreciation, as the associated optimized coefficient is zero in numerous cases and much

[20] The underlying Taylor rule is a conventional rule with parameters $\rho_{r_n} = 0.84$, $\varphi_\pi = 1.87$ and $\varphi_y = 0.16$ similar to the ones used by BGG et al. (1999) and Smets and Wouters (2007).

smaller compared to the obtained output and credit response coefficients in the other rules. This finding is better understood when the model generated volatility and cross-correlation of key model variables are studied, as we report in tables 6 and 5, respectively. Specifically, table 5 shows that due to the exchange rate passthrough, the real exchange rate and inflation comove, which limits the capability of exchange rate augmented rule in reducing volatilities. Therefore, following the adverse shocks, the sharp contractionary response of policy rates to the real depreciation is detrimental to the domestic demand, increasing the volatilities in macroeconomic and financial variables.

Second, credit augmented monetary policy rule outperforms the conventional Taylor rule under mandates that target financial and external stability and in response to financial shocks. Recall that external financial shocks lead to a positive correlation between bank credit and output, while inflation moves in the opposite direction (see table 5). Moreover, as illustrated by table 6, volatility of credit relative to output is much greater in response to external shocks than the cases of domestic real shocks. Therefore, the central bank chooses to LATW, especially when it considers financial stability explicitly in its mandate.[21]

To illustrate the second point, we compare the impulse responses of model variables to the country risk premium shocks under rules T1 and T2 in the next section. In figures 3 and 4, we plot model implied deviations of selected macroeconomic and financial variables from their steady state values. The deviations are presented in annualized basis point changes for policy rate, loan deposit spreads and country risk premium; in annualized percentage point change in CPI inflation, and in percentage changes for the rest of the variables. In each figure, the straight and dashed plots represents the impulse response functions under the policy rules T1 and T2, respectively. For ease of exposition, we exclude T3, since it is dominated by the other rules.

3.2.3 Taper tantrum shock

The initial impact of country borrowing premium shock is reflected on the floating exchange rate in the direction of a sharp depreciation, which amplifies the increase in the cost of foreign borrowing (see the straight plots in Figure 3). In particular, the model produces a depreciation of 5% in the real exchange rate, which is comparable to the experience of emerging economies during the taper tantrum. The resulting correction in the cyclical component of current account balance-to-GDP ratio is about 0.25%. In line with capital outflows, the liability structure of banks evolve substantially towards domestic deposits. Under the baseline policy rule T1, the exchange rate pass-through from increased nominal depreciation leads to a rise in inflation by about 0.8 percentage points per annum. Banks cannot substitute foreign funds with domestic deposits easily as domestic funds also get more expensive after the shock. Therefore, banks cannot compensate the fall in their foreign funds with increasing domestic borrowing, leading to a fall in their demand for capital claims issued by nonfinancial firms to collapse and igniting a 0.2% decline in asset prices (see Figure 3).

[21] The study of Abbasoglu et al. (2015) documents that for the period 2003Q1:2013Q4, the volatility of credit relative to output is 1.46 in the Turkish economy.

The fall in asset prices feeds back into the endogenous leverage constraint, (39) and hampers bank capital severely (1.5% fall on impact).[22] The tightening financial conditions and declining asset prices in total, reduces bank credit (0.2%) on impact, and amplifies the decline in investment (up to 1%), and output (up to 0.025%) in five quarters. Observed surges in credit spreads over both domestic and foreign borrowing costs reflect the tightened financial conditions in the model. The decline in output and increase in inflation eventually calls for about 35 basis points increase in the short term policy rate in the baseline economy.

When the short term interest rate policy is augmented with a credit target, i.e., under T2, policy reaction of the interest rate rule changes substantially in response to the risk premium shock. In particular, there is a much less pronounced rise in the policy rate on impact as opposed to the significant hike in the baseline case under T1 (30 basis points vs. 20 basis points at the peak). The central bank's policy response is moderate in this case compared to the conventional Taylor rule since it also cares about the fluctuations in the credit market. The more aggressive the central bank responds to the risk premium shock, the more loan rate increases and the more detrimental effects are observed in the credit supply side of the economy. Therefore, a muted response of the policy rate under T2 leads to a limited increase in the real interest rate due to nominal rigidities, which eases financial conditions substantially for bankers. Consequently, the reduction in bankers' demand for capital claims is much lower, reducing both the contraction in credit and fall in asset prices. The relatively less pronounced rises in the loan-deposit spreads (by 20 and 2 basis points less over cost of foreign and domestic borrowing, respectively) reflect the more contained tightening in financial conditions.

These findings suggest that monetary authorities in emerging economies might have had domestic financial stability considerations when they reduced their policy rates as observed during the financial crisis episode. Our results indicate that monetary policy can lean against the wind by responding to domestic financial conditions.

3.2.4 The US monetary policy normalization as a flight to quality

A relevant policy experiment for emerging economies is to explore how macroeconomic and financial conditions are going to unfold following the policy normalization by the Fed. In figure 4, we assess the policy performances of the rules T1 and T2 under a 39 basis points per annum increase in the U.S. policy rate. As clearly implied by the Fisher equation associated with the country borrowing rate, (17), this shock increases the cost of foreign funds for banks due to both the rise in world interest rates and the depreciation in real exchange rates. Higher cost of foreign funds induces banks to borrow less from abroad over time and

[22] Three different forces affect the evolution of bank net worth and bank profitability in general after shocks: the change in the volume of bank credit, the change in domestic and foreign lending spreads, and the change in the asset prices. The response of bank net worth following shocks depends on the strength of these opposing forces. Following an unfavorable risk premium shock, on impact, the decline in the volume of bank credit and the fall in asset prices dominate the dynamics of bank net worth, leading to a decline in this variable. However, after a few periods, the rise in the domestic and foreign lending spreads starts to dominate the fall in bank credit and the reduction in asset prices, leading to an increase in bank net worth.

this leads to a reduction in country borrowing premium along the transition.

Capital outflows due to the rate hike causes a depreciation in the real exchange rate by 1.75%, creating a current account reversal of about 0.1 in percent to output due to the increase in external competitiveness. The nominal exchange rate depreciation of nearly 2% raises the inflation rate by 0.375 percentage points, causing the policy rate to eventually tighten by about 15 basis points, per annum. Therefore, in the baseline economy under T1, monetary policy responds by less than one-to-one to the flight to quality shock.

Similar to the risk premium shock experiment, domestic and foreign lending spreads rise by 30 and 3.5 basis points per annum, respectively, due to higher real interest rates, which translates into a tightening in financial conditions for banks. The banks' balance sheets deteriorate due to the exchange rate depreciation, igniting a decline in asset prices by 0.15% and consequently reductions in bank capital and bank credit by 0.5% and 0.2%, respectively. Although output and consumption fall by less than a percent in response to this shock of small magnitude, investment declines by more than 0.4% along a period of 6 quarters. The comparison of the conventional and credit augmented monetary policy rules under this experiment are qualitatively similar to the case of country risk premium shocks.

3.2.5 Uncertainty in the US monetary policy normalization

The FOMC publishes the distribution of its members' current, one year-ahead, and longer term expectations regarding the evolution of the Federal Funds Rate. The lack of consensus within the FOMC manifests itself as the uncertainty regarding the policy normalization calendar of the Federal Reserve. In our model, we capture this phenomenon by simulating the model under two alternative paths. The first path, denoted as Path 1, involve a gradual 350 basis points increase in the fed funds rate over twelve quarters from 2016:Q1 to 2018:Q4 as announced in the FED's monetary policy report on July 15, 2015. The second path, denoted as Path 2 involve the same magnitude of increase in the policy rate over six quarters from 2016:Q1 to 2017:Q2. Therefore, the uncertainty regarding the policy normalization is defined as the uncertainty about which exact policy rate path (Path 1 vs. Path 2) the FED will actually follow. Although we feed the actual series of shocks into the model, they are perfectly anticipated by the agents in the economy as they predict future values of U.S. policy rate using the AR(1) process.

Figure 5 reports the responses of selected model variables under the Path 1 (blue dashed lines) and the Path 2 (red dashed lines). One might easily observe that the Path 1 involves a more gradual and less aggressive rate hike compared to the Path 2. Here we would like to note that we conduct this particular experiment using the standard Taylor rule under BGG(1999) response coefficients. The responses of model variables under each policy path are consistent with the ones from the previous section on the U.S. interest rate shock. We would like to emphasize that all selected model variables display more pronounced quarter-by-quarter responses under the Path 2 compared to the Path 1. However, some financial variables such as bank net worth, asset prices, domestic and foreign lending spreads together with the real exchange rate and the CPI inflation rate also feature more amplified responses at the end of the normalization period.

The U.S. policy rate hike under both paths generates an economic downturn in the small open economy. It leads to capital outflows, bringing current account reversals of the same magnitude under both paths. However, the liability composition of banks shifts to domestic deposits more severely under the Path 2, leading to a higher real exchange rate depreciation and more rapid rise in the CPI inflation rate. Therefore, the domestic policy rate hike is more aggressive under the Path 2. The more severe reduction in funding sources of banks under Path 2 leads them to tighten the credit conditions more. This hampers the supply of credit, investment by non-financial firms, asset prices and bank net worth, all of which decline more substantially under Path 2. The former causes both domestic and foreign lending spreads to increase more rapidly under the Path 2. Based on these results, we conclude that the exact policy normalization calendar of the FED (both in terms of the magnitudes and the timing of rate hikes) is crucial for macroeconomic and external dynamics of EMEs together with their domestic policy response to the U.S. policy rate hike.

3.3 Asymmetry in financial frictions

In figure 6 we explore the impact of the asymmetry in financial frictions by using different ω_l values, which capture the fraction of nondiverted domestic deposits. The value of ω_l increases as we move along the dashed, straight, and dotted-straight plots in which the straight plots correspond the benchmark value of this parameter. As expected, we find that the volatility of macroeconomic and financial variables, as well as monetary variables get smaller as the fraction of nondiverted domestic deposits increases. Furthermore, when the steady-states of these economies are compared we find that the share of foreign debt in the liability composition increases. This is because when ω_l goes up, bankers are able to relax their financial constraint by demanding smaller amounts of domestic deposits, all else equal. Therefore, a higher ω_l levers up their ability to enjoy the cost advantage of the risky foreign debt.

3.4 Optimal interest rate and reserve requirement policies

Coordination of policymaking among monetary and supervisory authorities has been a central issue since the aftermath of the recent global financial crisis.[23] In this section, first we explore whether optimized reserve requirement policies that aim to stabilize noncore bank funding improve upon a standard Taylor rule in achieving macroeconomic stabilization. Furthermore, we investigate whether a supervisory authority should separately optimize a reserve requirement policy or coordinate with the central bank (in minimizing the sum of volatilities of inflation and output).

Figure 7 compares the impulse responses of the model economy under the optimized standard Taylor rule (dashed plots), an economy in which the reserve requirement (as described in section 2.5) and short term interest policies are jointly optimized (cooperation,

[23] Angelini et al. (2012) find that inadequate cooperation between monetary and macroprudential policies might result in suboptimal results.

straight plots), and an economy in which the two policies are separately optimized (lack of cooperation, dotted-straight plots). Following the adverse risk premium shock, cost of foreign debt rises inducing a portfolio switch towards domestic deposits, which bear more interest cost. When the economy under lack of cooperation is considered, the separately optimized reserves policy calls for a decline of 1.8 percentage point in the reserve requirement ratio over 15 quarters, which reduces the tax on deposits and supports bankers' funding structure. This limits the decline in funds available to purchase security claims issued by nonfinancial production firms and substantially limit the tightening in domestic financial conditions as measured by the decline in asset prices and the rise in credit spreads. Since the adverse effect of this supply side shock is partly eliminated, inflation rises less and short term interest rates display a relatively weak response. As a result, the overall decline in real economic activity is smaller compared to the absence of the reserves policy, implying that an independent supervisory authority might lean against the wind by operationalizing required reserves to induce banks to prudent borrowing. When the policy coordination is considered (straight plots), we find that policy accommodation brought by the decrease in reserve requirements is stronger (2.5 percentage points in 15 quarters). Consequently, the economy under jointly optimized monetary and reserve requirement policies produces less volatilities in inflation, credit, asset prices, and the real exchange rate compared to the other two economies. These results are confirmed by the loss values that are listed in table 7, which reports the optimized response coefficient of reserve requirement policies under cooperation and lack of cooperation.

4 Conclusion

This paper contributes to the previous literature by investigating the quantitative performances of LATW type monetary policy rules and reserve requirement policies in mitigating the negative impacts of external shocks on macroeconomic, domestic and external financial stability. To this aim, we build a New Keynesian small open economy model of banking with domestic and foreign borrowing where external and financial conditions influence macroeconomic dynamics. We show that the model is quite successful in explaining the observed dynamics of real, financial and external sides of EMEs during the recent financial crisis. Three main results stand out. First, we find that LATW type monetary policy rules, in particular, credit-augmented IT rules, outperform conventional and RER augmented interest rate rules under financial and external stability mandates of a central bank due to more balanced policy rate responses to adverse external financial shocks. Second, our results also show that augmenting a conventional inflation targeting rule with a RER stabilization objective does not contribute to macroeconomic stabilization because of the detrimental effects of the fear of floating-which manifests itself as a sharp interest rate hike-that curbs the supply of credit and hurts the real economy. Finally, we show that a countercyclical reserve requirement policy responding to the noncore liabilities share of banks can improve upon a conventional Taylor rule due to its cost balancing effect against the rising cost of foreign debt led by adverse external shocks.

We would like to note some caveats regarding the analysis in this paper. First, as in any quantitative macroeconomic model of policy advice, the quantitative policy prescriptions regarding the LATW and reserve requirement policies might be model-specific. In particular, the volatility of credit relative to output under the case of financial shocks is considerably higher in our model economy, which might overestimate the stabilization ability of the credit-augmented rule. Therefore, policymakers must conduct a battery of robustness checks with different parameters and model specifications before incorporating the model insights into their decisions. Second, from a methodological point of view, our model is suitable to study the interaction of monetary and macroprudential policies in crisis times, since we always assume that leverage constraints are always binding.

Important avenues for further research can be summarized as follows. In order to cover the dynamics in the run up to a crisis, the model might be extended to one that allows occasionally binding leverage constraints, which would require the use of global approximation routines in its quantitative analysis. Second, the model can be estimated using Bayesian techniques rather than to be calibrated to the data. In this way, the EME data can guide the researcher to estimate the important parameters of the model. Finally, one can also incorporate the firms' balance sheets considerations into the model in addition to the banks' balance sheets to study how the policy prescriptions of the model are affected from this additional source of financial amplification.

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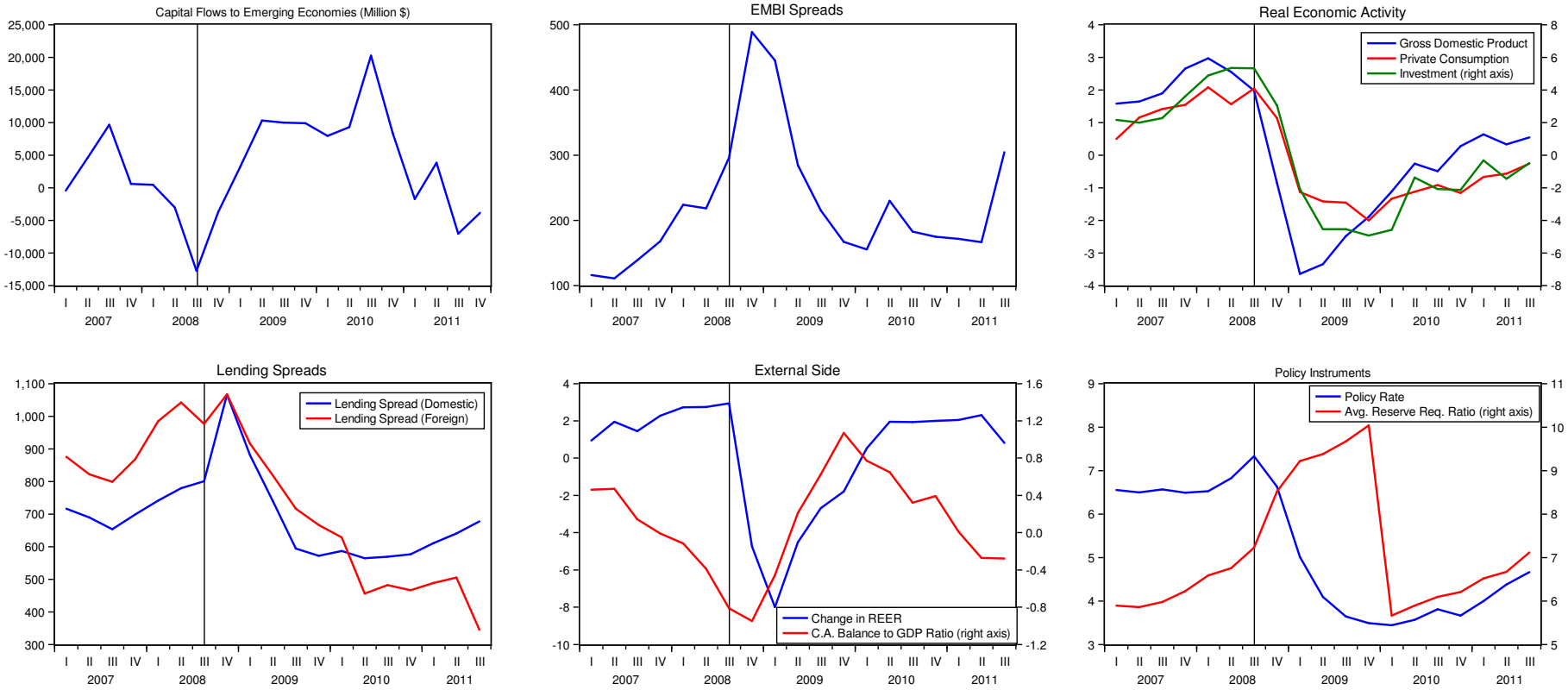

Figure 1: Macroeconomic Dynamics around the 2007-09 Crisis in Emerging Markets

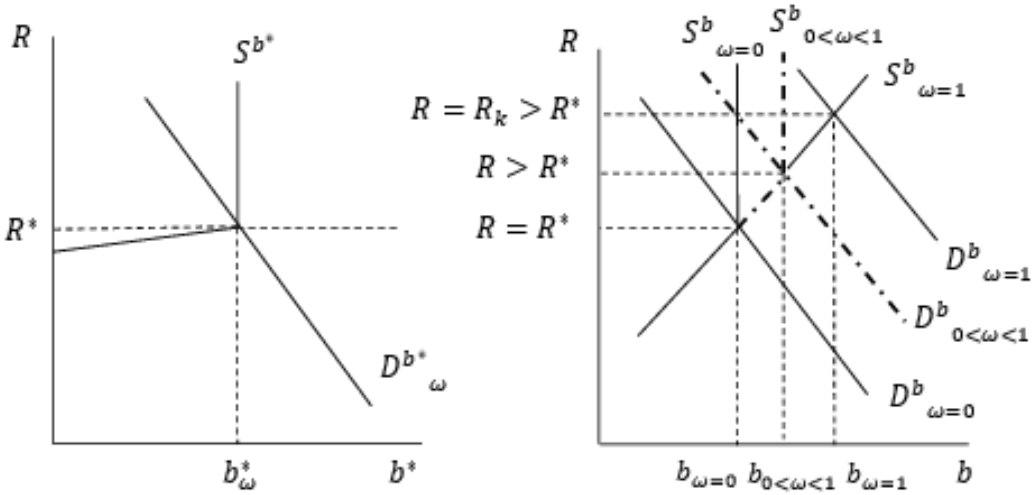

Figure 2: Financial Frictions and Spreads

Figure 3: Taper tantrum shock (127 bp increase in risk premium)

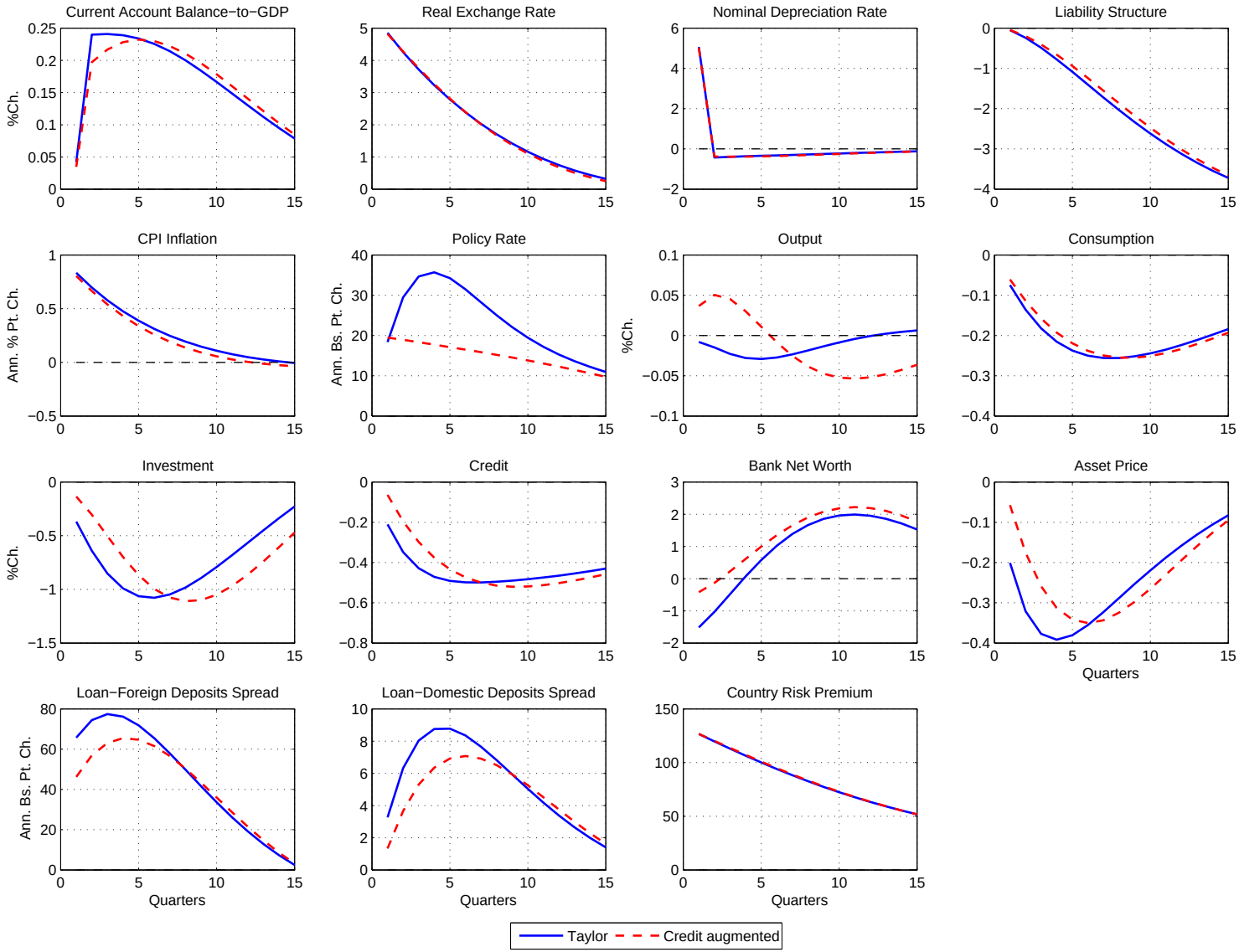

Figure 4: US interest rate shock (39 bp increase)

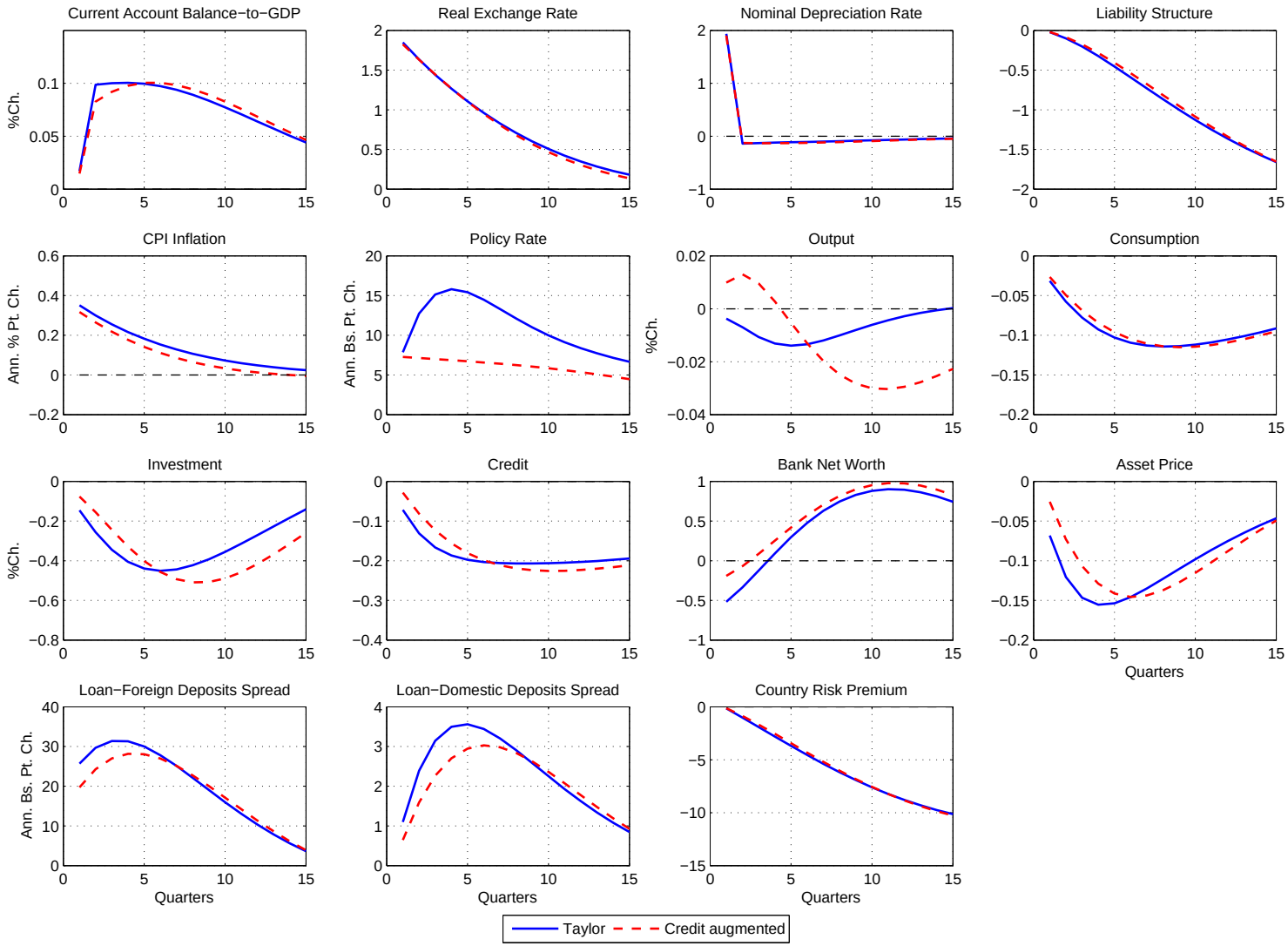

Figure 5: Uncertainty regarding Fed's policy normalization

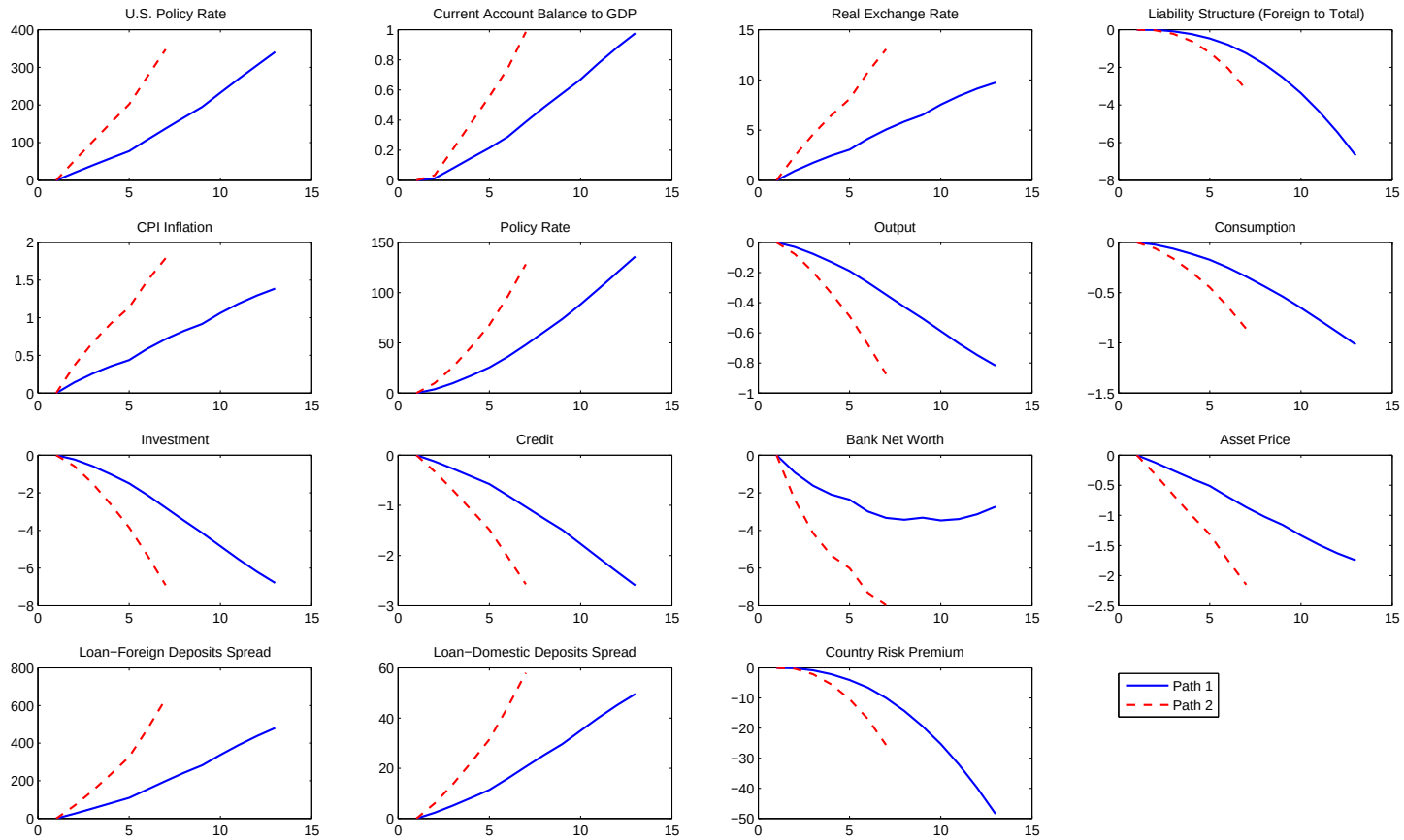

Figure 6: Role of asymmetric frictions (under optimal Taylor rule)

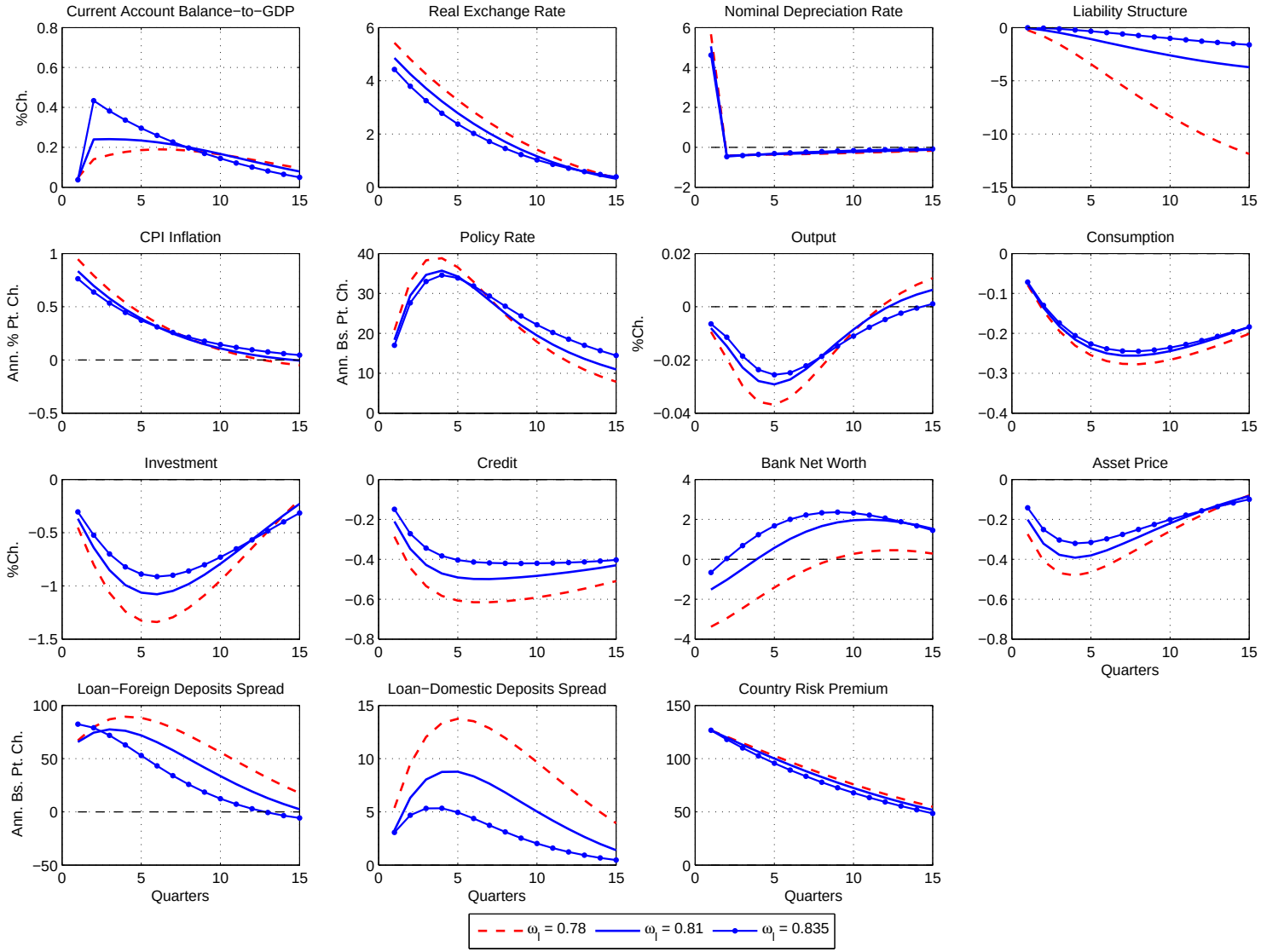

Figure 7: Optimal interest rate and reserve requirement policies

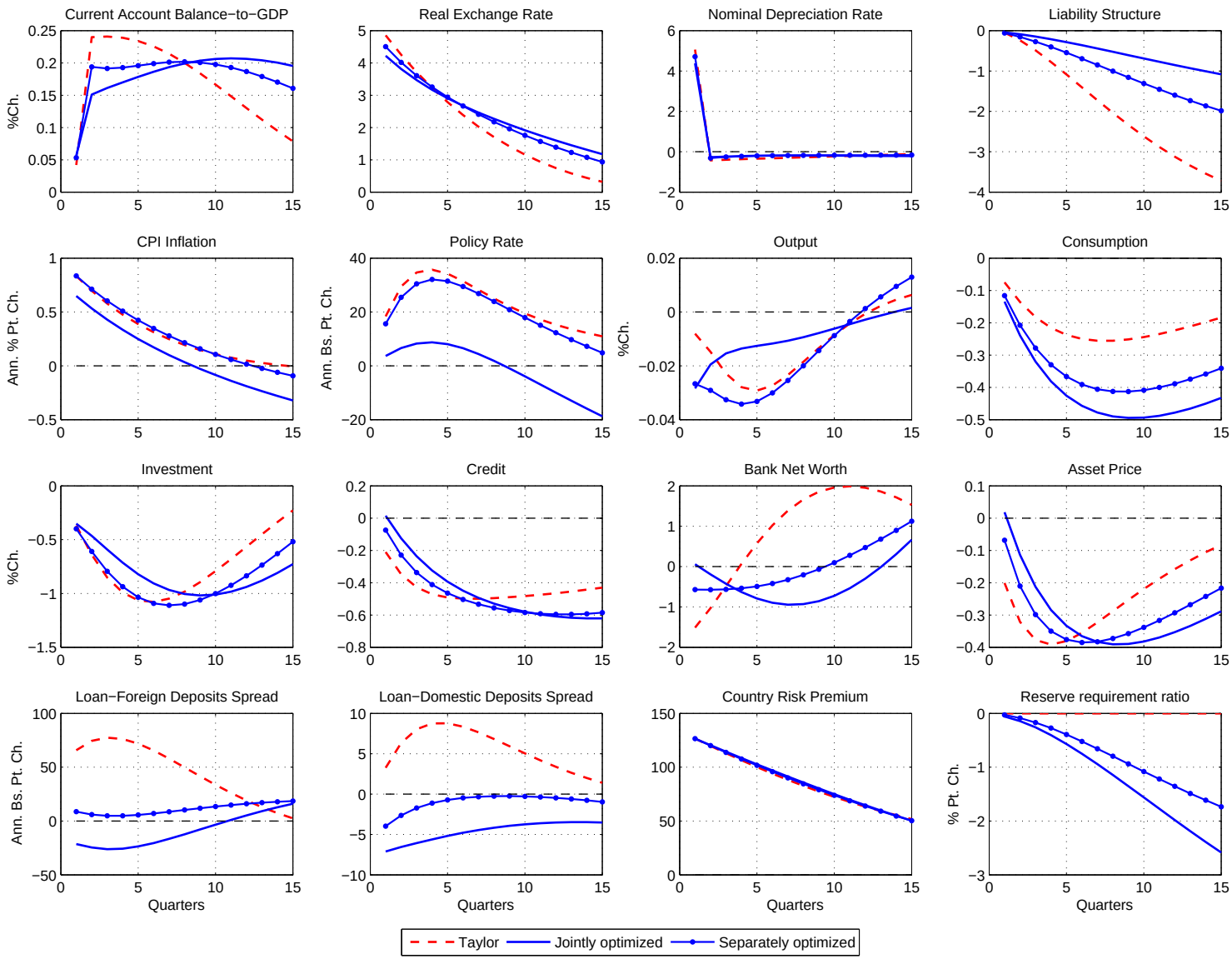

Table 1: Changes in Macroeconomic and Financial Variables in 2007:Q1-2011:Q3 episode: Peak-to-Trough

Country	EMBI Spread (bps)	Output (%)	Consumption (%)	Investment (%)	CA-to-GDP Ratio (pp)
Brazil	279	-7.6	-4.8	-23.0	1.43
Chile	260	-8.2	15.0	-29.2	–
China	175	-3.6	–	–	2.70
Colombia	379	-6.5	-4.9	-17.3	1.53
Czech Rep.	–	-7.5	-6.3	-19.8	2.50
Hungary	477	-7.5	-10.2	-17.1	5.60
India	–	-1.8	-4.3	-11.3	1.53
Indonesia	597	-1.8	-7.7	-5.1	2.38
Israel	–	-4.1	-7.9	-20.4	8.70
Korea Rep.	–	-6.0	-7.8	-5.2	4.80
Malaysia	297	-10.2	-7.2	-17.7	3.20
Mexico	330	-9.8	-9.6	-14.0	1.87
Peru	392	-7.1	-8.0	-21.6	4.60
Philippines	391	-5.3	-5.7	-14.7	4.90
Poland	266	-3.8	-3.2	-19.3	2.80
Russia	703	-13.6	-10.6	-20.0	–
Singapore	162	-15.5	–	–	3.10
S. Africa	489	-5.2	-8.5	-26.1	6.30
Thailand	–	-10.6	-8.7	-27.0	7.40
Turkey	345	-19.7	-19.4	-41.0	4.90

Country	REER (%)	Lend. Spr. Dom. (bps)	Lend. Spr. For. (bps)	Policy Rate (pp)	Res. Req. (pp)
Brazil	-24.7	970	1000	-5.00	-3.33
Chile	-20.0	700	1140	-7.80	0.00
China	-12.3	900	1240	-1.89	-2.50
Colombia	-21.9	830	1030	-7.00	-16.0
Czech Rep.	-12.6	–	–	-3.00	0.00
Hungary	-19.8	190	260	-4.70	-1.00
India	-15.0	–	–	-4.20	-4.00
Indonesia	-22.1	86	410	-2.75	–
Israel	-8.3	–	–	-3.75	0.00
Korea Rep.	-37.3	–	–	-3.25	–
Malaysia	-7.5		188	-1.50	-3.00
Mexico	-22.0	183	440	-3.75	0.00
Peru	-8.1	120	330	-5.20	-9.00
Philippines	-12.6	107		-3.50	-2.00
Poland	-27.2	221		-2.50	-0.50
Russia	-16.3	380	460	-5.00	-3.00
Singapore	-5.2	–	–	-2.43	0.00
S. Africa	-29.0		460	-6.50	–
Thailand	-9.3	–	–	-3.25	0.00
Turkey	-19.9	1480	340	-11.5	-1.50

Table 2: Model parameters

Description	Parameter	Value	Target
Preferences			
Quarterly discount factor	β	0.9821	Average annualized real deposit rate (7.48%)
Relative risk aversion	σ	2	Literature
Habit persistence	h_c	0.7	Literature
Labor supply elasticity	ξ	5	Literature
Relative utility weight of labor	χ	$4x10^3$	Steady state hours worked of 0.33
Relative utility weight of money	υ	0.35	M2 to GDP ratio.
Relative weight of domestic goods in consumption basket	ω	0.4	Average consumption to GDP ratio
Intra-temporal elasticity of substitution for consumption composite	γ	1	Gertler et al. (2007)
Intra-temporal elasticity of substitution for investment composite	γ_i	0.25	Gertler et al. (2007)
Firms			
Share of capital in output	α	0.4	Labor share of output (0.6)
Share of domestic goods in the investment composite	ω_i	0.87	Average share of investment in GDP (0.15)
Depreciation rate of capital	δ	0.035	Average annual ratio of investment to capital (14.8%)
Steady-state utilization rate	$\overline{u}$	1	Literature
Elasticity of marginal depreciation with respect to the utilization rate	ϱ	1	Gertler et al. (2007)
Elasticity of substitution between varieties	ϵ	11	Steady state mark-up of 1.1
Investment adjustment cost parameter	ψ	4	Elasticity of price of capital w.r.t. investment-capital ratio
Price adjustment cost for domestic intermediate goods producers	φ_H	120	Frequency of price change per quarter
Price adjustment cost for domestic intermediate goods producers	φ_F	120	Frequency of price change per quarter
Financial Intermediaries			
Fraction of the revenues that can be diverted	λ	0.65	Commercial loan/domestic deposits spread
Fraction of domestic deposits that cannot be diverted	ω_l	0.81	Banks' liability composition (foreign funds)
Survival probability of the bankers	θ^b	0.925	Leverage ratio of 7.95 for commercial banks
Proportional transfer to the entering bankers	ϵ^b	0.00195	Commercial loan/foreign deposits spread
Monetary Authority and Government			
Domestic and foreign currency required reserve ratios	rr	0.09	Required reserve ratio for 1996 - 2015
Steady state government expenditure to GDP ratio	g_H	0.1	Average share of government spending in GDP
Shock Processes			
Persistence of TFP process	ρ_A	0.662	Bahadir and Gumus (2014)
Standard deviation of TFP shocks	σ_A	0.0283	Bahadir and Gumus (2014)
Persistence of government spending process	ρ_{g_H}	0.4574	Estimated from the Turkish data
Standard deviation of risk premium shocks	σ_{g_H}	0.04	Estimated from the Turkish data
Persistence of risk premium process	ρ_Ψ	0.9628	Estimated from the Turkish EMBI data
Standard deviation of risk premium shocks	σ_Ψ	0.0032	Estimated from the Turkish EMBI data
Persistence of U.S interest rate process	$\rho_{R_n^*}$	0.977	Estimated from the US data
Standard deviation of U.S. interest rate shocks	$\sigma_{R_n^*}$	0.00097	Estimated from the US data
Persistence of export demand process	ρ_{y^*}	0.425	Persistence of the Euro area GDP
Standard deviation of export demand shocks	σ_{y^*}	0.0048	Standard deviation of the Euro area GDP

Table 3: Variance decomposition, %

Real variables	**TFP**	**Government Spending**	**Country risk premium**	**U.S. interest rate**	**Export demand**
Output	86.93	10.87	1.76	0.36	0.08
Consumption	15.99	0.53	70.93	12.42	0.12
Investment	92.67	1.93	4.55	0.83	0.02
Financial and external variables					
Credit	20.14	2.25	66.51	11.01	0.09
Liability composition (foreign)	48.15	0.50	43.28	7.52	0.56
Domestic lending spread	35.12	0.93	53.42	9.28	1.25
Foreign lending spread	28.33	0.24	59.98	10.49	0.96
Real exchange rate	0.96	0.01	86.55	12.41	0.07
C.A. balance to GDP ratio	33.98	0.40	55.17	9.50	0.94
Nominal variables					
CPI inflation rate	36.68	0.12	54.91	8.22	0.07
Policy rate	58.38	2.27	34.36	4.98	0.02

Table 4: Loss function values for alternative policies and mandates

	TR1			**TR2**			**TR3**		
$\sigma_\pi^2 + \sigma_y^2$	Loss	φ_π	φ_y	Loss	φ_π	φ_l	Loss	φ_π	φ_s
TFP	**2.012e-04**	3.000	2.786	3.752e-04	2.286	0.643	3.740e-04	2.286	0.643
Government Spending	**2.912e-05**	2.001	2.571	4.821e-05	2.286	0.643	4.783e-05	2.286	0.643
Risk premium	**5.520e-06**	1.858	2.786	6.395e-06	3.000	2.786	1.173e-05	1.287	0.000
US interest rate	**9.718e-07**	1.858	2.786	9.929e-07	3.000	2.786	1.920e-06	1.144	0.000
Export demand	**5.993e-08**	1.715	2.786	2.204e-07	1.144	1.500	3.468e-07	1.001	0.000
All	**2.421e-04**	2.143	2.786	4.478e-04	2.143	1.071	5.071e-04	1.858	0.000
$\sigma_\pi^2 + \sigma_y^2 + \sigma_{ql}^2$									
TFP	**3.136e-04**	2.286	0.643	4.045e-04	2.286	0.643	4.048e-04	2.286	0.643
Government Spending	5.031e-05	2.286	0.643	4.842e-05	2.286	0.643	**4.806e-05**	2.286	0.643
Risk premium	2.739e-05	1.001	2.357	**2.517e-05**	2.001	2.143	4.287e-05	1.287	0.214
US interest rate	4.338e-06	1.858	2.786	**4.019e-06**	2.001	2.143	7.105e-06	1.144	0.000
Export demand	3.258e-07	1.572	0.214	**2.783e-07**	1.715	2.786	4.442e-07	1.001	0.214
All	**4.348e-04**	1.001	0.857	5.157e-04	2.429	2.571	6.422e-04	1.144	0.214
$\sigma_\pi^2 + \sigma_y^2 + \sigma_s^2$									
TFP	**3.258e-04**	2.286	0.643	4.082e-04	2.286	0.643	3.998e-04	2.286	0.643
Government Spending	**3.713e-05**	2.001	2.357	4.862e-05	2.286	0.643	4.814e-05	2.286	0.643
Risk premium	0.0030	1.429	0.427	**0.0030**	1.429	0.429	0.0031	1.572	0.000
US interest rate	4.377e-04	1.429	0.429	**4.352e-04**	1.429	0.429	4.395e-04	1.572	0.000
Export demand	2.409e-06	1.572	0.000	**2.185e-06**	1.429	0.429	2.358e-06	1.429	0.429
All	**0.0037**	2.857	1.286	0.0038	2.857	1.286	0.0041	2.572	0.000

Table 5: Correlations of key variables with output under alternative policies and mandates

	TR1						**TR2**						**TR3**					
$\sigma_\pi^2 + \sigma_y^2$	$\rho(y,\pi)$	$\rho(y,credit)$	$\rho(y,RER)$	$\rho(y,r_n)$	φ_π	φ_y	$\rho(y,\pi)$	$\rho(y,credit)$	$\rho(y,RER)$	$\rho(y,r_n)$	φ_π	φ_l	$\rho(y,\pi)$	$\rho(y,credit)$	$\rho(y,RER)$	$\rho(y,r_n)$	φ_π	φ_s
TFP	0.53	-0.70	-0.53	0.43	3.00	2.79	0.66	-0.65	-0.66	0.42	2.29	0.64	0.66	-0.65	-0.66	0.42	2.29	0.64
Government spending	0.68	-0.73	-0.23	0.54	2.00	2.57	0.91	-0.73	-0.26	0.54	2.29	0.64	0.91	-0.73	-0.26	0.54	2.29	0.64
Risk premium	-0.66	0.78	-0.74	-0.94	1.86	2.79	-0.83	0.87	-0.87	-0.98	3.00	2.79	-0.16	0.69	-0.27	-0.71	1.29	0.00
US interest rate	-0.66	0.80	-0.73	-0.94	1.86	2.79	-0.83	0.88	-0.87	-0.98	3.00	2.79	0.20	0.60	0.11	-0.45	1.14	0.00
Export demand	-0.65	-0.95	-0.22	0.73	1.71	2.79	-0.66	-0.96	-0.23	0.74	1.14	1.50	-0.62	-0.95	-0.18	0.73	1.001	0.00
All	0.40	-0.72	-0.13	0.48	2.14	2.79	0.43	-0.59	-0.14	0.44	2.14	1.07	0.45	-0.61	-0.13	-0.45	1.86	0.00
$\sigma_\pi^2 + \sigma_y^2 + \sigma_{ql}^2$																		
TFP	0.76	-0.45	-0.79	0.40	2.29	0.64	0.66	-0.65	-0.66	0.42	2.29	0.64	0.66	-0.65	-0.66	0.42	2.29	0.64
Government spending	0.75	-0.73	-0.50	0.56	2.29	0.64	0.91	-0.73	-0.26	0.54	2.29	0.64	0.91	-0.73	-0.26	0.54	2.29	0.64
Risk premium	0.53	0.31	0.44	-0.07	1.001	2.36	-0.73	0.83	-0.79	-0.96	2.00	2.14	-0.17	0.69	-0.27	-0.71	1.29	0.21
US interest rate	-0.66	0.80	-0.73	-0.94	1.86	2.79	-0.73	0.84	-0.78	-0.97	2.00	2.14	0.20	0.60	0.11	-0.45	1.14	0.00
Export demand	-0.92	-0.37	-0.70	0.16	1.57	0.21	-0.76	-0.95	-0.37	-0.78	1.71	2.79	-0.62	-0.95	-0.18	0.73	1.001	0.21
All	0.53	-0.45	-0.08	0.47	1.001	0.86	0.42	-0.58	-0.15	0.42	2.43	2.57	0.50	-0.62	-0.09	0.48	1.14	0.21
$\sigma_\pi^2 + \sigma_y^2 + \sigma_s^2$																		
TFP	0.76	-0.45	-0.79	0.40	2.29	0.64	0.66	-0.65	-0.66	0.42	2.29	0.64	0.66	-0.65	-0.66	0.42	2.29	0.64
Government spending	0.73	-0.73	-0.23	0.54	2.00	2.36	0.91	-0.73	-0.26	0.54	2.29	0.64	0.91	-0.73	-0.26	0.54	2.29	0.64
Risk premium	-0.51	0.80	-0.59	-0.89	1.43	0.43	-0.41	0.76	-0.50	-0.84	1.43	0.43	-0.55	0.79	-0.63	-0.91	1.57	0.00
US interest rate	-0.54	0.84	-0.60	-0.92	1.43	0.43	-0.41	0.80	-0.48	-0.86	1.43	0.43	-0.55	0.82	-0.62	-0.92	1.57	0.00
Export demand	-0.93	0.81	-0.89	-0.38	1.57	0.00	-0.72	-0.96	-0.31	0.76	1.43	0.43	-0.72	-0.96	-0.31	0.76	1.43	0.43
All	0.40	-0.56	-0.17	0.41	2.86	1.29	0.40	-0.56	-0.17	0.41	2.86	1.29	0.41	-0.57	-0.16	0.42	2.57	0.00

Table 6: Volatilities of key variables under alternative policies and mandates

	TR1						**TR2**						**TR3**					
$\sigma_\pi^2 + \sigma_y^2$	σ_π	σ_y	σ_{credit}	σ_{RER}	φ_π	φ_y	σ_π	σ_y	σ_{credit}	σ_{RER}	φ_π	φ_l	σ_π	σ_y	σ_{credit}	σ_{RER}	φ_π	φ_s
TFP	0.27	1.43	2.36	1.58	3.00	2.79	0.24	1.66	1.36	1.09	2.29	0.64	0.24	1.66	1.36	1.09	2.29	0.64
Government spending	0.01	0.56	0.95	0.37	2.00	2.57	0.01	0.61	0.66	0.15	2.29	0.64	0.01	0.61	0.66	0.15	2.29	0.64
Risk premium	0.28	0.06	0.64	6.79	1.86	2.79	0.26	0.23	0.81	6.74	3.00	2.79	0.28	0.05	0.63	6.78	1.29	0.00
US interest rate	0.12	0.02	0.25	2.59	1.86	2.79	0.11	0.10	0.32	2.56	3.00	2.79	0.12	0.02	0.24	2.59	1.14	0.00
Export demand	0.02	0.02	0.11	0.23	1.71	2.79	0.02	0.03	0.09	0.24	1.14	1.50	0.02	0.03	0.09	0.24	1.001	0.00
All	0.37	1.61	2.50	6.71	2.14	2.79	0.35	1.84	1.58	6.61	2.14	1.07	0.35	1.84	1.52	6.62	1.86	0.00
$\sigma_\pi^2 + \sigma_y^2 + \sigma_{ql}^2$																		
TFP	0.21	1.84	0.80	0.85	2.29	0.64	0.24	1.66	1.36	1.09	2.29	0.64	0.24	1.66	1.36	1.09	2.29	0.64
Government spending	0.01	0.66	0.43	0.06	2.29	0.64	0.01	0.61	0.66	0.15	2.29	0.64	0.01	0.61	0.66	0.15	2.29	0.64
Risk premium	0.28	0.03	0.61	6.79	1.001	2.36	0.28	0.12	0.69	6.76	2.00	2.14	0.28	0.05	0.63	6.78	1.29	0.21
US interest rate	0.12	0.02	0.25	2.59	1.86	2.79	0.11	0.05	0.27	2.57	2.00	2.14	0.12	0.02	0.24	2.59	1.14	0.00
Export demand	0.01	0.06	0.04	0.22	1.57	0.21	0.02	0.03	0.08	0.24	1.71	2.79	0.02	0.03	0.09	0.24	1.001	0.21
All	0.37	1.96	1.00	6.61	1.001	0.86	0.34	1.83	1.63	6.60	2.43	2.57	0.37	1.85	1.38	6.63	1.14	0.21
$\sigma_\pi^2 + \sigma_y^2 + \sigma_s^2$																		
TFP	0.21	1.84	0.80	0.85	2.29	0.64	0.24	1.66	1.36	1.09	2.29	0.64	0.24	1.66	1.36	1.09	2.29	0.64
Government spending	0.01	0.56	0.91	0.34	2.00	2.36	0.01	0.61	0.66	0.15	2.29	0.64	0.01	0.61	0.66	0.15	2.29	0.64
Risk premium	0.28	0.12	0.69	6.75	1.43	0.43	0.28	0.06	0.64	6.78	1.43	0.43	0.28	0.07	0.65	6.77	1.57	0.00
US interest rate	0.11	0.06	0.27	2.57	1.43	0.43	0.12	0.03	0.25	2.58	1.43	0.43	0.12	0.03	0.26	2.58	1.57	0.00
Export demand	0.01	0.09	0.05	0.19	1.57	0.0	0.02	0.03	0.09	0.24	1.43	0.43	0.02	0.03	0.09	0.24	1.43	0.43
All	0.33	1.83	1.71	6.60	2.86	1.29	0.33	1.83	1.71	6.60	2.86	1.29	0.34	1.83	1.66	6.60	2.57	0.00

Table 7: Optimal interest rate and reserve requirement policies

	Taylor rule			**No-coordination**		**Coordination**			
Underlying shock	$\sigma_\pi^2 + \sigma_y^2$	φ_π	φ_y	$\sigma_\pi^2 + \sigma_y^2$	φ_{rr}	$\sigma_\pi^2 + \sigma_y^2$	φ_π	φ_y	φ_{rr}
Risk premium	5.520e-06	1.858	2.786	6.278e-06	0.857	**3.957e-06**	1.001	2.571	2.357

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