ISSN 1518-3548

BANCO CENTRAL DO BRASIL

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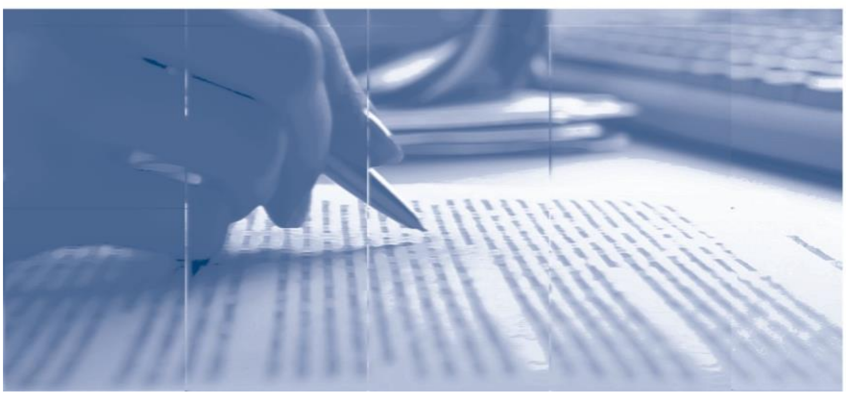
Fabia A. de Carvalho and Marcos R. Castro

May, 2015

Working Papers



387

ISSN 1518-3548
CGC 00.038.166/0001-05

Working Paper Series	Brasília	n. 387	May	2015	p. 1-99

Working Paper Series

Edited by Research Department (Depep) – E-mail: workingpaper@bcb.gov.br

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The Banco Central do Brasil Working Papers are all evaluated in double blind referee process.

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Foreign Capital Flows, Credit Growth and Macroprudential Policy in a DSGE Model with Traditional and Matter-of-Fact Financial Frictions *

Fabia A. de Carvalho**
Marcos R. Castro ***

Abstract

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We investigate the transmission channel of reserve requirements, capital requirements, and risk weights of different types of credit in the computation of capital adequacy ratios and compare the power of each macroprudential instrument to counteract the impact of domestic and international shocks that potentially challenge financial stability. To this end, we model a small open economy that receives inflows of foreign direct investment, foreign portfolio investment, and issues foreign debt. The central bank manages international reserves, with an impact on the foreign exchange market and on the country risk premium. Shocks in international markets affect domestic credit even though foreign capital flows are directly destined to non-financial institutions. Banks operate in four distinct credit markets: consumer, housing and commercial– each of them facing default risk and having specific borrowing constraints– and safe export-related credit lines in the form of working capital loans to exporters. Consumer loans are granted based on banks' expectations with respect to borrowers' future labor income net of senior debt services. Banks optimize their balance sheet allocation facing frictions intended to reproduce banks' incentives given regulatory constraints. The model is estimated with Bayesian techniques using data from Brazil.

Keywords: DSGE models, Bayesian estimation, financial regulation, monetary policy, macroprudential policy
JEL classification: E4, E5, E6.

*We are grateful to Pierpaolo Benigno, Emanuel Kohlscheen and the participants in the BIS CCA Research Network Conference for insightful comments and suggestions. Errors and omissions in the paper are of course the authors' sole responsibility.
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1 Introduction

This paper investigates the transmission channel of a comprehensive set of macroprudential instruments in a small open economy with the following features: 1) banks operate in heterogeneous credit markets; i.e., they extend consumer, housing and commercial loans, each having a different type of borrowing constraint, and all of them facing default risk; 2) consumer loans are extended based on banks' ex-ante assessment of borrowers' capacity to pay the loans with future labor income; 3) housing loans are subject to loan-to-value constraints and are senior to consumer loans, thus affecting expected available income; 4) banks have liquidity preferences and face frictions to optimize balance sheet allocations; 5) the country receives inflows of foreign direct and portfolio investment, and domestic investors issue foreign debt, facing adjustment costs when the rollover rate deviates from the steady state; 6) exporters are price takers, face costs to adjust the export quantum and take working capital loans to finance a share of their exports; 7) international reserves are a policy instrument; 8) monetary policy seeks to stabilize inflation and output; and 9) the regulatory authority institutes capital requirements, remunerated and non-remunerated reserve requirements, and risk weights for each credit segment to compute capital adequacy ratios.

The model is suited to address important concerns related to financial stability in emerging economies. The unconventional policies adopted by advanced economies as a response to the financial crisis have led to substantial excess liquidity in international markets, which has been channeled to emerging market economies in the form of strong inflows of foreign investment and easier international credit conditions. Owing to tight bank regulatory environment, FX exposure risks have built mainly in the non-banking private sector, through foreign direct investment and intercompany loans. Notwithstanding, these developments have played an important role in the recent strong expansion of bank credit, even in domestic currency[1].

To account for these facts, the flows of foreign investment in this model are directly received by agents in the real economy. In fact, the most relevant issuers of foreign debt are non-banking institutions owned by domestic investors. Banks are assumed to face virtually no exposure to foreign currency, extending trade-related credit lines to exporters only in the form of safe working capital loans. Therefore, the direct impact of imbalances in international markets into the domestic economy bypass banks, although these shocks might be amplified by the domestic banking system. The model can endogenously produce contagion from international

[1] In fact, IMF's 2014 Global Financial Stability Report and BIS's 2013/2014 Annual Report warn about the significant role that these sources of funding might have played in stimulating the strong bank credit expansion over the past years, even in domestic currency.

markets to the domestic credit market. The effects of international shocks on prices, interest rates and the risk premium significantly impact the real economy, affecting both the demand and the supply of credit through changes in the value of collateral, in the prospects for the labor market, and in banks' funding costs. Hence, even when banks are not the main receivers of foreign flows, they are not insulated from the risks originated in the international funding of non-financial corporations. In the presence of adjustment costs to issue foreign debt, the spillover effects of imbalances in international markets can be amplified.

The model incorporates financial frictions and foreign investment flows in a novel way, keenly trying to realistically reproduce the dynamics of the Brazilian credit market given the regulatory framework with which banks have to comply and including the necessary ingredients to address important policy questions, some of which brought about by the recent financial crisis.

The model of the banking sector elicits banks' incentives when they are constrained by macroprudential regulation, so as to be able to reproduce both price and quantity effects of macroprudential policies. Banks have preferences with respect to some balance sheet allocations, and optimize an intertemporal plan of capital accumulation and dividend distribution, facing default risk on consumer, housing and commercial loans, constrained by regulation on capital requirements, reserve requirements, risk weights on capital adequacy ratios, savings deposits, and operational taxes. Housing loans face loan-to-value constraints, but interfere in borrowers' capacity to take consumer loans, given that banks extend consumer loans based on their expectations with respect to borrowers' future labor income net of housing debt services. Commercial loans are subject to time-varying loan-to-value constraints with capital as collateral.

To validate the modeling choices, we estimated the model with Bayesian techniques using Brazilian data from the inflation targeting regime (1999Q3 to 2013Q4). We mapped Brazil's balance of payment accounts into the model variables by observing stocks and flows of international reserves, flows of foreign direct and portfolio investment, unilateral transfers, imports and exports of goods and services, and the exchange rate. A number of series from the credit market and the real economy were also observed.

The model is able to closely reproduce most of the second moments of observed data (Table 3). The variance decomposition (Table 4) shows that private consumption, government consumption and capital investment are strongly impacted by shocks related to the open economy. Shocks to the share of households' income committed to unsecured loans also has some power to explain the variance of output and government spending. The variance decomposition also suggests an important participation of international shocks to commercial loans. Shocks to the LTV ratio, productivity and bank capital preferences also drive the variance of commercial loans. Unsecured consumer loans are importantly impacted not only by shocks to debt commitment but also by leverage in housing mortgages. This indicates that the seniority of housing loans over the other types of consumer credit really poses a restriction on the latter.

The dynamic responses of the model show that financial frictions feed into the transmission of shocks originating in international markets. Tighter international conditions represented by higher international interest rates or higher country risk premia depreciate the exchange rate and this is a strong channel through which international shocks affect the economy as a whole. Output rises under the influence of the export channel, but the credit channel reinforces the contractionist impact of monetary policy, and investment is significantly depressed. On the other hand, favorable shocks to the terms of trade have an expansionist impact on domestic credit.

When international imbalances are passed through to the domestic economy through foreign capital flows, the heterogeneity in credit segments differentiates the transmission of each type of flow. In our estimations, foreign direct investment has the strongest expansionist impact on domestic credit. Notwithstanding, the estimated power of the export sector in the economy is such that the appreciation of the exchange rate that follows from the strong inflow of FDI negatively impacts the overall demand for labor, and hence consumer loans do not benefit from these flows. On the other hand, investment and housing loans surge, a feature that seems to conform with the recent Brazilian history.

We also show that macroprudential instruments have important effects on banks' balance sheet composition. In fact, it is on the credit market that macroprudential instruments have their strongest impact. The transmission to the rest of the economy differs according to the type of instrument.

We compared the responses of the model in a situation where countercyclical capital buffers were activated. We show that this instrument has an important role to mitigate the impact of adverse shocks to the credit market when the shocks originate in the financial system. However, if the shock comes from the real sector, the power of the instrument to stabilize variables other than the credit variables is significantly reduced. The theoretical model can also be used to investigate the impact of changes in bank liquidity preference. We compare the power of macroprudential instruments and monetary policy to counteract the impact of domestic and foreign shocks that potentially challenge financial stability.

The paper is presented as follows. Section 2 describes the theoretical model. Section 3 discusses the stationarization of the model, the computation of the steady state, and the estimation. Section 4 analyzes the transmission mechanism of macroprudential and monetary policies. Section 5 analyzes the transmission of international shocks to the domestic credit market. Section 6 discusses alternative countercyclical capital requirement rules. The final section concludes.

2 The theoretical model

The model was built to replicate important features of a credit market where risk taking is associated to developments in both the labor market and real asset prices, and whose dynamics can also be affected by the international environment. To properly understand the impact of regulatory constraints on banks' portfolio allocation and liability management, we introduce an intertemporal optimization program for banks, where they choose an intertemporal plan of dividend distribution and capital accumulation facing credit risk, regulatory constraints, and internal preferences with respect to some balance sheet components, including liquidity. This structure allows the model to display not only price effects but also quantity effects of macroprudential policies. As a result, we can assess the impact of each macroprudential instrument on banks' incentives to lend to a particular sector, to change their liquidity positions, to reduce excess capital, or to build up new capital. International financial flows bypass the banking system, directly impacting the real sector. Notwithstanding, these flows can generate spillover effects on the banking system and stimulate credit expansion in domestic currency. International shocks that transmit to the exchange rate can also impact the domestic credit market through prices and interest rates. The interaction of the financial system with the real economy can amplify the impact of imbalances in international markets.

The agents in the economy are households (savers and borrowers), labor unions, entrepreneurs, firms producing intermediate and final goods, import and export firms, retailers, distributors, a retail money market fund, a bank conglomerate, the external sector and the government. In this session, we describe the main features of the theoretical model, emphasizing our contributions to existing models and adjustments to Brazilian particularities. A detailed description of the theoretical model is available in the companion technical appendix. A closed economy version of this model is described in Carvalho, Castro e Costa (2014).

2.1 Households

Households are distributed in two groups: savers and borrowers. Both supply labor to a continuum of labor unions that operate under monopolistic competition, consume traditional consumption goods and housing, and make demand deposits. Savers can invest in savings deposits and quotas from the retail money fund, receive net-of-tax profits from all business activities in the economy, trade claims to entrepreneurs' net worth with the foreign direct investor, and earn dividends distributed by banks. Borrowers take risky loans to finance both consumption and housing. Consumer loans are granted by the bank conglomerate based on ex-ante assessment of borrowers' capacity to settle debt obligations with labor income, taking into account that a share of borrowers' future income will already be committed to housing loans, which are senior to consumer loans, and which are also subject to collateral constraints. Consumer loans are risky since labor income is subject to idiosyncratic shocks that realize only after loan contracts are established. Next, we present the borrowers' optimization program. For the sake of brevity, we omit the details of the savers' and union's optimization programs, which are exactly the same as in Carvalho, Castro e Costa (2014) and are thoroughly described in the technical appendix.

2.1.1 The borrowers' optimization program

Borrowers are distributed in a continuum $(0, \omega_B)$. They derive utility from a composite $(\mathcal{X}_{B,t})$ of consumption goods $(C_{B,t})$ and housing $(H_{B,t})$, in addition to demand deposits $(D^D_{B,t})$, with habit formation in consumption $(\bar{h}_{C,B})$ and labor supply $(\bar{h}_{N,B})$. The utility function of the representative borrower is

$$E_0 \left\{ \sum_{t \geq 0} \beta_B^t \left[\begin{array}{c} \frac{1}{1-\sigma_X} \left(\mathcal{X}_{B,t}\right)^{1-\sigma_X} - \frac{\varepsilon_t^L \psi_{N,B}}{1+\sigma_L} \left(\frac{N_{B,t}}{\epsilon_{L,t}} - \bar{h}_{N,B} \frac{N_{B,t-1}}{\epsilon_{L,t-1}} \right)^{1+\sigma_L} \\ + \frac{\psi_{D,B}}{1-\sigma_D} \varepsilon_t^{D,B} \left(\frac{D^D_{B,t}}{P_{C,t}\epsilon_{L,t}\epsilon_{A,t}} \right)^{1-\sigma_D} \end{array} \right] \varepsilon_t^{\beta,B} \right\} \tag{1}$$

where

$$\mathcal{X}_{B,t} = \left[\begin{array}{c} \left(1 - \varepsilon_t^H \omega_{H,B}\right)^{\frac{1}{\eta_H}} \left(\frac{C_{B,t}}{\epsilon_{L,t}\epsilon_{A,t}} - \bar{h}_{C,B} \frac{C_{B,t-1}}{\epsilon_{L,t-1}\epsilon_{A,t-1}} \right)^{\frac{\eta_H - 1}{\eta_H}} \\ + \left(\varepsilon_t^H \omega_{H,B}\right)^{\frac{1}{\eta_D}} \left(\frac{H_{B,t}}{\epsilon_{L,t}\epsilon_{A,t}} \right)^{\frac{\eta_H - 1}{\eta_H}} \end{array} \right]^{\frac{\eta_H}{\eta_H - 1}} \tag{2}$$

and where ε_t^L and ε_t^H are preference shocks common to both types of households, $\varepsilon_t^{\beta,B}$ is a group-specific preference shock, $\varepsilon_t^{D,B}$ is a preference shock associated to demand deposits, $\psi_{N,B}$ and $\psi_{B,D}$ are scaling parameters, $\omega_{H,B}$ is a bias for housing in the consumption basket, δ_H is housing depreciation, and $\tau_{C,t}$ and $\tau_{W,t}$ are tax rates on consumption and labor income, respectively. Housing is priced at $P_{H,t}$. Variables $\epsilon_{L,t}$ and $\epsilon_{A,t}$ are stochastic trends in population and labor productivity, respectively, introduced in the utility function to make the resulting first order conditions compatible with a balanced growth path. Shocks $\varepsilon_t^{\beta,B}$, ε_t^H ε_t^L, and $\varepsilon_t^{D,B}$ follow AR(1) processes.

Labor is competitively supplied to labor unions at a nominal wage W_t^N. Labor unions are monopolistically competitive, and distribute their net-of-tax profits (Π_t^{LU}) back to households as lump-sum transfers.

At period t, borrower i gets a one-period retail loan $B^C_{B,i,t}$ and a housing loan $B^H_{B,i,t}$ at fixed interest rates $R^{L,C}_{B,t}$ and $R^{L,H}_{B,t}$, respectively[2]. Banks' decisions with respect to lending rates are strongly associated to borrowers' capacity to pay the loans with their available labor income, as we shall describe with more details in what follows[3].

At every period, borrowers' labor income (which includes transfers of profits from the labor union) is subject to log-normally distributed idiosyncratic shocks $\varpi_{B,i,t} \sim lognormal\,(1, \sigma_{B,t})$, a short-cut for idiosyncratic productivity shocks that do not affect firms' aggregate production but that affect borrowers' available income. The shock's standard deviation $\sigma_{B,t}$ follows an AR(1) process and its value $\sigma_{B,t+1}$ at $t+1$ is known in advance, i.e., $\sigma_{B,t}$ is a predetermined variable.

After $\varpi_{B,i,t}$ realizes, borrower i's net-of-tax nominal labor income is

$$\varpi_{B,i,t}\left[(1-\tau_{W,t})\,N_{B,i,t}W_t\right] \tag{3}$$

where W_t is the wage negotiated between firms and unions.

Bad shocks to labor income can jeopardize borrowers' capacity to pay their loans. Depending on the magnitude of the shock, borrowers might default on all their loans (i.e., consumer and housing loans) or only on consumer loans, given that housing loans have seniority over consumer loans[4]. If there is no default, the total face value of borrowers' debt payment at period $t+1$ is $R^{L,C}_{B,t}B^{C}_{B,i,t} + R^{L,H}_{B,t}B^{H}_{B,i,t}$. In case of default, the consumer lending branch and the housing loan branch can seize a fraction $\gamma^{B,C}_t$ of the borrower's net-of-tax labor income, after incurring proportional monitoring costs $\mu_{B,C}$ and $\mu_{B,H}$, respectively. Hence, at period $t+1$, after the shock $\varpi_{B,i,t+1}$ realizes, the borrower chooses to default on consumer loans if realized labor income previously committed to pay the loan is less than the face value of the total debt. This threshold value $\overline{\varpi}_{B,i,t+1}$ for shock $\varpi_{B,i,t+1}$ is given by

$$R^{L,C}_{B,i,t}B^{C}_{B,i,t} + R^{L,H}_{B,t}B^{H}_{B,i,t} = \gamma^{B,C}_t\overline{\varpi}_{B,i,t+1}\left(1-\tau_{W,t+1}\right)N_{B,i,t+1}W_{t+1} \tag{4}$$

[2]We did not introduce state-contingent lending rates since most consumer loans in Brazil are extended at fixed-rates

[3]This modeling strategy was adopted to replicate the way consumer loans are extended in Brazil, and in many other countries where consumer loans are unsecured or weakly collateralized. Non-corporate loans in Brazil amount to 43% of total bank loans. About half the stock of retail loans are not collateralized with housing or any other type of physical capital and neither are they extended to finance the purchase of any particular good. Credit lines financing purchases of vehicles represent another third part of consumer loans, but the underlying goods are not necessarily collateral. Moreover, regardless of collateral requirements, banks decisions on consumer credit heavily rely on borrowers' capacity to settle their debt obligations with labor income. For more details on the impact of this modeling strategy and a comparison with standard collateral assumptions, please refer to Carvalho, Castro e Costa (2014)

[4]This assumption is necessary to replicate the fact that default rates in Brazil are much higher for consumer loans than for housing loans.

For convenience, we define another threshold $\overline{\varpi}^{H}_{B,i,t+1}$ which will determine default on housing loans:

$$R^{L,H}_{B,t} B^{H}_{B,i,t} = \gamma^{B,C}_{t} \overline{\varpi}^{H}_{B,i,t+1} \left(1 - \tau_{W,t+1}\right) N_{B,i,t+1} W_{t+1} \tag{5}$$

The expected zero profit condition of the bank's risk neutral competitive lending branch is given by

$$R^{C}_{B,t} B^{C}_{B,i,t} = \gamma^{B,C}_{t} \left[E_t \left(1 - \tau_{W,t+1}\right) N_{B,i,t+1} W_{t+1} G_{B,C} \left(\overline{\varpi}_{B,i,t+1}, \overline{\varpi}^{H}_{B,i,t+1}; \sigma_{B,t+1}\right)\right] \tag{6}$$

where

$$\begin{aligned} G_{B,C}\left(\overline{\varpi}_{B}, \overline{\varpi}^{H}_{B}; \sigma_{B}\right) = \left(1 - \mu_{B,C}\right) & \left[\int_{\overline{\varpi}^{H}_{B}}^{\overline{\varpi}_{B}} \varpi dF\left(\varpi; \sigma_{B}\right) - \overline{\varpi}^{H}_{B}\left[F\left(\overline{\varpi}_{B}; \sigma_{B}\right) - F\left(\overline{\varpi}^{H}_{B}; \sigma_{B}\right)\right]\right. \\ & \left. + \left(\overline{\varpi}_{B} - \overline{\varpi}^{H}_{B}\right)\left(1 - F\left(\overline{\varpi}_{B}; \sigma_{B}\right)\right)\right] \end{aligned} \tag{7}$$

and where $R^{C}_{B,t}$ is the funding cost for consumer credit operations and $F\left(\cdot; \sigma_{B,t+1}\right)$ and $dF\left(\cdot; \sigma_{B,t+1}\right)$ are respectively log-normal CDF and PDF.

On average, the expected repayment to retail lending branches is

$$\gamma^{B,C}_{t} E_t \left(1 - \tau_{W,t+1}\right) N_{B,i,t+1} W_{t+1} H \left(\overline{\varpi}_{B,t+1}, \overline{\varpi}^{H}_{B,i,t+1}; \sigma_{B,t+1}\right) \tag{8}$$

where

$$\begin{aligned} H\left(\overline{\varpi}_{B}, \overline{\varpi}^{H}_{B}; \sigma_{B}\right) = & \int_{\overline{\varpi}^{H}_{B}}^{\overline{\varpi}_{B}} \varpi dF\left(\varpi; \sigma_{B}\right) - \overline{\varpi}^{H}_{B}\left(F\left(\overline{\varpi}_{B}; \sigma_{B}\right) - F\left(\overline{\varpi}^{H}_{B}; \sigma_{B}\right)\right) \\ & + \left(\overline{\varpi}_{B} - \overline{\varpi}^{H}_{B}\right)\left(1 - F\left(\overline{\varpi}_{B}; \sigma_{B}\right)\right) \end{aligned} \tag{9}$$

The difference between this amount and that represented in equation (6) corresponds to the proportional monitoring costs, which are received by the patient households as lump-sum transfers.

Similarly, the expected repayment to the housing lending branch is

$$\gamma^{B,C}_{t} E_t \left(1 - \tau_{W,t+1}\right) N_{B,i,t+1} W_{t+1} H \left(\overline{\varpi}^{H}_{B,i,t+1}, 0; \sigma_{B,t+1}\right) \tag{10}$$

Hence, total expected loan payment is

$$\gamma^{B,C}_{t} E_t \left(1 - \tau_{W,t+1}\right) N_{B,i,t+1} W_{t+1} H \left(\overline{\varpi}_{B,i,t+1}, 0; \sigma_{B,t+1}\right) \tag{11}$$

To model the demand for housing loans, some features of the Brazilian credit market have to be taken into account. First, the bulk of loans to households that take real estate as collateral are housing loans. Hence, it makes sense to introduce loan-to-value constraints to model housing loans. Second, there are factors that can break the tight connection between asset prices and credit volumes that LTV constraints impose. One of these factors is the remarkably high housing deficit in the country (8 million units as of 2012 [5]). At the beginning of the sample used in our estimation, the stock of housing loans was extremely low due to a cumbersome framework for collateral execution, to several escape clauses to the mandatory allocation of savings deposits on housing loans, and to prohibitive interest rates. In spite of the acceleration observed in this credit segment after these constraints were relieved, the current stock of housing loans is still very small by international standards.These facts explain why the bulk of the past acceleration is associated mostly with purchases of first homes. In addition, the supply of housing loans in Brazil is mainly driven by Caixa Economica Federal, a state-owned financial institution whose policies and practices in this market are strongly aligned with redistribution policies commanded by the federal government. To account for these aspects of the housing loans market, and given the fact that the stock of housing loans in the model is determined by the demand, we model the demand for housing loans according to a variant of traditional loan-to-value constraints:

$$B^{H}_{B,i,t} = \rho^{B,H} B^{H}_{B,i,t-1} + \left(1 - \rho^{B,H}\right) \gamma^{B,H}_{t} P_{H,t} H^{B}_{i,t} \tag{12}$$

A representative borrower exists if we assume that an insurance contract homogenizes income available to each borrower after the idiosyncratic shock realizes and after default decisions are made. We impose that every single borrower follows the same allocation plan that maximizes average utility in the group of borrowers. This shortcut allows us to drop subscript i and solve the optimization program in terms of aggregate allocations.

The aggregate budget constraint of the borrower (already incorporating insurance) is

$$\begin{aligned} &(1 + \tau_{C,t}) P_{C,t} C_{B,t} + P_{H,t} \left(H_{B,t} - (1 - \delta_H) H_{B,t-1}\right) \\ &+ \gamma^{B,C}_{t-1} (1 - \tau_{W,t}) N_{B,t} W_t H \left(\overline{\varpi}_{B,t}, 0; \sigma_{B,t}\right) + D^{D}_{B,t} \\ &\leq B^{C}_{B,t} + B^{H}_{B,t} + D^{D}_{B,t-1} + (1 - \tau_{W,t}) \left(W^{N}_{t} N_{B,t}\right) + TT_{B,t} + \Pi^{LU}_{B,t} \end{aligned} \tag{13}$$

where W^N_t is the wage paid by unions to households[6]. The borrowing constraint is the consumer lending branches' expected zero profit condition (equation 6).The borrower maximizes its utility function (1) subject to constraints (2), (4), (5), (6), (12), and (13).The complete set of first order conditions is presented in the companion technical appendix.

[5]http://www.globalpropertyguide.com/Latin-America/brazil/Price-History

[6]It is straightforward to show that $(1 - \tau_{\omega,t}) N_{B,t} W_t = (1 - \tau_{\omega,t}) \left(W^N_t N_{B,t}\right) + \Pi^{LU}_{B,t}$

2.2 Entrepreneurs

Entrepreneurs manage productive capital and this activity involves financing. We introduce financial frictions in the accumulation and management of capital following Christiano, Rostagno e Motto (2010), but we let LTV ratios vary with time. Our main innovation in entrepreneurs' optimality conditions is related to the introduction of foreign direct investment.

Entrepreneurs are agents working on behalf of domestic savers and foreign investors, who respectively own a share $N^S_{E,t}$ and $N^{FDI}_{E,t}$ of entrepreneurs' net worth. Hence

$$N_{E,t} = N^{FDI}_{E,t} + N^S_{E,t}$$

where $N_{E,t}$ is total net worth. We assume that the inflows of foreign direct investment are destined to acquire shares of entrepreneurs' net worth held by domestic savers, and that is the only way to change the participation of each group of investors in entrepreneurs' net worth. Hence

$$N^{FDI}_{E,t} = N_{E,t}\frac{N^{FDI}_{E,t-1}}{N_{E,t-1}} + S_t FDI_t$$

where (FDI_t) are the inflows of foreign direct investment.

We assume that FDI inflows are driven by the following exogenous process:

$$\frac{FDI_t}{P^*_t \epsilon_{L,t}\epsilon_{A,t}} = -\gamma^{FDI}\left(\frac{N_{E,t-1}}{P_{C,t-1}\epsilon_{L,t-1}\epsilon_{A,t-1}} - n^{FDI}_E\right) + \varepsilon^{FDI}_t \tag{14}$$

where n^{FDI}_E is the steady state value of foreign investors' share in entrepreneurs' net worth, ε^{FDI}_t is an AR(1) process and the term in parenthesis is included to keep the model stationary. When foreign investors purchase a share of entrepreneurs' net worth, savers receive lump sum transfers $(TT^{FDI}_{E,t})$ as payment for this operation.

At the end of period t, entrepreneurs purchase capital $(K_{E,t})$ and, at $t+1$, rent it to intermediate goods producers. After its use, capital depreciates at the rate δ_K and is sold at the market price $(P_{K,t})$. Capital purchases are carried out with entrepreneurs' own resources $(N_{E,t})$ and bank loans extended by the commercial lending branches $(B_{E,t})$ at the lending rate $R^{L,E}_t$, where a fraction (γ^E_t) of the entrepreneur's capital stock is put up as collateral. At the beginning of period $t+1$, before rental at rate R^K_{t+1}, capital is subject to a multiplicative mean 1 idiosyncratic shock ω_{t+1}, lognormally distributed with standard deviation $\sigma_{E,t+1}$, which represents the risk of business activity. If, after capital renting and depreciation, the value of the enterprise put up as collateral is lower than the value of the bank loan, the entrepreneur goes bankrupt, and lending branches execute the collateral warranties, after incurring in monitoring costs (μ_E).

At the end of each period, only a fraction (γ_t^N) of the entrepreneurs survive. Entrepreneurs that quit their projects transfer their wealth $\left(\Pi_t^E\right)$ to patient households and foreign investors. This wealth is given by

$$\Pi_t^E = \left(1 - \gamma_t^N\right)(R_{t+1}^K + P_{K,t+1}(1 - \delta_K))K_{t-1}\left[1 - \gamma_{t-1}^E H(\overline{\varpi}_{E,t}, \sigma_{E,t}]\right)$$

The share of wealth distributed to foreign investors and patient households depends on their shares in total net worth

$$\Pi_t^E = \Pi_t^{E,S} + \Pi_t^{E,FDI}$$

where

$$\Pi_t^{E,FDI} = \frac{N_{E,t-1}^{FDI}}{N_{E,t-1}}\Pi_t^E$$

For the sake of brevity, we will not present the details of the entrepreneurs' optimization problem here. The complete derivation of the model is in the companion technical appendix.

2.3 Domestic intermediate goods producers

Domestic intermediate goods producers are distributed in the continuum $j \in (0, 1)$ and operate under perfect competition. Output is produced with the following technology:

$$Z_{j,t}^d = A.\varepsilon_t^A\left[u_{j,t}K_{j,t}\right]^\alpha\left(\epsilon_{A,t}L_{j,t}\right)^{1-\alpha} \tag{15}$$

where A is a scaling constant, u_t is capital utilization, $L_{j,t}$ is labor demand, ε_t^A is a temporary AR(1) shock to total factor productivity, and $\epsilon_{A,t}$ is a permanent shock to labor productivity whose growth rate follows

$$\ln\left(\frac{g_{A,t}}{g_A}\right) = \rho_{gA}\ln\left(\frac{g_{A,t-1}}{g_A}\right) + \upsilon_t^{gA} \tag{16}$$

where $g_{A,t} = \epsilon_{A,t}/\epsilon_{A,t-1}$, and g_A is the steady state of $g_{A,t}$.

Intermediate goods producers maximize profits

$$MC_tZ_{j,t}^d - R_t^KK_{j,t} - \Gamma_u\left(u_{j,t}\right)P_{C,t}K_{j,t} - W_tL_{j,t} \tag{17}$$

subject to (15), where MC_t is the market price of domestic intermediate goods, which also represents the marginal cost for the retailers, $\Gamma_u(u_t)$ is a quadratic adjustment cost of capital utilization, and W_t are wages. The first order conditions are presented in the technical appendix.

2.4 Retailers, distributers, importers, and final goods producers

Final goods producers use domestic and imported intermediate goods in the production of goods for private and public consumption, investment, and exports. Price rigidities are introduced in the purchases of both domestic and imported intermediate goods. Decisions on capital and housing investment are made by capital and housing stock producers. Since this part of the model is very standard in the DSGE literature, we present a brief description in the appendix. For more details, please refer to the companion technical appendix.

2.5 Exports and foreign variables

Brazilian exports are relatively well diversified but are still strongly based on commodities. The country is a price taker in the global commodities market but the responses of the export quantum to developments in global prices is sluggish.

Taking these facts into account, we model the export firm as a price taker that faces adjustment costs to change export volumes. We assume that it purchases export goods (X_t) from domestic producers at the price $P_{X,t}$ (expressed in domestic currency) and sells them abroad at a foreign currency price $P_t^{X^*}$, which is a function of world prices (P_t^*), the rest-of-the-world output gap (y_t^*) and an exogenous shock (Z^{X^*}), both represented by AR(2) processes.

$$\frac{P_t^{X^*}}{P_t^*} = \left(\frac{Z_t^{X^*}}{\alpha_{Y^*} y_t^*}\right)^{-\frac{1}{\epsilon_{Y^*}}} \tag{18}$$

where P_t^* is a world price index and α_{Y^*} is a proportionality parameter[7]. We assume that world price inflation follows an AR(1) process.

At the beginning of period t, the exporter gets a loan at the amount of $\omega_t^X P_t^{X^*} X_t$ in foreign currency to finance its working capital. The interest rate associated with this operation is $R_{X,t}^{L,f}$, which is basically equal to the international interest rate added by the country risk premium and an additional non-state contingent risk premium related to this type of operation. The loan redeems at the end of the same period.

Our choice to introduce export credit lines as working capital loans was based on the actual nature of export loans in Brazil that are extended at non-regulated rates. Most export bank credit lines are short term, with very low default rates. Import financing lines represent only a very small share (4%) of total credit lines for foreign trade, so we chose not to include them in the model.

[7]This model choice was based on exploratory econometric estimations of the univariate series.

The exporter chooses X_t to maximize its discounted cash flow:

$$E_0 \sum_{t=0}^{\infty} \beta_S^t \frac{\Lambda_{S,t}}{P_{C,t}\epsilon_{L,t}\epsilon_{A,t}} \Pi_t^X$$

where

$$\Pi_t^X = S_t P_t^{X^*} X_t \left[1 - \left(1 + \tau_t^{R_X^{L,f}}\right) \omega_t^X \left(R_{X,t}^{L,f} - 1\right)\right] - P_{X,t} X_t \left[1 + \Gamma_X \left(X_t / \left(g_{L,t} g_{A,t} X_{t-1}\right); \varepsilon_t^X\right)\right] \tag{19}$$

$$R_{X,t}^{L,f} = R_t^* \phi_t^* \phi_t^{L,X} \tag{20}$$

and where R_t^* is the foreign interest rate, modeled as an AR(1) process, ϕ_t^* is the country risk premium, Γ_X is a quadratic adjustment cost, $\phi_t^{L,X}$ is a lending spread specific to this credit segment, modeled as an AR(1) process, ω_t^X is the time-varying share of exports that are financed with bank loans, and it also follows an AR(1) process, $\tau_t^{R_X^{L,f}}$ is a proportional tax on export loans' interest payments, and ε_t^X is an AR(1) shock to the adjustment cost of exports.

2.6 The retail money market fund

Instead of letting the saver choose the share of each financial instrument in its investment portfolio, we assume, without loss of generality, that a retail money market fund (RMMF) makes these decisions on behalf of the savers, without any transaction cost. The investment portfolio of this fund comprises time deposits (D_t^T) issued by banks, government bonds ($B_{F,t}$), and foreign bonds ($B_{F,t}^*$), which yield R_t^T, R_t and $R_t^* \phi_t^*$, respectively. Foreign bonds issued by the fund are denominated in foreign currency, while the other assets are denominated in domestic currency.

The RMMF seeks to maximize the total nominal return of its portfolio according to the following optimization program:

$$\max_{\left\{D_t^T, B_t^F, B_t^*\right\}} E_t \left\{R_t^T D_t^T + B_{F,t} R_t - S_{t+1} R_t^* \phi_t^* B_{F,t}^*\right\} - \Gamma_{F,B^*} \left(\frac{B_{F,t}^*}{\pi_t^* g_{L,t} g_{A,t} B_{F,t-1}^*}\right) S_t B_{F,t}^* \tag{21}$$

subject to the balance sheet constraint

$$D_t^F = D_t^T + B_{F,t} - S_t B_{F,t}^*$$

where $\Gamma_{F,B^*}(r) \equiv \phi_{F,B^*}(r-1)^2/2$ is an adjustment cost that issuers face when attempting to issue bonds in the foreign market at a rollover rate different from the trend. The presence of this cost may magnify the quantity effect of shocks to foreign capital inflows on the domestic economy and the creditmarket[8].

The resulting first order conditions imply a non-arbitrage condition between R_t^T and R_t and a modified UIP equation:

$$R_t^T = R_t \tag{22}$$

$$R_t = \frac{P_{C,t}}{S_t P_t^*} E_t \left\{ \frac{S_{t+1} P_{t+1}^*}{P_{C,t+1}} \frac{\pi_{C,t+1}}{\pi_{t+1}^*} R_t^* \phi_t^* \varepsilon_t^{UIP} \right\} + \phi_{F,B^*} \left(\frac{B_{F,t}^*}{\pi_t^* g_{L,t} g_{A,t} B_{F,t-1}^*} - 1 \right) \frac{B_{F,t}^*}{\pi_t^* g_{L,t} g_{A,t} B_{F,t-1}^*} \tag{23}$$
$$+ \phi_{F,B^*} \frac{1}{2} \left(\frac{B_{F,t}^*}{\pi_t^* g_{L,t} g_{A,t} B_{F,t-1}^*} - 1 \right)^2$$

where ε_t^{UIP} is an AR(1) shock.

The nominal return of the RMMF from period $t-1$ to period t is given by

$$R_t^F D_{t-1}^F = R_{t-1}^T D_{t-1}^T + R_{t-1} B_{F,t-1} + S_t R_{t-1}^* \phi_{t-1}^* B_{F,t-1}^* - \Gamma_{F,B^*} \left(\frac{B_{F,t-1}^*}{\pi_{t-1}^* g_{L,t-1} g_{A,t-1} B_{F,t-2}^*} \right) S_{t-1} B_{F,t-1}^* \tag{24}$$

2.7 The balance of payments and foreign capital flows

We introduce a detailed balance of payments equation that adequately represents Brazilian data series. In addition to exports, imports, and private sector debt, which are traditionally present in open economy models, the balance of payments also includes foreign direct investment (FDI_t), foreign portfolio investment (FPI_t), changes in the volume of foreign exchange reserves, and unilateral transfers (ULT_t). The BoP equation is:

$$B_t^f = R_{t-1}^f B_{t-1}^f + \omega_t^X \left(R_t^* \phi_t^* - 1 \right) P_t^{X^*} X_t - \left(P_t^{X^*} X_t - P_t^{M,*} Z_t^M \right) - ULT_t \tag{25}$$
$$- \left(FDI_t - \frac{\Pi_t^{E,FDI}}{S_t} \right) + \left(B_t^{FER} - R_{t-1}^* \phi_t^{FER} B_{t-1}^{FER} \right) - \left(\frac{B_{FPI,t}}{S_t} - \frac{R_{t-1} B_{FPI,t-1}}{S_t} \right)$$

where B_t^{FER} and B_t^{FPI} are the stocks of foreign exchange reserves and foreign portfolio investment, respectively. The interest rate R_t^f on foreign debt (B_t^f) is asssumed to be the foreign risk free interest rate (R_t^*) plus a risk premium (ϕ_t^*), as follows:

$$R_t^f = R_t^* \phi_t^* \tag{26}$$

As mentioned earlier, FDI inflows are acquisitions of domestic productive capital by foreign investors. This is represented in the model as foreigners' stake on entrepreneurs's net worth N_t^E. The exogenous process driving FDI inflows is represented in equation (14).

[8]Notwithstanding, the estimated value of the parameter associated with this cost using Brazilian data was not sufficiently high to make this transmission channel relevant

On the other hand, foreign portfolio investment (FPI) is a short term investment of the foreign investor in domestic financial markets, we represent it in the model as the acquisition of short term risk free government bonds ($B_{FPI,t}$) by foreign investors. These bonds are denominated in domestic currency and yield the base rate. We represent foreign investors' decision process as a rule that depends on the interest rate differential between domestic and foreign rates, as follows:

$$\ln\left(\frac{B_{FPI,t}}{P_{C,t}\epsilon_{L,t}\epsilon_{A,t}}\frac{1}{b_{FPI}}\right) = \gamma^{R,FPI}\left[\ln\left(E_t\frac{R_t}{\pi_{C,t+1}}\frac{\pi^*_{t+1}}{R^*_t\phi^*_t}\right) - \ln\left(\frac{R}{\pi_C}\frac{\pi^*}{R^*\phi^*}\right)\right] + \varepsilon^{FPI}_t \tag{27}$$

where ε^{FPI}_t is an AR(1) process. In the model, the monetary authority is also responsible for managing the stock of foreign exchange reserves, according to the policy rule presented in section 2.9 (see equation 55). The reserves are remunerated at the foreign risk free rate (R^*_t) plus an additional exogenous premium (ϕ^{FER}_t).

In the model, the country risk premium affects the funding costs of exporters and of domestic investors (i.e., the RMMF). We assume that it changes with foreign investors' global risk aversion ($risk_t$) and with the net stock of foreign debt (i.e., $B^f_t - B^{FER}_t$). We also assume that foreign portfolio investment affects the risk premium, since they are usually more susceptible to herd behavior and are traditionally seen as a source of vulnerability in the external accounts of emerging economies. Hence, the risk premium equation can be expressed according to the following equation:

$$\phi^*_t = \phi^* \exp\left(\kappa^{\phi^*}_{bf}\left[\frac{S_t\left(B^f_t - B^{FER}_t\right) + \kappa^{\phi^*}_{B^{FPI}}B_{FPI,t}}{P_{C,t}\epsilon_{L,t}\epsilon_{A,t}} - \left(b^f - b^{FER} + \kappa^{\phi^*}_{B^{FPI}}b_{FPI}\right)\right] + \kappa^{\phi^*}_{risk}\ln\left(\frac{risk_t}{risk}\right)\right)\varepsilon^{\phi^*}_t \tag{28}$$

where $\varepsilon^{\phi^*}_t$ and $risk_t$ are AR(1) processes.

Unilateral transfers (ULT_t) are introduced in the balance of payments equation in order to fully map the Brazilian BoP. Although actual flows of unilateral transfers account for only a small fraction of Brazilian BoP flows, the observational series related to this variable of the model includes all minor BoP flows that cannot be properly classified as FDI, FPI, FER or debt.

In the model, the only domestic agent that borrows from abroad is the retail money market fund. Therefore

$$B^f_t = B^*_{F,t} \tag{29}$$

This equality introduces a direct link between the BoP equation and the modified UIP (equation 23). Given that we observe the flows of FPI, FDI, FER and the trade balance, the variable that corresponds to foreign debt is obtained as a residual in the BoP equation. Hence, any variation in the investment and trade flows or in international reserves will generate an equivalent variation in the stock of foreign debt. In fact, the larger the adjustment cost of issuing new foreign debt, which is a term added to the optimization problem of the RMMF that consequently appears in the UIP equation, the larger will be the immediate impact of changes in the stock of foreign debt on the exchange rate.

In addition to this direct impact, there is also an indirect effect of foreign debt through the risk premium channel. However, this indirect effect depends on the kind of flow considered. For instance, if the monetary authority decides to increase the stock of international reserves (B_t^{FER}), it will purchase foreign currency from the RMMF, and all else equal, the stock of foreign debt must increase. As a result, the net position $\left(B_t^f - B_t^{FER}\right)$ remains unaltered and the country risk premium ϕ_t^* is not affected. On the other hand, the risk premium equation does not depend directly on the stock of FDI, under the reasoning that this source of foreign funding is regarded as stable and it is not expected to be swiftly withdrawn. In this case, a surge in FDI_t produces a reduction in B_t^f, through the BoP equation, and a subsequent decrease in the risk premium, through the risk premium equation. A similar effect happens when a shock to the terms of trade increases the trade balance, thus reducing foreign debt. With respect to the effect of FPI, the role of $B_{FPI,t}$ in the risk premium equation will depend on the value of parameter $\kappa_{B^{FPI}}^{\phi^*}$ and may stand between the two extreme cases analyzed above.

2.7.1 A quick note on observable variables in the BoP equation

The observation equations used to estimate the model relate the BoP equation to actual foreign exchange flows. FDI, FPI, FER and ULT cashflow series are observed, as well as exports' and imports' volumes and prices. Variation of private sector debt B_t^f is obtained as a residual of the BoP equation.

In the case of FDI and FPI, timely series are available only for flows, not for stocks. Therefore, only flows are observed in the estimation. But, in the case of FER, there are timely series of both the stock and the variation of reserves. As the actual remuneration of the stock of FER is not exactly the risk-free international rate (R_t^*), we introduced an interest rate premium (ϕ_t^{FER}) specific to international reserves in order to reconcile the observation of these two data series, and it is obtained from the following observation equation:

$$\Delta_t^{FER} = B_t^{FER} - R_{t-1}^* \phi_t^{FER} B_{t-1}^{FER} \tag{30}$$

$$\ln\left(\phi_t^{FER}\right) \sim N\left(0, \sigma_{\phi^{FER}}^2\right)$$

where series Δ_t^{FER}, B_t^{FER} and R_t^* are observed.

The other observed components of the BoP equation are unilateral transfers ULT_t and the net cashflows of FDI and FPI, related to the model variables according to

$$\Delta_t^{FDI} = FDI_t - \frac{\Pi_t^{E,FDI}}{S_t} \tag{31}$$

$$\Delta_t^{FPI} = \frac{B_{FPI,t} - R_{t-1} B_{FPI,t-1}}{S_t} \tag{32}$$

2.8 The banking sector

Our modeling strategy for the banking sector is adequate to assess the impact of macroprudential policy instruments not only on bank rates (prices) but also on quantities, through shifts in the composition of banks' balance sheets.

The bank conglomerate is composed of a continuum [0, 1] of competitive banks that get funding from deposit branches and extend credit to households, entrepreneurs, and export firms through their lending branches. Banks are the financial vessel of the conglomerate: they channel money market funds to the lending branches and make all important decisions with respect to the composition of the conglomerate's balance sheet. The conglomerate is subject to regulatory requirements and can only accumulate capital by retaining profits. The share of profits to be distributed or reinvested is a choice variable in the intertemporal optimization program of the bank. Our adopted segmentation of the bank conglomerate allows the model to endogenously reproduce the most relevant determinants of lending spreads in the main credit segments in Brazil and the effects of regulatory requirements on bank rates and volumes.

2.8.1 Deposit branches

There is one representative deposit branch for each type of deposit. The demand deposit branch costlessly takes unremunerated demand deposits, $\omega_S D_{S,t}^D$ and $\omega_B D_{B,t}^D$, which are determined from households' optimization problems. It then costlessly distributes this funding to each bank $j \in [0, 1]$. In the following period, these resources return to households. Hence:

$$\omega_S D_{S,t}^D + \omega_B D_{B,t}^D = D_t^D = \int_0^1 \omega_{b,j} D_{j,t}^D dj \tag{33}$$

The savings and time deposit branches operate analogously, except that these deposits accrue interest. The savings deposits market is strongly regulated in Brazil. To account for empirical evidence, we assume that deviations of the interest rate on savings deposits (R_t^S) from the steady state are proportional to those of the base rate:

$$\ln\left(\frac{R_t^S}{R^S}\right) = \varphi_R^S \ln\left(\frac{R_t}{R}\right) + \ln\left(\varepsilon_t^{R,S}\right) \tag{34}$$

where $\varphi_{R,t}^S$ is an AR(1) process. We assume that the time deposit branch issues deposit certificates to the retail money market fund, at an interest rate equal to the base rate $\left(R_t^T = R_t\right)$. The motivation for this assumption is as follows.

In Brazil, banks' time deposits face fierce competition from domestic federal bonds. About half the outstanding balance of domestic federal bonds are held by non-financial clients of the banking system, either through direct ownership of securities or through quotas of mutual funds. In fact, domestic federal bonds held by money market funds account for about 30% of domestic federal bonds. Private individuals can also hold claims to federal bonds negotiated at National Treasury's facility 'Tesouro Direto'[9],

Such competition results in very narrow markdowns of time deposit rates on the base rate of the economy. For instance, in the period analyzed in this paper, the quarterly base rate was merely 0.2 p.p higher on average than the effective 90-day time deposits (CDB) rate.

The assumption that interest rates on time deposits, R_t^T, and on domestic public bonds, R_t, are equal at every point in time has implications for the response of credit conditions after changes in reserve requirements. If these rates were not equal, the impact of reserve requirements shocks on credit would be partially attenuated by adjustments in the cost of funding to banks.

2.8.2 Lending branches

Lending branches get funding from banks and extend commercial loans to entrepreneurs and consumer loans to borrowers.

The representative commercial lending branch is competitive in the market of credit to entrepreneurs and seeks to diversify its funding sources. It borrows $B_{E,j,t}^b$ from bank j at the interest rate $R_{E,j,t}$. Total loans extended to entrepreneurs ($B_{E,t}$) are a CES aggregate of funding resources:

$$B_{E,t} = \left[\int_0^1 \omega_{b,j} \left(B_{E,j,t}^b\right)^{\frac{1}{\mu_{E,t}^R}} dj\right]^{\mu_{E,t}^R} \tag{35}$$

where $\mu_{E,t}^R$ follows an AR(1) process.

The lending branch chooses the amount to borrow from each bank ($B_{E,j,t}$) so as to

[9]The stock of outstanding debt negotiated at Tesouro Direto is about 1% of the stock outstanding of domestic federal bonds.

minimize total funding costs

$$\int_0^1 \omega_{b,j} R_{E,j,t} B^b_{E,j,t} dj \tag{36}$$

subject to the aggregation technology (35).

The first order condition yields:

$$B^b_{E,j,t} = \left(\frac{R_{E,j,t}}{R_{E,t}}\right)^{\frac{\mu^R_{E,t}}{1-\mu^R_{E,t}}} B^{LB,E}_{E,t} \tag{37}$$

Total funding collected from banks $j \in [0,1]$ at period t is:

$$B^b_{E,t} = B_{E,t} \Delta^R_{E,t} \tag{38}$$

where

$$\Delta^R_{E,t} = \int_0^1 \omega_{b,j} \left(\frac{R_{E,j,t}}{R_{E,t}}\right)^{\frac{\mu^R_{E,t}}{1-\mu^R_{E,t}}} dj > 1$$

The total cash flow of the commercial lending branch is

$$\Pi^{LB,E}_t = \gamma^E_{t-1} R^{TK}_t K_{t-1} G_E\left(\varpi_{E,t}, \sigma_{E,t}\right) - R^E_{t-1} B_{E,t-1} + B_{E,t}\left(\Delta^R_{E,t} - 1\right)$$

which is proportionally distributed to the banks.

The decisions of the representative consumer lending branch are analogous, and they are presented in the technical appendix.

2.8.3 Housing loan branch

The Brazilian housing credit market is heavily regulated by the government. The regulatory authority requires that a fraction of savings deposits be channeled to housing loans, most of which at regulated lending rates[10]. We therefore assume that the final lending rate $R^{L,H}_{B,t}$ is set by the government as a markup on the savings deposits rate:

$$\frac{R^{L,H}_{B,t}}{R^S_t} = \left(\frac{R^{L,H}_{B,t-1}}{R^S_{t-1}}\right)^{\rho_{RH}} \left(\frac{R^{L,H}_B}{R^S}\right)^{1-\rho_{RH}} \exp\left(\upsilon^{R,L,H}_t\right) \tag{39}$$

Consequently, the only role played by the housing loan branch is to channel housing loans from banks to households, making no strategic decisions with respect to lending rates or volumes. It

[10] Housing loans that finance expensive real estate are less tightly regulated. However, the bulk of housing credit in Brazil finances low-priced real estate, which is subject to regulation.

follows that

$$\omega_B B^H_{B,t} = \int_0^1 \omega_{b,j}\left(B^{H,b}_{B,j,t}\right) dj \equiv B^{H,b}_{B,t} \tag{40}$$

where $B^{H,b}_{B,j,t}$ are funds collected from bank j and $B^{H,b}_{B,t}$ represents aggregate housing loans.

Since housing loans are risky, the actual cash flow received by the housing loan branch is

$$\Pi^{LB,H}_t = \omega_B \gamma^{B,C}_{t-1}\left(1-\tau_{W,t}\right) N_{B,t} W_t G_{B,H}\left(\overline{\varpi}^H_{B,t}, 0; \sigma_{B,t}\right) - R^{L,H}_{B,t-1} B^{H,b}_{B,t-1} \tag{41}$$

The bank conglomerate absorbs the cost of default on housing loans as a loss since it cannot be passed through to volumes or rates in this market.

2.8.4 Working capital loans to exporters

Export credit lines offered by the Brazilian banking system represent only a small fraction of the total volume of loans negotiated in the financial system at non-regulated interest rates. As of December 2013, they amounted to 4.4% of total bank credit, consisting mostly of export credit. As a share of quarterly exports, the stock of outstanding loans to exporters averaged 63% from 2002 to 2013, with a standard deviation of 13%.

Most of these export credit lines is short term, with very low default rates. As a result, w.l.g. we modeled them as working capital loans[11].

We assume that the banking sector makes no strategic decisions with respect to export loans. Lending rates are set with a premium over the rate applicable to foreign debt, and volumes are decided by the exporters.

2.8.5 Banks

Banks are distributed in a continuum $[0, 1]$. Their operations are funded with resources from the deposit branches and from retained earnings. They optimally choose the composition of their balance sheet, constrained by regulation on reserve requirements, capital requirements, risk weights on CAR's, and facing nominal frictions in addition to operational and fiscal costs. They are allowed to choose the proportion of profits to be distributed to their owners (i.e., savers) or to be retained in order to build capital.

The regulatory environment in the model has the following features. First, funding

[11]The Brazilian Development Bank (BNDES) has important credit lines intended to foster the export sector. Both working capital and investment loans are extended at subsidized rates. Decisions on subsidies and quantities follow a development-oriented strategy that tightly adheres to the principles guiding fiscal policy. However, since our intention was to model a channel of contagion from adverse international conditions to the banking system, we focused only on non-regulated loans.

from time deposits is subject to reserve requirements, which can be remunerated or non-remunerated[12]. Second, the benchmark model introduces a simplified version of Basle 1 and Basle 2-type capital requirement, which is based on the computation of capital adequacy ratios after weighting bank assets according to their risk factors. Third, there are regulatory requirements on savings deposits and housing loans. Finally, there is tax incidence on specific credit operations and on banks' profits.

Bank j's balance sheet can be represented as:

$$\begin{aligned} &B_{Bank,j,t} + B^{b}_{E,j,t} + B^{C,b}_{B,j,t} + B^{H,b}_{B,j,t} - RR^{S,H}_{j,t} + RR^{T}_{j,t} + RR^{S}_{j,t} + RR^{D}_{j,t} + RR^{add}_{j,t} \\ &= D^{T}_{j,t} + D^{S}_{j,t} + D^{D}_{j,t} + Bankcap_{j,t} \end{aligned} \tag{42}$$

where $B_{Bank,j,t}$ are liquid assets (i.e., public bonds held by the bank), $B^{b}_{E,j,t}$, $B^{C,b}_{B,j,t}$, and $B^{H,b}_{B,j,t}$ are funds to commercial, consumer and housing lending branches, $Bankcap_{j,t}$ is net worth, $RR^{T}_{j,t}$, $RR^{S}_{j,t}$, and $RR^{D}_{j,t}$ are required reserves on time, savings and demand deposits, respectively, and $RR^{add}_{j,t}$ are additional required reserves[13], and $RR^{S,H}_{j,t}$ is an exogenous source of funding to housing loans that fulfills[14]:

$$RR^{S,H}_{j,t} + \tau_{H,S,t} D^{S}_{j,t} = B^{H,b}_{B,j,t} \tag{43}$$

Export credit does not show in banks' balance sheet equation because it redeems within the same period at which it was extended. It will only show in banks' cash flow.

[12]Reserve requirements in Brazil have been used for a number of reasons: general financial stability concerns, disruptions in specific segments of the credit or bank liquidity market, overall economic stability, or, outside the sample considered for estimation in this paper, for income distribution (Carvalho e Azevedo (2008), Montoro e Moreno (2011), Mesquita e Torós (2011), Tovar, Garcia-Escribano e Martin (2012))

[13]In addition to traditional reserve requirements on the main types of bank deposits, the Central Bank of Brazil has often used the so called "additional reserve requirements", whose incidence base is the same as of standard required reserves. However, these additional reserve requirements can be remunerated differently from their standard counterparts or have a different form of compliance. For simplicity, we assume in our model that they have a homogeneous incidence rate upon the simple average of all deposits. Other types of reserve requirements have been eventually introduced in Brazil, such as requirements on marginal changes in deposits, among others, but we focused on the ones that have lasted longer.

[14]The motivation to introduce this exogenous source of funding is the following: In Brazil, banks that take savings deposits are required to extend a fraction $\tau_{H,S,t}$ of their savings deposits to finance low-priced housing. However, the estate-owned bank Caixa Economica Federal (CEF), which is the main player in the mortgage loan market in Brazil, also funds mortgage loans from resources deposited at the Severance Indemnity Fund (FGTS). We represent funding from this external source as $RR^{S,H}_{j,t}$, which is assumed to fill the gap between required and actual destination of savings deposits to housing loans

Reserve requirements are determined according to:

$$\begin{aligned} RR^{D}_{j,t} &= \tau_{RR,D,t} D^{D}_{j,t} \\ RR^{S}_{j,t} &= \tau_{RR,S,t} D^{S}_{j,t} \\ RR^{T}_{j,t} &= \tau_{RR,T,t} D^{T}_{j,t} \\ RR^{add}_{j,t} &= \tau_{RR,add,t} \left(D^{D}_{j,t} + D^{T}_{j,t} + D^{S}_{j,t} \right) \end{aligned} \tag{44}$$

where $\tau_{RR,D,t}$, $\tau_{RR,S,t}$, and $\tau_{RR,T,t}$ are required ratios set by the government on demand, savings and time deposits, respectively, and follow AR(1) processes. Required reserves deposited at the monetary authority accrue the same rate paid by banks to their clients on each of these deposits[15].

Banks have preferences over some balance sheet components, particularly liquid assets and time deposits. Deviation from the steady state allocation is costly. These frictions are necessary for the model to pin down the balances of public bonds and time deposits at the retail money fund's portfolio and play an important role in the dynamic responses of the model, particularly in financial variables. We let the data determine the power of each of these frictions by estimating cost-elasticity parameters.

Banks make no strategic decisions with respect to housing loans or interest rates on savings deposits. On the other hand, the balance of time deposits is chosen by the bank, subject to quadratic adjustment costs ($\Gamma_T \left(\frac{D^T_{j,t}}{g_{\epsilon,t} \pi_{C,t} D^T_{j,t-1}} \varepsilon^{DT}_t \right)$), introduced in the model to reproduce the strong persistence in the data[16].

Banks accumulate capital from the net flow of resources from bank operations, $CF^b_{j,t}$, net of distributed dividends, $div^b_{j,t}$. Capital accumulation is subject to shock $\varepsilon^{bankcap}_t$ that can capture changes in market perception about bank capital quality or any other shocks that change the marked-to-market value of banks' net worth. The capital accumulation rule is:

$$Bankcap_{j,t} = Bankcap_{j,t-1} + CF^b_{j,t} - div^b_{j,t} + Bankcap_{j,t} \varepsilon^{bankcap}_t \tag{45}$$

where $\varepsilon^{bankcap}_t$ is an AR(1) process.

Banks are constrained by a minimum capital requirement, γ^{BankK}_t. We assume that when the regulatory authority changes the capital requirement, agents cannot foresee the moment when another change will occur. Hence, we model γ^{BankK}_t as an AR(1) with very high persistence (0.999).

Compliance with the minimum requirement is assessed through the computation of the

[15]This assumption replicates the common practice in Brazil

[16]We assume that ε^{DT}_t follows an AR(1) process

capital adequacy ratio $CAR^b_{j,t}$, which measures how much of risk-weighted assets can be backed up by the bank's net worth:

$$CAR^b_{j,t} = \frac{Bankcap_{j,t}}{\tau_{\chi 1,t} B^{C,b}_{B,j,t} + \tau_{\chi 2,t} B^{b}_{E,j,t} + \tau_{\chi 3,t} B^{H,b}_{B,j,t} + \tau_{\chi 4,t} B_{Bank,j,t} + \varepsilon^{CAR}_t} \tag{46}$$

where τ_χ is the risk weight modeled as AR(1) processes and ε^{CAR}_t is an AR(1) process centered on the value of risk-weighted assets that are not explicitly included in the model but that exist in the actual computation of CAR's in Brazil.

The Brazilian financial system operates with a significant capital buffer (5.4 p.p. over the minimum required as of 4Q2013, and 5.7 p.p. on average since 2000). After the break of the financial crisis in 2008, banks raised capital buffers even further to reach 7 p.p. above the required minimum in 2009. Although internal financing is generally costlier than external financing, high capital buffers send positive signals about the bank's soundness, with favorable effects on the costs to raise funds in the wholesale market and on the probability of sudden stops in funding sources. In addition, capital buffers can also prevent banks from falling short of the required minimum, an event that triggers undesired supervisory intervention.

We introduce a precautionary capital buffer by letting banks face an appropriate cost function when deviating from the minimum capital requirement. Since the model solution is linearized around the balanced-growth path, it suffices to introduce a cost function that fulfills$\Gamma'_{bankK} < 0$, $\Gamma''_{bankK} > 0$, and, at the balanced growth path, $\Gamma_{bankK}\left(\frac{\overline{CAR^b}}{\gamma^{BankK}}\right) = 0$, where $\frac{\overline{CAR^b}}{\gamma^{BankK}} > 1$ $\dot{\text{F}}$or convenience, and w.l.g. since the cost parameters that affect the model dynamics are estimated, we choose the following representation:

$$\Gamma_{bankK}\left(\frac{CAR^b_{j,t}}{\gamma^{BankK}_t}\right) = \frac{\chi_{bankK,2}}{2}\left(\frac{CAR^b_{j,t}}{\gamma^{BankK}_t}\right)^2 + \chi_{bankK,1}\left(\frac{CAR^b_{j,t}}{\gamma^{BankK}_t}\right) + \chi_{bankK,0} \tag{47}$$

Let $Lb^b_{j,t}$ be bank j's total liabilities:

$$Lb^b_{j,t} = D^T_{j,t} + D^S_{j,t} + D^D_{j,t} + Bankcap_{j,t} \tag{48}$$

The one-period cash flow from bank j's operations is:

$$\begin{aligned}
CF^b_{j,t} = & \left(R_{E,j,t-1} - \tau_{B,E,t-1} - s^{adm,E}_{t-1}\right) B^b_{E,j,t-1} - B^b_{E,j,t} \\
& + \left(R^C_{B,j,t-1} - \tau_{B,B,t-1} - s^{adm,B}_{t-1}\right) B^{C,b}_{B,j,t-1} - B^{C,b}_{B,j,t} \\
& + R^H_{B,t-1} B^{H,b}_{B,j,t-1} - B^{H,b}_{B,j,t} + R_{t-1} B_{Bank,j,t-1} - B_{Bank,j,t} \\
& - R^T_{t-1} D^T_{j,t-1} + D^T_{j,t} - \Gamma_T \left(\frac{D^T_{j,t}}{g_{L,t} g_{A,t} \pi_{C,t} D^T_{j,t-1}} \varepsilon^{DT}_t \right) D^T_{j,t} \\
& - R^S_{t-1} D^S_{j,t-1} + D^S_{j,t} - D^D_{j,t-1} + D^D_{j,t} \\
& + R^{RR,T}_{t-1} RR^T_{j,t-1} + R^{RR,S}_{t-1} RR^S_{j,t-1} + RR^D_{j,t-1} \\
& + R^{RR,add}_{t-1} RR^{add}_{j,t-1} - R^{S,H}_{t-1} RR^{S,H}_{j,t-1} \\
& - RR^T_{j,t} - RR^S_{j,t} - RR^D_{j,t} - RR^{add}_{j,t} + RR^{S,H}_{j,t} \\
& + S_t P^{X^*}_t X_t \omega^X_t \left(R^{L,f}_{X,t} - R^*_t \phi^*_t \right) \\
& - \Gamma_{bankK} \left(\frac{CAR^b_{j,t}}{\gamma^{BankK}_t} \right) Bankcap_{j,t} \\
& - \frac{\chi_{B,Bank}}{2} \left(\frac{B_{Bank,j,t}}{Lb^b_{j,t}} - \nu^{B,Bank}_t \right)^2 Lb^b_{j,t} \\
& - \frac{\chi_{d_T}}{2} \left(\frac{D^T_{j,t}}{Lb^b_{j,t}} - \nu^{d_T}_t \right)^2 Lb^b_{j,t} \\
& + \Pi^L_{j,t} + \Xi^b_{j,t}
\end{aligned} \tag{49}$$

where $\tau_{B,t}$ is a tax on bank credit transactions, s^{adm}_t are administrative costs, assumed to be proportional to bank credit volumes, $R^{RR,(D,S,T,add)}_t$ are the interest rates paid by the monetary authority on bank reserves, $\nu^{B,Bank}_t$ and $\nu^{d\_T}_t$ are AR(1) processes that respectively translate into financial terms the gap between banks' liquidity and time deposit positions from their targeted paths, and $S_t P^{X^*}_t X_t \omega^X \left(R^{L,f}_{X,t} - 1\right)$ is the cash flow from working capital loans to exporters. We introduce lump sum transfers ($\Pi^L_{j,t}$) from lending branches to bank j to facilitate aggregation:

$$\Pi^L_{j,t} = \Pi^{LB,E}_{j,t} + \Pi^{LB,C}_{j,t} + \Pi^{LB,H}_{j,t} \tag{50}$$

We also assume that banks get insurance $\Xi^b_{j,t}$ to eliminate the heterogeneity that results from interest rate rigidity, and this allows us to aggregate banks' decisions in the form of a representative agent. The insurance can be represented as

$$\Xi^b_{j,t} = \left(R_{E,t-1} - R_{E,j,t-1}\right) B^b_{E,j,t-1} + \left(R^C_{B,t-1} - R^C_{B,j,t-1}\right) B^{C,b}_{B,j,t-1} \tag{51}$$

The law of motion of administrative costs on borrowers' loans $s^{adm,B}_t$ is assumed to follow an

AR(1) process. Administrative costs on entrepreneurs' loans $s_t^{adm,E}$ are proportional to those of consumer loans. Banks choose the stream of real dividend distribution $\left\{C_{Bank,j,t}\right\}$ to maximize the intertemporal plan

$$E_0 \left\{ \sum_{t \geq 0} \beta_{Bank}^t \left[\frac{1}{1-\sigma_B} \left(\frac{C_{Bank,j,t}}{\epsilon_{L,t} \epsilon_{A,t}} \right)^{1-\sigma_B} \right] \varepsilon_t^{\beta,Bank} \right\} \tag{52}$$

subject to (37) and its analogous representation for the demand for consumer loans, and to (42) to (49), where $\varepsilon_t^{\beta,Bank}$ is an AR(1) process affecting banks' intertemporal preferences. We assume that banks' intertemporal discount factor, β_{Bank}, is lower than that of banks' stockholders. This is a short-cut to risk-to-return considerations, so as to account for the fact that in practice bank shareholders demand a higher return on their portfolio than the risk-free opportunity cost R_t. Since $\beta_{Bank} < \beta_S$, in the balanced-growth path the shadow price of one additional unit of bank capital is higher than one unit of external funds.

The first order conditions obtained from banks' optimization program show that the relevant opportunity cost for the bank is not just the base rate. In fact, higher capital buffers and deviations from optimal time deposit balances increase banks' opportunity costs (holding fixed the impact on the following period). In addition, positive deviations from the steady state share of liquid assets on banks' liabilities decrease the opportunity cost so that loans can have more attractive rates to bank clients. On the other hand, when there is shortage of liquidity, the opportunity cost increases and loans become more expensive, which leads to asset reshuffling. The complete set of first order conditions is presented in the technical appendix.

2.9 The public sector

The public sector is composed of a monetary, a regulatory and a fiscal authority. The monetary authority makes decisions with respect to the base rate of the economy and international reserves accumulation. The regulatory authority decides on: 1) ratios and remuneration of reserve requirements; 2) minimum capital requirement; 3) risk weight of banks' assets to compute capital adequacy ratios; 4) lending rates of housing loans; 5) required allocation of savings deposits on housing loans; and 6) interest rate on savings deposits. The fiscal authority purchases goods, issues public bonds, levies taxes, and makes lump sum transfers to households.

2.9.1 The monetary and regulatory authorities

The base interest rate is set by the monetary authority according to a forward looking rule:

$$R_t^4 = \left(R_{t-1}^4\right)^{\rho_R} \left[\left(E_t \frac{P_{C,t+4}}{P_{C,t}} \frac{1}{\overline{\pi}_t^4}\right)^{\gamma_\pi} \left(\frac{gdp_t}{gdp}\right)^{\gamma_Y} R^4\right]^{1-\rho} \upsilon_t^R \tag{53}$$

where unsubscribed R is the equilibrium nominal interest rate of the economy given the steady state inflation $\overline{\pi}$, $\overline{\pi}_t^4$ is a time-varying inflation target, and $gdp_t = \frac{GDP_t}{P_{C,t}\epsilon_t\epsilon_{A,t}}$ is the stationary level of nominal output:

$$GDP_t = P_{C,t}C_t + P_{IH,t}I_{H,t} + P_{IK,t}I_{K,t} + P_{G,t}G_t + S_tP_t^{X^*}X_t - S_tP_t^{M,*}Z_t^M \tag{54}$$

Foreign exchange interventions with international reserves are an instrument used by the monetary authority to dampen fluctuations of the real exchange rate. The intervention rule is given by:

$$\ln\left(\frac{B_t^{FER}}{P_t^*\epsilon_{A,t}\epsilon_{L,t}} \frac{1}{\overline{b}^{FER}}\right) = -\gamma^{S,FER} \ln\left(\frac{S_tP_t^*}{P_{C,t}} \frac{1}{s}\right) + \varepsilon_t^{FER} \tag{55}$$

where ε_t^{FER} is an AR(1) process, s is the steady state value of the real exchange rate, and $\overline{b}^{FER}$ is the steady state amount (in the balanced growth path) of foreign exchange reserves.

The regulatory authority sets the interest rate on savings accounts according to (34) and its remaining policy instruments are modeled as AR(1) processes with high persistence.

2.9.2 The fiscal authority

Government consumption follows a rule with a term that stabilizes net public sector debt, which is defined as the sum of public sector liabilities (i.e., public bonds and banks' required reserves deposited at the central bank) net of public sector assets (i.e., international reserves):

$$\begin{aligned} \frac{G_t}{\epsilon_{A,t}\epsilon_{L,t}} &= \left(1-\rho_g\right)\left[\overline{g} - \mu_{B,G}\left(\begin{array}{c} \frac{B_{t-1}+RR_{t-1}^D+RR_{t-1}^T+RR_{t-1}^S+RR_{t-1}^{add}-S_{t-1}B_{t-1}^{FER}}{P_{C,t-1}\epsilon_{A,t-1}\epsilon_{L,t-1}} \\ -\left(b + rr^D + rr^T + rr^S + rr^{add} - b^{FER}\right) \end{array}\right)\right] \\ &+ \rho_g\left(\frac{G_{t-1}}{\epsilon_{A,t-1}\epsilon_{L,t-1}}\right) + \upsilon_t^G \end{aligned} \tag{56}$$

where lower-case variables denote stationary variables, and g is the steady state value of stationarized government consumption.

The amount of public debt issued by the government meets the demand for public bonds from the retail money market fund, the foreign portfolio investors and the wholesale bank.

Hence

$$B_t = B_{Bank,t} + B_{F,t} + B_{FPI,t} \tag{57}$$

Tax rates $\tau_{C,t}$, $\tau_{W,t}$, $\tau_{\Pi,t}$, $\tau_t^{R_X^{L,f}}$ and $\tau_{B,B,t}$ follow AR(1) processes around their steady states[17].

The joint public sector budget constraint can be expressed as:

$$\begin{aligned}
&P_{G,t}G_t + TT_t - R_{t-1}^{S,H}RR_{t-1}^{S,H} + RR_{t-1}^{D} + R_{t-1}^{RR,T}RR_{t-1}^{T} \\
&+ R_{t-1}^{RR,S}RR_{t-1}^{S} + R_{t-1}^{RR,add}RR_{t-1}^{add} + R_{t-1}B_{t-1} - S_tR_{t-1}^{*}\phi_t^{FER}B_{t-1}^{FER} \\
&= \tau_{W,t}\Pi_t^{LU} + \tau_{\Pi,t}\Pi_t + \tau_{W,t}W_t^NN_t + \tau_{C,t}P_{C,t}C_t \\
&+ \tau_t^{R_X^{L,f}}S_tP_t^{X^*}X_t\omega_t^X\left(R_{X,t}^{L,f} - 1\right) \\
&+ \tau_{B,E,t-1}B_{E,t-1}^{b} + \tau_{B,B,t-1}B_{B,t-1}^{C,b} \\
&+ RR_t^D + RR_t^T + RR_t^S + RR_t^{add} - RR_t^{S,H} + B_t - S_tB_t^{FER}
\end{aligned} \tag{58}$$

where TT_t are lump-sum transfers that follow an AR(1) process and are distributed to savers and borrowers at a fixed proportion:

$$TT_{B,t} = \frac{\overline{TT}_B}{\overline{TT}}TT_t, \quad TT_{S,t} = \frac{\overline{TT}_S}{\overline{TT}}TT_t \tag{59}$$

where υ_t^{TT} is white noise, $\overline{TT}_B$ is the steady state transfer to borrowers, and $\overline{TT}$ are total transfers in the steady state.

2.10 Market clearing, aggregation, and the resource constraint of the economy

Market clearing requires that the following supply and demand equalities hold:

$$Y_t^M = Y_t^{C,M} + Y_t^{G,M} + Y_t^{IK,M} + Y_t^{IH,M} + Y_t^{X,M} \tag{60}$$

$$Q_t^G = G_t \tag{61}$$

$$Q_t^{IH} = I_{H,t} \tag{62}$$

$$Q_t^{IK} = I_{K,t} \tag{63}$$

$$Q_t^C = C_t \tag{64}$$

$$Q_t^X = \left(1 + \Gamma_X\left(X_t/\left(g_{L,t}g_{A,t}X_{t-1}\right); \varepsilon_t^X\right)\right)X_t \tag{65}$$

[17]Due to lack of time series of tax levied on financial intermediation disaggregated in private individuals and firms, we assume that $\tau_{B,E,t}$ is a fixed proportion of $\tau_{B,B,t}$.

We assume that the costs that do not deplete final goods are transferred as a lump sum to savers.

$$TT_{\Gamma,t} = \Gamma_u(u_t) P_{QQ,t} K_{t-1} \tag{66}$$

$$TT_{\Gamma,t} = \omega_S TT_{\Gamma,S,t} \tag{67}$$

Aggregate cash flow Π_t from firms and banks is defined as

$$\Pi_t = \Pi_t^{non-finan} + \Pi_t^{finan} \tag{68}$$

where

$$\Pi_t^{finan} = P_{C,t} C_{Bank,t} + Bankcap_t - Bankcap_{t-1} - \varepsilon_t^{bankcap} Bankcap_t \tag{69}$$

$$\Pi_t^{non-finan} = \Pi_t^D + \Pi_t^{CP} + \Pi_t^M + \Pi_t^X + \Pi_t^{E,S} \tag{70}$$

These flows are received by the savers after tax deductions

$$(1 - \tau_{\Pi,t}) \Pi_t = \omega_S (\Pi_{S,t}) \tag{71}$$

Bank adjustment and monitoring costs are proportionally distributed to savers

$$TT_{bank,t} = \omega_S TT_{bank,S,t} \tag{72}$$

Hence, the resource constraint of the economy is

$$Y_t^D = Y_t^{C,D} + Y_t^{IH,D} + Y_t^{IK,D} + Y_t^{G,D} + Y_t^{X,D} \tag{73}$$

The complete set of market clearing and aggregation conditions can be found at the companion technical appendix.

3 Taking the model to the data

3.1 The steady state and calibration

The model variables were stationarized by dividing real variables by both the technology trend $\epsilon_{A,t}$ and the populational trend $\epsilon_{L,t}$. Nominal variables were divided by both previous trends and also the consumer price level, P_t^C.

Pinning down the steady state of the Brazilian economy is an exercise that involves a great amount of judgement. Most series have trends, and long series are the exception, not the rule. In addition, some markets have been deepening over the past years, adding uncertainty about what is trend, what is transition, or what is structural change. The prescription of using filtered series when trends are an issue does not apply indistinctly to Brazilian data. Filtered series in many cases give the wrong idea of where economic variables are in the business cycle.

With that in mind, our strategy to calibrate the steady state involved fixing the main economic ratios according to their average during the inflation targeting period (Table 1)[18]. GDP growth and the base rate were also fixed according to the average in this period. To calibrate the share of credit- and deposits-to-GDP, as well as lending rates and the markdown of savings rates, we used the most recent observations in the data. The reason for this choice is that these series have been affected by a financial deepening process in the economy, which should continue as income distribution and regulatory framework improve.

The ex-ante default ratios in the steady state were set at 3.72% for investment loans and 7.45% for consumer loans, in line with the average default rate from 2009 to 2013. We fixed steady state lending rates and stocks as shares of GDP, in addition to banking spread components. We set the variance of the idiosyncratic shock to entrepreneur's collateral value (σ_E) to 0.2 to calibrate capital depreciation at 2% per quarter. The variance of the idiosyncratic shock to borrower's committed income (σ_B) was fixed at 0.2 so as to find an intertemporal discount factor of 0.94 for the borrower[19]. From these assumptions, all the remaining variables related to financial accelerators, including threshold levels of idiosyncratic shocks, LTV-ratios, and monitoring costs are obtained after evaluating the model at the steady state. The stock of capital is then determined from the entrepreneur's financial accelerator.

The capital adequacy ratio was fixed according to the actual average value for the Brazilian Financial System[20] in most recent quarters. Required capital was set at 11%, the regulatory rate for tier-1 capital since the implementation of Basle 1 in Brazil. Risk weights on bank assets were set at the actual values reported by Brazilian banks on portfolios with a direct correspondence to the ones included in the model (i.e., 1.5 for consumer loans, 1 for investment loans, 0.9 for housing loans, and 0 for government bonds). Given the capital adequacy ratio and banks' intertemporal discount factor, we calibrated the intercept and the slope parameter of the cost function associated with deviations from the capital requirement. Hence, the curvature parameter could be estimated.

We assumed a log-linear utility function for banks' optimization problem, and set banks' intertemporal discount factor at 0.98 which would represent a 17.5% nominal return on banks' dividends.

[18] In this table, GDP ratios are expressed in terms of yearly GDP. In the implementation of the model, the ratios were all computed in terms of quarterly GDP.

[19] This parameter has an important effect on the model's impulse responses. Higher values drive the responses of consumer loans to monetary policy rate shocks to a very unlikely region.

[20] The reported capital adequacy ratio does not include development banks, such as the National Development Bank (BNDES).

Reserve requirement ratios were fixed at the average of their effective ratios, which were calculated as the share of reserves deposited at the central bank to the volume of deposits in the economy. For time deposits, the average ratio was taken from December 2001, when this requirement was last reintroduced, to December 2012. Average additional reserves were calculated from the series starting in December 2002, when they were introduced. Requirements on savings accounts and demand deposits are averages of the entire inflation targeting period. The minimum required allocation of funds from savings deposits in housing loans was set according to actual compliance[21].

The tax on financial transactions was calibrated to match the share of indirect tax on banking spreads, as reported by the Central Bank of Brazil in its Banking Reports[22].

The participation of each group of households in labor, consumption goods and housing has important implications for the model dynamics. As a result, we attempted to find out-of-the-model relations that could help pin down this participation. We fixed the share of housing consumed by borrowers in the steady state as the ratio between the approximate value of collateral put up in housing loans and the model's implied value of real estate in the economy[23]. We also assumed that the government does not make transfers to borrowers[24].

From the assumed ratios of banks' balance sheet components, we obtained the steady state balance of public bonds at banks' assets, and consequently pinned down banks' liquidity target. From the assumed ratio of public debt, we calibrated the total stock of public bonds in the economy and at the retail money fund's portfolio.

3.2 Estimation

The model was estimated using Brazilian data from the inflation targeting period (1999:Q3 to 2013:Q4). We used Bayesian techniques, after linearizing the model around the balanced-growth path.

We observed all components of the Brazilian balance of payments, in addition to several series from the real economy and from the banking sector. The list of observables is detailed in the appendix.

For the choice of prior means, we used empirical evidence for Brazil, whenever available,

[21]The actual compliance does not include compliance in the form of securitized debt (FCVS) or other instruments that alleviate the burden of the requirement.

[22]www.bcb.gov.br/?spread

[23]Since the LTV ratio in housing loans was 0.73 in 2013, we assumed that the value of the collateral in this market was twice the stock of loans divided by the LTV ratio.

[24]By the time we finished this version of the paper, we had not had access to data on debt commitment by indebted households. We thus fixed borrowers' participation in the labor market according to the actual value of debt commitment in Brazil (50% of annual labor income).

or drew from the related literature. We tried to compensate the arbitrariness in the choice of some priors by setting large confidence intervals. Table 2 shows the results of the estimation, including prior and posterior moments[25].

The model is able to closely reproduce most of the the second moments of observed data (Table 3). The variance decomposition (Table 4) shows that private consumption, government consumption and capital investment are strongly impacted by shocks related to the open economy. Shocks to the share of households' income committed to unsecured loans also has some power to explain the variance of output and government spending. The variance decomposition also suggests an important participation of international shocks to commercial loans. Shocks to the LTV ratio, productivity and bank capital preferences also drive the variance of commercial loans. Unsecured consumer loans are importantly impacted not only by shocks to debt commitment but also by leverage in housing mortgages. This indicates that the seniority of housing loans over the other types of consumer credit really poses a restriction on the latter.

4 The transmission mechanism of macroprudential policies

4.1 Capital requirement

An unanticipated 1 p.p. increase in capital requirementl, from 11% to 12%, has important real effects that are triggered by changes in the composition of banks' balance sheet composition and by their decisions with respect to the share of profits to be distributed to bank owners (Figure 10).

The transmission mechanism is as follows. Given that deviations from the required capital are costly to the banks, the shadow cost of banks' operations increases, and it is passed through to lending rates. More expensive consumer loans reduce income available for consumption. The drop in consumption and capital investment that follows from consumer and commercial credit contraction is enough to depress GDP. Monetary policy reacts to subdued economic conditions by reducing the base rate, which causes an exchange rate depreciation, but that is not enough to stimulate exports. On the other hand, a depreciated exchange rate and unfavorable demand conditions make imports dip. The impact on the labor market is such that even though housing lending rates fall – and that results from our assumption that these rates are decided by the government and are tightly linked to the base rate of the economy – the demand for housing loans also falls.

Since banks can decide how much of their earnings will be distributed and how much will

[25]We used Dynare to conduct the linear approximation of the model to the calibrated steady state and to perform all estimation routines. We ran 2 chains of 700,000 draws of the Metropolis Hastings to estimate the posterior.

be retained, they also accommodate part of the cost of higher capital requirements by retaining profits. This, together with the drop in risky assets, allows them to improve their net worth position, hence liquid assets increase. Since banks hold a large amount of excess capital in the steady state, final compliance with the capital requirement comes mostly from reducing this capital buffer.

With respect to the impact of capital requirement on different types of loans, we find that the demand for collateralized loans is more sensitive to changes in lending rates. This, together with the fact that the risk weight of commercial loans in the CAR is lower than that of unsecured loans, causes the increase in commercial lending rates to be less than that in consumer lending rates and also to show less persistence.

These conclusions were obtained from the baseline model, where monetary policy is responding to economic conditions by lowering the base rate. However, this response is not strong enough to offset the impact of tighter capital regulation on the shadow price of banks' operations. Hence, even if monetary policy is kept unchanged after a shock to capital requirement ratios (Figure 25) [26], bank funding costs, capital accumulation, and liquidity are not substantially changed compared to the baseline scenario. However, since monetary policy does not alleviate the burden of tighter credit conditions on the real economy, there is a more pronounced drop in consumption, investment and employment. The final drop in GDP is therefore slightly more severe as the impact of the shock builds up.

4.1.1 Anticipated vs. unanticipated announcements of changes in capital requirements

The baseline model assumes that changes in capital requirements cannot be anticipated. However, regulatory changes of this nature are usually announced with a substantial lag to the implementation. To investigate whether announcements made prior to the implementation period trigger any anticipatory behavior, we compare the impulse responses of the model in two alternative scenarios: one in which the macroprudential authority announces a 1 p.p. increase in required capital to be implemented only 4 quarters after the announcement, and the other in which the announcement is made together with the implementation. Figure 11 shows the results.

Announcements trigger an anticipatory behavior of banks: consumer and commercial loans fall from start. Households and entrepreneurs anticipate the impact of the shock and the demand for loans reacts more swiftly to lending rates. As a result, lending rates do not need to rise as much to curtail credit as when the shock is unanticipated. Moreover, banks immediately start to retain earnings and improve their capital adequacy ratios over the entire period. As a matter of fact, the announcement is more effective in reducing the banks' risk exposure even

[26] All counterfactual exercises use the mean of the posterior estimation to produce impulse responses

after the shock hits. Real variables, such as GDP and inflation are also impacted from start, but show smoother trajectories. Since monetary policy reduces the base rate from the start, and lending rates for housing loans automatically fall, housing loans show a slight increase when the shock is anticipated.

4.2 Reserve requirement shocks

Reserve requirement ratios (RR) were shocked at 10 p.p., a reasonable magnitude considering the Brazilian practice. This implies that RR on demand deposits rise on impact to 59.2%, from the steady state level of 49.2%, RR on time deposits rise to 20.7% from 10.7%, RR on savings accounts rise to 32% from 22%, and the additional RR rises to 17.5% from 7.5%.

Figure 13 shows the impulse responses to a 10 p.p. shock to (unremunerated) RR on demand deposits $\left(\tau^{D}_{RR,t}\right)$. This instrument has a small contractionist impact on the real economy and on the credit market. Although this might seem at odds with the literature, we argue below that the small base of incidence has an important contribution to this result. The most important effects of changes in RR are restricted to banks' balance sheets, with marginal spillover to capital and housing investment decisions. On impact, banks immediately unleash liquidity (i.e., sell public bonds in their portfolio) and cut down on dividend distribution to alleviate the burden of strained liquidity. Funding from time deposits increases only gradually due to nominal rigidities. The liquidity strain causes an important increase in banks' funding cost, which is partially passed through to final lending rates. Higher lending rates of commercial loans reduce the demand for investment goods, which drives down the price of capital, further constraining credit conditions in the commercial segment. The overall impact of this shock on banks' balance sheet slightly improves the capital adequacy ratio.

A shock to (remunerated) RR on time deposits (Figure 14) has a much stronger impact on the economy. The transmission channel differs with respect to banks' dividend distribution. Since this reserve is remunerated at the base rate, the loss of revenues from interest rate accrued on bank assets is not as big as in the case of an increase in unremunerated RR. As a result, banks choose to distribute dividends, instead of retaining. A shock to (remunerated) RR on savings accounts (Figure 15) is qualitatively similar, yet the amplitude of the responses is lower given the smaller incidence base.

In Brazil, reserve requirements on time deposits have been the instrument of choice when the central bank needs to drain liquidity from the economy. There is an implicit assumption that this would be the least distortionary instrument for this purpose. However, the frictions introduced in the optimal bank balance sheet allocation in our model, and that are validated by the estimation, imply that an exogenously imposed asset allocation is costly to the bank, and thus higher funding costs translate into higher lending rates. This has important policy implications[27].

The total balance of time deposits in Brazil is almost eight times as large as that of demand deposits. A fair comparison of the potential impact of RR needs to take into account the size of their incidence base. After scaling the shocks to generate an equivalent impact in terms of the amount of funds seized by the central bank, we obtain the traditional prediction that reserve requirements on demand deposits have stronger marginal impact on the economy mostly through the direct impact on banks' profits and less so on banks' balance sheet allocations. In particular, we applied a 50 p.p. shock to RR on demand deposits, a 7 p.p. shock to RR on time deposits, and a 15 p.p. shock to RR on savings deposits. Figure 16 compares the impulse responses. In all cases, monetary policy was kept unresponsive so that we could evaluate the full impact of RR.

4.3 Risk weight shocks

Figures 18 and 19 show the impact of a 10 p.p. hike in the risk weight of consumer and commercial loans, respectively. The shocks have an immediate impact on the lending rate of their specific credit segment, and credit falls. In addition, banks choose to retain dividends so as to avoid further deterioration in capital adequacy ratios. The net funds that become available after the drop in loans are redirected to liquid assets. Altogether, banks accommodate the overall impact of risk weight shocks on their balance sheet by releasing part of the capital buffer, which implies that the Basle ratio remains below pre-shock values for a prolonged period of time. Tighter credit conditions impact consumption and capital investment, depressing output.

With respect to risk weights of housing loans (Figure 20), the tight regulation of the lending rate in this market shifts the main burden of the adjustment to the other credit segments. Hence, banks increase lending rates of commercial and consumer loans and cut dividends so as to improve capital adequacy ratios. The contractionist impact that follows worsens labor market conditions in such a way that the demand for housing loans also drops, notwithstanding the fact that the lending rate falls by tracking the base rate.

Figure 21 shows a comparative exercise in which risk weights increase by the same percentage rate from the steady state[28]. The shock to the commercial credit segment has a much stronger impact on capital investment, and consequently on output. On the other hand,

[27]Montoro e Moreno (2011) claim that if RR are partially remunerated, the distortionary tax effect is reduced, but their overall impact on the banking system is also lessened. In our model, the estimated impulse responses of changes in remunerated reserve requirements on time deposits can have non-negligible effects on the real economy notwithstanding the fact that there is no mismatch between the interest rate paid on bank deposits and that accrued on required reserves.

[28]In this exercise, we keep the base rate constant

consumption is more substantially affected by the shock to the consumer credit segment. The impact on the balance sheet of the bank also varies according to the type of credit segment that was targeted by the regulatory authority. The immediate impact of the shock to the commercial credit segment causes the Basle ratio of the financial system to fall by 0.5 p.p., half of what obtains from the same shock to the consumer credit segment. However, because of the stronger persistence observed in the dynamics of the commercial credit, the pace of capital recovery in the case of consumer loans is faster.

4.4 Monetary policy under financial frictions

The estimated model features traditional shapes of the responses of the key macroeconomic variables to a monetary policy shock (Figure 24). Notwithstanding, the financial frictions of the model imply a more elaborate transmission channel. A 100 bp shock to the nominal base rate reduces consumption, hours worked and output through the traditional channels. Financial frictions reinforce the responses. The reduction in labor income puts pressure on the default rates of consumer loans, increasing final lending rates. Hence, the demand for consumer loans falls, and borrowers' consumption further adjusts to accommodate tighter funding conditions.

Worsened demand conditions reduce prices. In particular, the fall in the price of capital reduces the value of collateral put up for commercial loans, putting pressure on default rates and, consequently, on lending rates. This reduces the demand for investment loans, further depressing investment.

The monetary policy shock has important implications for the composition of banks' balance sheets. The increase in the base rate puts pressure on external and internal bank funding costs. The reduction in the stock of loans resulting from higher funding costs is accommodated through an expansion in bank liquidity and an increase in the share of retained earnings. The recomposition of banks' balance sheet towards safer assets and the increase in greater capital accumulation improve the capital adequacy ratio. The price of housing falls given depressed demand conditions. As a consequence, housing loans drop.

4.5 Comparative analysis of macroprudential vs. monetary policy shocks

To better understand the differences in the power of macroprudential instruments comparatively with monetary policy, we simulated scenarios in which the regulatory and monetary authorities tighten macroprudential and monetary policy in the first four quarters, phasing them out at the same pace in the 4 subsequent periods. The magnitude of each shock on impact was chosen arbitrarily[29]. Figure 26 shows the results, and each response corresponds to a complete simulation of the model after activating one particular shock.

Monetary policy has the strongest impact on GDP compared to any of the macroprudential instruments considered in this exercise. The main channels are the labor market, housing investment, and exports. The increase in the base rate is automatically passed through to housing lending rates, and this strongly depresses investment in housing. In addition, higher interest rates also trigger an appreciation of the domestic currency, which dampens exports. Altogether, these movements result in a depressed demand for intermediate goods, which deteriorates labor market conditions, further reducing the demand for consumer and housing loans.

Capital requirements have the strongest impact on non-regulated credit markets (i.e., consumer and commercial), given the fact that deviations from capital requirements are costly to the bank. Reserve requirements on time deposits also have an important impact on non-regulated loans[30].

With respect to the remaining balance sheet components, reserve requirements trigger a sizable adjustment of bank liquidity, whereas increased capital requirements bring about a strong cut in bank dividend distribution. In regard to risk weights, when the weight of a particular bank asset increases in the computation of capital adequacy ratios, banks show a clear preference for cutting off excess capital instead of building up new capital; hence the capital adequacy ratio deteriorates. The opposite holds for reserve and capital requirements, and for monetary policy shocks. For these instruments, banks prefer to accumulate capital, and actual capital adequacy ratios improve.

5 Transmission channels of international shocks

Financial frictions feed into the transmission of shocks originating from international markets. Shocks that increase the cost of funding in foreign currency, such as the shock to international rates or to the country risk premium, transmit through the exchange rate, and the response of exports to undervalued exchange rates is strong enough to stimulate domestic output, at the expense of higher consumer inflation. Nonetheless, these shocks depress domestic credit and worsen banks' capital adequacy. In more details, a persistent 100 bps shock to the foreign interest rate (Figure 27) induces a depreciation of the domestic exchange rate,

[29]Although this choice is arbitrary, we believe it is better than using the estimated variance of macroprudential shocks since over the sampled period, there have not been changes to capital requirements and we do not have aggregate series of risk weights that were actually used to compute capital adequacy ratios that would conform to the credit segmentation used in this paper. Our choice seems reasonable considering our understanding of policy choices in Brazil.

[30]We did not include RR on demand and savings deposits in this exercise, since we have shown that in the baseline model RR on time deposits have the strongest impact

which passes through to nominal prices of imported goods, causing consumer prices to rise. This entails a contractionist response from monetary policy, passing through to lending rates. Higher lending rates cause a drop in consumption and investment. However, the improvement of the trade balance given the exchange rate depreciation is so strong that the increase in exports stimulates the demand for intermediate goods, positively affecting hours. Government consumption is also a driver of economic growth. The drop in foreign debt that is associated with increased funding costs in this market results in international reserves accumulation, and that gives room for the government to increase spending. Hence, the overall effect of the shock to international interest rates on the output gap is positive. The slight increase in labor demand compensates the downward pressure of higher lending rates of consumer loans; hence credit in this segment presents a slight increase over time. On the other hand, total credit falls driven by the drop in commercial and housing credit. Over time, as the domestic economy accumulates trade surpluses, foreign debt decreases and the country risk premium falls. Hence, the exchange rate gradually returns to the steady-state. Lower foreign debt issuance affects the composition of the RMMF's portfolio, dropping banks' stable source of funding from time deposits. This shrinks banks' balance sheet, negatively impacting their capital adequacy ratios.

The impulse responses to an exogenous 100bps shock to country risk premium (Figure 28) are analogous to the shock to international rates, since both of them generate a depreciation of the domestic exchange rate. The main difference between these two sets of impulse responses is mostly related to the persistence of each shock.

A shock that positively affects the country's terms-of-trade causes a substantial exchange rate appreciation, but the financial frictions operate to turn the overall impact of the shock beneficial to the rest of the economy. In more details, a persistent 10% increase in export prices (Figure 29) stimulates exports, albeit slowly due to the adjustment cost on exports volumes. The persistence of this shock is high, hence the rational expectations response results in a strong appreciation of the exchange rate (in fact, it appreciates by roughly 10%, with a high persistence). This shock to the terms-of-trade produces a significative reduction in inflation, inducing the monetary authority to slash interest rates. An expansionist stance of monetary policy stimulates consumption and investment. This represents more collateral available to use in credit operations, improving leverage. Hence, banks lower lending rates, and this gives another layer of stimulus to the economy through a substantial increase in credit. Greater demand for intermediate goods generates higher employment and higher real wages, further stimulating the demand for consumer and housing loans. In response to currency appreciation, the monetary authority accumulates foreign exchange reserves at the expense of higher foreign debt issuances made by domestic private agents. The overall impact of an improvement in the terms of trade on the real economy and the credit market is expansionist.

5.1 Comparative effects of international capital flows and foreign exchange reserves

Foreign direct investment (FDI), foreign portfolio investment (FPI) and foreign exchange reserves (FER) are three components of the balance of payments which we represent in the model as simple exogenous autoregressive processes (FDI) or as simple rules (FPI and FER). In the model, FDI is introduced through the acquisition of part of domestic productive capital by a foreign investor, and this investment is settled in foreign currency. Hence, FDI inflows reduce the share of domestic investors in the productive capital of the economy, thus reducing their earnings from entrepreneurial projects. On the other hand, given the constraint that the balance of payments equation should be fulfilled at each point in time, FDI inflows reduce the exposure of domestic agents to foreign debt.

FPI is introduced in the model as an acquisition, by foreign investors, of government bonds denominated in domestic currency and remunerated at the policy interest rate. Again, this ends up being a transaction between foreign investors and domestic investors, the latter selling government bonds in exchange for a reduction in their holdings of foreign debt.

Likewise, when the monetary authority decides to decrease the stock of foreign exchange reserves, it does so by selling foreign currency to domestic investors, in exchange for government bonds.

In these three situations, the inflows of foreign currency cause a reduction in net foreign currency debt issued by domestic agents. However, the origin of the inflow of foreign currency matters for the transmission to the rest of the economy. In fact, shocks to foreign direct investment have a substantially larger impact on the economy, as we shall explain in what follows.

Figure 30 compares the effects of shocks on these three variables (i.e., FDI, FPI and FER). In this exercise, FDI and FPI exogenously increase by a 1 p.p. of quarterly nominal GDP, and remain positive for 10 periods, subsequently reverting to -1 p.p. in the following 10 periods. In addition, FER are set to move in the opposite direction, to produce the same direct effect on foreign debt issued by domestic agents. In the case of FDI, the drop in foreign debt reduces the risk premium, which, through the UIP, causes the exchange rate to appreciate. As a result, inflation falls, as imported goods become cheaper. However, an appreciated exchange rate negatively impacts the trade balance, and output falls. Responding to this scenario, the monetary authority further decreases the interest rate, which induces a reduction in lending rates in all credit segments. Lower interest rates stimulate investment, both in capital and in housing, and this is further reinforced by an expansion in credit to these segments. On the other hand, the overall impact on the demand for intermediate goods generates a drop in hours worked. As a result, consumer loans fall. The final impact of this set of shocks on total credit is positive.

The transmission of FER and FPI to the economy is similar, yet considerably smaller, since they have a negligible impact on the risk premium. This is a result of our assumption that the country risk premium reacts to changes in net foreign debt– i.e., gross foreign debt deducted by foreign exchange reserves and foreign portfolio investment. The rationale for this modeling choice is that FPI is usually not regarded as a steady source of funding in foreign currency. Instead, it is usually perceived as highly volatile, with a purely arbitrage nature, since foreign investors tend to quickly quit their positions in domestic assets when their prospects for the domestic economy deteriorate. Foreign exchange reserves, on the other hand, have a mitigating effect on the risk premium, since they are a resource available for the monetary authority to intervene in the foreign exchange market if it deems necessary.

This highlights the importance of the country risk premium channel to the transmission of shocks to foreign currency flows to the economy. Through this channel, these shocks generate price effects that disseminate to the rest of the economy.

However, another channel of international contagion has been introduced into the theoretical model. The optimization problem of the RMMF fund was modified to include an adjustment cost to issue new foreign debt. This modification resulted in a UIP equation with an additional term that responds to variations in foreign debt. According to this modified channel, higher FX inflows would induce an immediate currency appreciation and intensify their impact on the real economy and on the credit market. However, the estimation with Brazilian data did not find a significant value for the parameter associated with this adjustment cost[31].

For the sake of illustration, we run a counterfactual exercise where we compare the estimated model response to a positive shock to FPI with an alternative calibration where the parameter associated with the cost of issuing new debt (ϕ_{F,B^*}) is arbitrarily higher (4.0). The results are presented in Figure 31. Now, foreign exchange flows have an important immediate impact on the exchange rate. The currency appreciation reduces inflation and net exports, and induce a mild reduction in interest rates. As imported goods become cheaper, investment and consumption increase, as well as real wages. The country risk premium rises as the stock of FPI and foreign debt builds up. The impact on bank variables is stronger, and housing and commercial loans expand. However, the model cannot generate an increase in consumer loans given the power of the transmission channel of the exchange rate to the labor market.As the FPI flows revert after 10 periods, the exchange rate depretiates and inflation rises, inducing the monetary authority to increase interest rates, with contractionary effects on consumption and investment, mostly compensated by higher esport volumes.

[31]The estimated mean value of ϕ_{F,B^*} is 0.2287

6 Countercyclical Capital Buffer

In the baseline model, capital requirement decisions are represented by an autoregressive process with very strong persistence (0.999). This is a fair representation of the Brazilian regulatory framework during our sampled period, in which Brazil had adhered to either Basel I or Basel II accords, and when capital requirement ratios remained practically invariable. [32]

However, the Basel III regulatory framework introduces a countercyclical capital buffer intended to prevent severe disruptions during financial crisis, or, more ambitiously, to prevent crisis itself. The framework uses the credit-to-GDP gap, given extensive evidence that this indicator is a simple, easy-to-compute, and efficient early warning indicator or crisis. Hence, the guide suggests that banks should increase capital in expansionary credit cycles, relaxing the requirement in downturns.

We compare the impact of a mechanical rule of the countercyclical capital buffer to the traditional capital requirement under several scenarios. In the first, we assume that banks reduce their liquidity target $\nu_t^{B,Bank}$ to simulate a supply-driven credit expansion associated with loosened risk-taking standards. In the second, we simulate a severe bank capital impairment that can potentially depress the economy. In a third scenario, we simulate an increase in foreign direct investment.

The capital buffers can react either to contemporaneous ($\chi_E = 0$) or expected ($\chi_E = 1$) deviations of credit-to-GDP from its stationary trend:

$$\begin{aligned}\gamma_{t,cc}^{BankK} &= (1-\rho_{BankK,cc})\left(\begin{array}{l}(1-\chi_E)\left(\omega_{BankK,cc}^{B}\left(\frac{B_t^{C,wb}+B_t^{C,wb}+B_t^{C,wb}}{b^{C,wb}+b^{C,wb}+b^{C,wb}}\frac{gdp}{GDP_t}\right)\right)\\ +\chi_E\left(\omega_{BankK,cc}^{B}E_t\left(\frac{B_{t+4}^{C,wb}+B_{t+4}^{C,wb}+B_{t+4}^{C,wb}}{b^{C,wb}+b^{C,wb}+b^{C,wb}}\frac{gdp}{GDP_{t+4}}\right)\right)\end{array}\right)\\ &\quad +\rho_{BankK,cc}\gamma_{t-1,cc}^{BankK}+\varepsilon_{t,cc}^{BankK}\end{aligned} \tag{74}$$

and $\gamma_t^{BankK,total} = \gamma_t^{BankK} + \gamma_{t,cc}^{BankK}$

Figure 32 shows the model responses to a drop in the bank liquidity target (ν_t^{OM}) such that total credit-to-GDP rises on impact by 1% from its stationary trend when traditional capital requirements are in effect[33]. Compared with traditional capital requirements, if the countercyclical capital buffer can be immediately adjusted to react to credit expansion, it drives down the variance of GDP by over 80% when the regulatory authority responds to contemporaneous credit conditions and by about 75% when the rule is forward looking and

[32]Although Basel II includes operational and market risk in the computation of capital adequacy ratios, we believe credit risk was the most preponderant factor in capital requirement rules, so that our rule is a reasonable approximation when associated with the CAR equation (46).

[33]For this exercise, we set $\rho_{BankK,cc} = 0.8$ and $\omega_{BankK,cc}^{B} = 20$, which implies a 1 p.p. rise in total capital requirement ($\gamma_t^{BankK,total}$) on impact.

reacts to credit conditions four-periods ahead. The countercyclical capital buffers also mitigate the expansionist impact of the liquidity shock on the real economy. We performed the same exercise but now assuming that the countercyclical buffer can only be altered 4 periods after the shock. This simulates the framework to be adopted in Brazil, which requires the regulatory authority to announce changes in the instrument one year in advance. In this case, the drop in the variance of credit-to-GDP is a little smaller but the proportionality between the contemporaneous and the forward-looking rule is maintained.

The second exercise makes a strong case in favor of the countercyclical capital buffer. Figure 33 shows the model responses to a shock to dividend distribution that severely impairs bank capital, such that total bank capital falls by 10%. Using the same rules as in the previous exercise, the introduction of countercyclical capital buffers drops the variance of credit-to-GDP by over 90%, and the difference in the types of countercyclical rules is not so relevant with respect to credit stabilization. If the implementation of the countercyclical buffer is lagged, the forward looking rule is a little less efficient in driving down credit variance. The countercyclical capital buffers also substantially mitigate the effect of the negative shock to bank capital on the real economy.

In the third exercise (Figure 34), we introduce the same FDI shock presented in the previous section. Although it is a financial flow, it does not directly affect the credit market, since banks do not have foreign currency funding in this model. Therefore, the transmission channel of FDI first impacts the exchange rate by decreasing the country risk premium. The subsequent reduction in the interest rate has an expansionist effect on the credit market, which is partially offset by the CCB. Since this shock is not originated in the domestic banking sector, the ability of the countercyclical buffer to reduce its impact is on the real economy is much more limited, although it is important for capital investment. Again, it makes little difference whether the CCB response is immediate or delayed.

Finally, the fourth exercise (Figure 35) shows the responses to a persistent reduction in foreign interest rates for 10 periods, followed by a sudden reversal in the next ten periods. Again, as the bank credit sector is not directly exposed to external financial markets, the influence of the CCB is mostly limited to the responses of bank- and credit-related variables. It reduces the expansionist effects on commercial loans and, to a smaller extent, on consumer loans. As a result, it dampens the responses of consumption and investment, but has negligible effect on exports, imports and the trade balance.

7 Conclusion

This paper builds a small open economy DSGE model with matter-of-fact financial frictions to assess the transmission channel of a set of selected macroprudential policy instruments and to understand the effectiveness of macroprudential instruments when international financial shocks impact the domestic credit market. Banks' decisions about risky retail loan concessions are grounded on the assessment of borrowers' labor income. Therefore, expectations with respect to future debt-to-income ratios replace loan-to-value in the financial accelerator of household credit.

The model also features frictions in the optimal composition of banks' balance sheet. Banks are assumed to have liquidity targets, and the optimal responses imply that liquid assets in the form of public bonds are used to relieve the impact of macroprudential instruments on credit markets. Banks can also optimally choose the source of funding: external, via deposits, or internal, via retained earnings. The fact that banks can choose how much of total profits they will retain or distribute considerably affects the impact of macroprudential instruments on actual capital adequacy ratios implemented by the banks. This effect is different for each type of macroprudential policy since each one affects banks' incentives in specific ways.

The main macroprudential instruments introduced in the model are traditional (Basle 1 and 2) core capital requirements, with anticipated or unanticipated implementation; reserve requirements on demand deposits, savings deposits, time deposits, and "additional" requirements; and risk-weights on the computation of capital adequacy ratios. Other policy instruments featuring some Brazilian singularities were also included to replicate the dynamics of mortgage loans.

We introduced several components of the balance of payments to assess the importance of sudden changes in foreign capital flows or imbalances in international markets to the economy and to credit markets.

The model is estimated using Brazilian data from the inflation targeting regime. The balance of payments is entirely observed in the estimation. We present Bayesian impulse responses and conduct counterfactual exercises.

The dynamic responses of the model show that macroprudential instruments have strong effects on banks' balance sheet composition. In fact, it is in the credit market that macroprudential instruments have their strongest impact. The transmission to the rest of the economy differs according to the type of instrument.

Financial frictions also feed into the transmission of shocks originating from international markets. Tighter international conditions that translate into higher international interest rates or higher country risk premia generate exchange rate depreciation. Since the export sector has a significant influence in the economy, output rises. However, the reaction of monetary policy to the overheating of the economy and to inflation negatively impacts credit extensions, specially in those lines granted with physical collateral. This dampens investment. Positive shocks to the terms of trade have an important expansionist impact on domestic credit.

With respect to foreign capital flows, although the main transmission occurs through the exchange rate, the heterogeneity in credit segments differentiates the transmission of each type of flow. In the estimated model, foreign direct investment has the strongest expansionist impact on domestic credit. Notwithstanding, the power of the export sector in the economy is such that the appreciation of the exchange rate that follows the strong inflow of FDI negatively impacts the overall demand for labor, and hence consumer loans are not significantly stimulated.

We also compared the responses of the model in a situation where countercyclical capital buffers were in place. We show that this instrument has an important role to mitigate the impact of adverse shocks to the credit market when the shocks originate in the financial system. However, if the shock comes from the real sector, the power of the instrument to stabilize credit is significantly reduced.

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8 Appendix A

8.1 Retailers and distributors

Retailers operate under monopolistic competition. Each retailer k costlessly differentiates the homogeneous intermediate goods and sells the output $Z_t^D(k)$ to competitive distributors which aggregate this continuum of differentiated goods using a CES production function

$$Y_t^D = \left[\int_0^1 Z_t^D(k)^{\frac{1}{\mu_{D,t}}} dk\right]^{\mu_{D,t}} \tag{75}$$

where $\mu_{D,t}$ follows an AR(1) process. This implies the following demand function and aggregate price index :

$$Y_t^D(k) = \left(\frac{P_{D,t}(k)}{P_{D,t}}\right)^{-\frac{\mu_{D,t}}{\mu_{D,t}-1}} Y_t^D \tag{76}$$

$$P_{D,t} = \left[\int_0^1 P_{D,t}(k)^{\frac{1}{1-\mu_{D,t}}} dk\right]^{1-\mu_{D,t}} \tag{77}$$

Retailers set prices on a staggered basis à la Calvo, with a probability $1-\xi^D$ of reoptimizing at each period. Prices that cannot be reoptimized follow the indexation rule

$$\begin{aligned} P_{D,t}(k) &= \pi_{D,t-1}^{\gamma_D}\bar{\pi}^{1-\gamma_D} P_{D,t-1}(k) \\ &= \tilde{\pi}_{D,t} P_{D,t-1}(k) \end{aligned} \tag{78}$$

From first order conditions, the price index of intermediate goods is

$$1 = \left(1-\xi^D\right)\left(\frac{P_{D,t}^o}{P_{D,t}}\right)^{\frac{1}{1-\mu_{D,t}}} + \xi^D\left(\frac{\tilde{\pi}_{D,t}}{\pi_{D,t}}\right)^{\frac{1}{1-\mu_{D,t}}} \tag{79}$$

where $P_{D,t}^o(k)$ is the optimized price and $\pi_{D,t,t+k} = P_{D,t+k}/P_{D,t}$.

Total consumption of intermediate goods is

$$Z_t^D = \int_0^1 Z_t^D(k)\, dk = \Delta_t^D Y_t^D \tag{80}$$

where Δ_t^D is a measure of price dispersion, defined as

$$\begin{aligned} \Delta_t^D &= \int_0^1 \left(\frac{P_{D,t}(k)}{P_{D,t}}\right)^{-\frac{\mu_{D,t}}{\mu_{D,t}-1}} dk \\ &= \left(1-\xi^D\right)\left(\frac{P_{D,t}^o}{P_{D,t}}\right)^{-\frac{\mu_{D,t}}{\mu_{D,t}-1}} + \xi^D\left(\frac{\tilde{\pi}_{D,t}}{\pi_{D,t}}\right)^{-\frac{\mu_{D,t}}{\mu_{D,t}-1}} \Delta_{t-1}^D \end{aligned} \tag{81}$$

8.2 Importers and distributers of imported goods

Each importer m imports homogeneous intermediate goods from foreign producers and, analogously to domestic retailers and distributers, sells a differentiated by-product $Y_t^M(m)$ to distributers, who, in turn, sell an aggregate by-product Y_t^M to final goods producers. Importers are subject to Calvo price rigidities, with a probability $1-\xi^M$ of reoptimizing nominal prices at each period, and operate under monopolistic competition, with $\mu_{M,t}$ being the price markup, modeled as an AR(1) process. Import distributers' nominal profits are:

$$\begin{aligned}\Pi_t^M &= \int_0^1 \left(P_{M,t}(m) - S_t P_t^{M,*}\right)\left(\frac{P_{M,t}(m)}{P_{M,t}}\right)^{-\frac{\mu_{M,t}}{\mu_{M,t}-1}} Y_t^M dm \\ &= P_{M,t} Y_t^M - S_t P_t^{M,*} Z_t^M\end{aligned} \tag{82}$$

which are transferred as a lump sum to patient households.

The solutions to importers' and import distributers' optimization programs are analogous to those of domestic retailers and distributers.

8.3 Final goods producers

There are 5 competitive firms in the economy producing the following final goods: government consumption, private consumption, capital investment, housing investment and export goods. All final goods are non-tradeable, except for export goods. Domestic and imported intermediate goods are inputs in the production of private consumption, export, and investment goods. To produce government consumption goods, the firm uses only domestic intermediate goods.

Let $J \in \{C, I_K, I_H, X\}$ denote a final goods producer sector. The firm in sector J takes prices $P_{M,t}$ and $P_{D,t}$ as given and chooses a combination of domestic ($Y_t^{J,D}$) and foreign ($Y_t^{J,M}$) intermediate goods that minimizes production costs $P_{D,t}Y_t^{J,D} + P_{M,t}Y_t^{J,M}$ subject to the aggregation constraint

$$Q_t^J = \left(\nu_J^{1/\mu_H}\left(Y_t^{J,D}\right)^{\frac{\mu_J-1}{\mu_J}} + (1-\nu_J)^{1/\mu_J}\left((1-\Gamma_{YJM})\,Y_t^{J,M}\right)^{\frac{\mu_J-1}{\mu_J}}\right)^{\frac{\mu_J}{\mu_J-1}} \tag{83}$$

where Γ_{YJM} is a quadratic adjustment cost to change the import share. This cost is affected by the shock ε_t^M, modeled as an AR(1) process . We assume that the foreign relative import price (P_t^{M*}/P_t^*) follows an AR(2) process.

To produce government consumption goods, the firm uses only domestic inputs.

8.4 Capital and housing stock producers

Perfectly competitive firms produce the stock of housing and fixed capital. At the beginning of period t, they buy back the depreciated capital stock $(1-\delta_K)K_{t-1}$ from entrepreneurs as well as the depreciated housing stock $(1-\delta_H)(\omega_S H_{S,t-1}+\omega_B H_{B,t-1})$ from households, at nominal prices $P_{K,t}$, and $P_{H,t}$ respectively. These firms augment their capital and housing stocks using final goods, facing adjustment costs. At the end of the period, they sell the augmented stocks back to entrepreneurs and households at the same prices.

The profit maximization program of the capital stock producer at period t is:

$$\begin{aligned} &\max_{\{K_{t+k},I_{K,t+k}\}} E_t \sum (\beta_S)^k \frac{\Lambda_{S,t+k}}{\Lambda_{S,t}\pi_{C,t,t+k}g_{L,t,t+k}g_{A,t,t+k}} \left\{ \begin{array}{c} P_{K,t+k}\left(K_{t+k}-(1-\delta_K)K_{t+k-1}\right) \\ -P_{IK,t+k}I_{K,t+k} \end{array} \right\} \\ &s.t. \quad K_{t+k} = (1-\delta_K)K_{t+k-1} + \left[1-\Gamma_K\left(\frac{I_{K,t+k}}{g_{L,t+k}g_{A,t+k}I_{K,t+k-1}}\varepsilon^{IK}_{t+k}\right)\right] I_{K,t+k} \end{aligned} \tag{84}$$

where $\Gamma_K(r) \equiv \phi_K/2\,(r-1)^2$, $\Gamma_K(r) \equiv \phi_K(r-1)$ and ε^{IK}_t is an AR(1) shock to investment adjustment costs.

The optimization problem of the housing stock producer is analogous.

9 Appendix B

The observable series used in the estimation of the model were:

Real sector observables

- Aggregate private consumption $\left(c_t^{obs}\right)$: share of private consumption in nominal GDP (s.a.[34]).
- Government consumption $\left(g_t^{obs}\right)$: share of government consumption in nominal GDP (s.a.).
- Investment $\left(i_t^{obs}\right)$: share of the gross formation of fixed capital in nominal GDP (s.a.).
- Civil construction $\left(\Delta const_t^{obs}\right)$: change in IBGE's[35] civil construction index (s.a.).
- Unemployment $\left(U_t^{obs}\right)$: interpolation of IBGE's unemployment series. The resulting series was detrended by its mean from 1999Q1 to 2012Q1.
- Nominal wage change $\left(\pi_t^{W,obs}\right)$: quarterly change in an interpolated series built from IBGE's nominal wage series (s.a.).
- Labor force growth rate $\left(g_t^{L,obs}\right)$: change in labor force trend. The trend is obtained by applying an HP filter to an interpolation of IBGE's series of economically active population (EAP).
- GDP $\left(\widehat{gdp}_t^{obs}\right)$: HP cycle of the log of IBGE's real GDP series.
- Installed capacity utilization $\left(u_t^{obs}\right)$: Fundação Getúlio Vargas's capacity utilization series, demeaned by the average from 1999Q3 to 2013Q4.

Balance of payments and the rest of the world

- Exports $\left(x_t^{obs}\right)$: share of exports of goods and services in nominal GDP (s.a.).
- Imports $\left(m_t^{obs}\right)$: share of imports of goods and services in nominal GDP (s.a.).
- Foreign direct investment $\left(FDI_t^{obs}\right)$: Net flow of foreign direct investment (deducted by Brazilian direct investment in foreign countries) as a share of nominal GDP in US dollars. Intercompany loans and interest accrued on these loans were excluded from the computation of FDI (and thus considered private debt in the model)

[34] seasonally adjusted
[35] Brazilian Institute of Geography and Statistics

- Foreign portfolio investment $\left(FPI_t^{obs}\right)$: Net flow of foreign portfolio investment as a share of nominal GDP in US dollars. We considered the following BoP accounts as FPI: net flows of portfolio investment, net remittances of interest accrued on fixed income investment, net remittances of dividends and earnings from portfolio investment.

- Unilateral transfers $\left(ULT_t^{obs}\right)$: Net flow of unilateral transfers as a share of nominal GDP in US dollars. In addition to the unilateral transfers account at the BoP, we also included labor income remittances in this observable series.

- Stock of foreign exchange reserves $\left(b_t^{FER,obs}\right)$: Stock of international reserves (liquidity concept) at the Central Bank of Brazil as a share of nominal GDP in US dollars.

- Flows of foreign exchange reserves $\left(FER_t^{obs}\right)$: BoP flows of international reserves as a share of nominal GDP in US dollars.

- Nominal exchange rate $\left(\Delta s_t^{obs}\right)$: change in nominal exchange rate (R$/US$).

- Country risk premium $\left(\phi_t^{*,obs}\right)$: JP Morgan's EMBI Brazil index.

- Foreign investor's risk aversion $\left(risk_t^{obs}\right)$: Chicago Board Options Exchange Market Volatility Index.

- Foreign nominal interest rate (R_t^*): Fed Funds interest rate.

- Foreign inflation rate $\left(\pi_t^{*,obs}\right)$: US Consumer Price Index for All Urban Consumers, computed by Bureau of Labor Statistics of the U.S Department of Labor.

- World output growth rate $\left(\Delta Y_t^{*,obs}\right)$: change in the proxy for world GDP. The proxy is a weighed sum of GDP's of the countries that import goods from Brazil. The weights correspond to the respective shares of each country on total Brazilian exports.

Inflation and monetary policy rate

- Consumer inflation $\left(\pi_{C,t}^{obs}\right)$: inflation index used to assess compliance with the inflation target (IPCA - Índice de Preços ao Consumidor Amplo – IBGE).

- Inflation target $\left(\bar{\pi}_{C,t}^{obs}\right)$: 4-quarter-ahead actual inflation target.

- Imported goods inflation index $\left(\pi_t^{M^*,obs}\right)$: change in the US$ imports price index as reported by FUNCEX [36].

- Exported goods inflation index $\left(\pi_t^{X^*,obs}\right)$: change in the US$ exports price index as reported by FUNCEX.

[36] Fundação Centro de Estudos do Comércio Exterior

- Nominal interest rate $\left(R_t^{obs}\right)$: quarterly effective nominal base rate (Selic).

Banking sector

- Bank capital $\left(bankcap_t^{obs}\right)$: Brazilian financial system's core capital as defined by the Central Bank of Brazil, as a share of quarterly nominal GDP (s.a.).
- Capital adequacy ratio $\left(CAR_t^{obs}\right)$: actual average capital adequacy ratio of the Brazilian financial system.
- Commercial loans $\left(b_{E,t}^{obs}\right)$: stock outstanding of investment loans granted by banks with freely allocated funds as a share of quarterly nominal GDP (s.a.).
- Consumer loans $\left(b_{B,t}^{C,obs}\right)$: stock outstanding of consumer loans granted by banks with freely allocated funds as a share of quarterly nominal GDP (s.a.).
- Housing loans $\left(b_{B,t}^{H,obs}\right)$: stock outstanding of housing loans to households as a share of quarterly nominal GDP (s.a.).
- Export loans $\left(\omega_t^{X,obs}\right)$: ratio of total export loans to total nominal exports. The series was built using an interpolation of current and discontinued series published by the Central Bank of Brazil.
- Export loans interest rate $\left(R_t^{L,X,obs}\right)$: average lending rates of export loans, expressed in US dollars. The series was built using an interpolation of current and discontinued series published by the Central Bank of Brazil.
- Lending spread for commercial loans $\left(\check{R}_{E,t}^{L,obs}\right)$: Ratio between the quarterly effective nominal interest rate on investment loans granted with freely allocated funds and the base rate. The lending rates on each type of loan are weighted by their respective stock outstanding. The series was built using an interpolation of current and discontinued series published by the Central Bank of Brazil.
- Lending spread for consumer loans $\left(\check{R}_{B,C,t}^{L,obs}\right)$: Ratio between the quarterly effective nominal interest rate on consumer loans granted with freely allocated funds and the base rate. The lending rates on each type of loan are weighted by their respective stock outstanding.
- Default rate on commercial loans $\left(default_{E,t}^{obs}\right)$: investment loans in arrears for over 90 days as a share of total outstanding investment loans.
- Default rate on consumer loans $\left(default_{B,t}^{obs}\right)$: retail loans in arrears for over 90 days as a share of total outstanding retail loans.

- Time deposits $\left(d_t^{T,obs}\right)$: quarterly average of the total stock of non-financial institutions' and households' time deposits held by the Brazilian financial system as a share of nominal quarterly GDP (s.a.).

- Demand deposits $\left(d_t^{D,obs}\right)$: quarterly average of the total stock of non-financial institutions' and households' demand deposits held by the Brazilian financial system as a share of nominal quarterly GDP (s.a.). Both series are seasonally adjusted.

- Savings deposits $\left(d_t^{S,obs}\right)$: quarterly average of the total stock of non-financial institutions' and households' savings accounts in the Brazilian financial system as a share of nominal quarterly GDP (s.a.).

- Markdown on savings rates $\left(\mu_t^{R^S,obs}\right)$: Ratio between the quarterly effective nominal interest rate on savings accounts and the base rate.

- Required reserve ratio on time deposits $\left(\tau_t^{RR,T,obs}\right)$: quarterly average balance of required reserves on time deposits held at the central bank as a share of the total balance of non-financial institutions' and households' time deposits held by the Brazilian financial system.

- Required reserve ratio on demand deposits $\left(\tau_t^{RR,D,obs}\right)$: quarterly average balance of non-remunerated required reserves on demand deposits held at the central bank as a share of the total balance of non-financial institutions' and households' demand deposits held by the Brazilian financial system.

- Required reserve ratio on savings deposits $\left(\tau_t^{RR,S,obs}\right)$: quarterly average balance of required reserves on savings accounts held at the central bank as a share of the total balance of non-financial institutions' and households' savings deposits held by the Brazilian financial system.

- Additional required reserves ratio $\left(\tau_t^{RR,add,obs}\right)$: quarterly average balance of supplementary required reserves on demand, time and savings deposits held at the central bank as a share of the total balance of demand, time and savings deposits held by the Brazilian financial system on behalf of non-financial institutions and households. Although the incidence base of additional required reserves singles out each type of deposit, we choose a simplified approach to calculate the aggregate effective required reserve ratio.

- Administrative costs with bank loans $\left(s_t^{adm,obs}\right)$: ratio of administrative costs to outstanding non-earmarked loans of the financial system.

- Tax on bank loans ($\tau_{B,obs,t}$): share of indirect tax on banking spreads, as reported by the Banking Reports of the Central Bank of Brazil.

Employment in the model was mapped into the unemployment series according to:

$$\left(1+\beta^{S}\right)\mathrm{E}_{t}=\beta^{S}\mathrm{E}_{t+1}+\mathrm{E}_{t-1}+\left(1-\beta^{S}\xi_{\mathrm{E}}\right)\frac{(1-\xi_{\mathrm{E}})}{\xi_{\mathrm{E}}}\left(N_{t}-\mathrm{E}_{t}\right)$$

where

$$\Delta w_{t}^{obs}=\frac{W_{t}/P_{t}^{C}\epsilon_{t}}{W_{t-1}/P_{t-1}^{C}\epsilon_{t-1}}/\Delta n \tag{85}$$

and Δn is the steady state growth of the employed population.

10 Tables

Table 1: Steady state and calibrated parameters

Description		Value
Steady State Values		
g_A	Productivity growth rate (% per annum)	1.98
g_L	Labor force growth rate (% per annum)	1.21
π_C	CPI inflation (% per annum)	4.50
R	Nominal interest rate (% per annum)	10.20
R^S	Savings deposits interest rate (% per annum)	7.22
R^T	Time deposits interest rate (% per annum)	10.20
$R^{L,X}$	Exporting firms working capital interest rate (% per annum)	11.50
$R^{RR,D}$	Interest rate on demand deposits RR (% per annum)	0.00
$R^{RR,S}$	Interest rate on savings deposits RR (% per annum)	7.22
$R^{RR,T}$	Interest rate on time deposits RR (% per annum)	10.20
$R^{RR,adic}$	Interest rate on additional RR (% per annum)	10.20
c	Consumption (% of GDP)	60.12
i^H	Investment in housing (% of GDP)	3.00
i^K	Investment in capital (% of GDP)	14.8
g	Government spending (% of GDP)	20.3
x	Exports (% of GDP)	13.9
m	Imports (% of GDP)	12.5
$w.N$	Wage income (% of GDP)	55.0
D^D	Demand deposits (in % of annual GDP)	3.4
D^T	Time deposits (in % of annual GDP)	20.1
D^S	Saving deposits (in % of annual GDP)	11.2
$B^{B,C}$	Credit for consumption (in % of annual GDP)	14.9
$B^{B,H}$	Credit for housing (in % of annual GDP)	6.2
$B^{B,E}$	Credit for investment (in % of annual GDP)	12.6
$bankcap$	Bank capital (in % of annual GDP)	12.9
CAR	Bank Capital Adequacy Ratio	16.9
$\gamma^{bankcap}$	Capital requirement ratio	11.0
$R^{L,B,c}$	Nominal interest rate on consumption credit (% per annum)	39.0
$R^{L,B,h}$	Nominal interest rate on housing credit (% per annum)	8.2
$R^{L,E}$	Nominal interest rate on investment credit (% per annum)	25.6
$R^{B,c}$	Consumption credit interest rate net of credit losses (% per annum)	29.3

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Table 1 – (cont.)

	Description	Value
R^E	Investment credit interest rate net of credit losses (% per annum)	20.8
σ_B	std. dev of wage income idiosyncratic shock	0.200
σ_E	std. dev of entrepreneurs' idiosyncratic shock	0.595
	Impatient households' probability of default (%)	7.45
	Entrepreneurs' probability of default (%)	3.72
$s^{adm,B}$	Admnistrative costs of retail loans (% per annum)	3.1
$s^{adm,E}$	Admnistrative costs of investment loans (% per annum)	1.6
$\tau_{B,B}$	Tax rate on retail loans (% per annum)	0.8
$\tau_{B,E}$	Tax rate on commercial loans (% per annum)	0.4
τ^C	Tax rate on consumption (%)	16.2
τ^W	Tax rate on wages (%)	15.0
τ^π	Tax rate on profits (%)	15.0
$\tau^{RR,T}$	Reserve requirement ratio on time deposits (%)	10.7
$\tau^{RR,S}$	Reserve requirement ratio on saving deposits (%)	22.0
$\tau^{RR,D}$	Reserve requirement ratio on demand deposits (%)	49.2
τ^{adic}	Additional reserve requirement on time deposits (%)	7.5
τ^H	Mininum required allocation of saving deposits funds in housing loans (%)	34.0
g^{F^*}	World output growth rate (% per annum)	3.2
R^*	Foreign interest rate (% per annum)	3.6
π^*	Foreign inflation rate (% per annum)	2.4
$risk$	Foreign risk index (VIX)	11.0
ω^X	Financed fraction of total exports (%)	66.86
$\tau^{R_X^{L,f}}$	Tax rate on exporting firms working capital interest rate (%)	3.0
b_{FER}	Foreign Exchange Reserves (in % of annual GDP)	12.50
b_{FPI}	Foreign Portfolio Investment Stock (in % of annual GDP)	9.15
b^f	Foreign currency debt (in % of annual GDP)	17.75
b	Government debt (in % of annual GDP)	53.81
ULT	Unilateral transfers (in % of GDP)	0.16
External Sector Parameters (estimated separately)		
ϵ_{Y^*}	Export demand price elasticity	0.220
ρ^{X^*}	Time persistence of export demand shock	0.234
κ_{X^*}	Error corr. coef. of export demand shock	0.015
$\rho_{Z^{F^*}}$	Time persistence of world output growth shock	0.657
$\kappa_{Z^{F^*}}$	Error corr. coef. of world output growth shock	0.077
ρ_{R^*}	Time persistence of foreign interest rate	0.990

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Table 1 – (cont.)

	Description	Value
ρ_{π^*}	Time persistence of foreign inflation rate	0.000
$\rho_{P^{M*}}$	Time persistence of relative imported goods price	0.367
$\kappa_{P^{M*}}$	Error corr. coef. of relative imported goods price	0.028
ρ_{risk}	Time persistence of foreign risk index	0.942
ρ_{ω^X}	Time persistence of financed fraction of exports	0.884
$\rho_{L,X}$	Time persistence exports interest rate	0.956
Reserve Requirements Shocks std. dev. (estimated separately)		
$\epsilon_{\tau_{RR,T}}$	Time deposits reserve requirement shock std. dev.	0.0024
$\epsilon_{\tau_{RR,add}}$	Time deposits reserve requirement shock std. dev.	0.0016
$\epsilon_{\tau_{RR,S}}$	Savings deposits reserve requirement shock std. dev.	0.0018
$\epsilon_{\tau_{RR,D}}$	Demand deposits reserve requirement shock std. dev.	0.0031
Calibrated Parameters		
ω_S, ω_B	Relative size of agents	1.0
η_H	EoS between housing and consumption goods	1.001
$\sigma_\varkappa$	Inverse of intertemporal EoS	1
σ_S	Interest rate elasticity of demand for saving deposits	100
σ_D	Interest rate elasticity of demand for demand deposits	100
$h_B/(h_B + h_S)$	Impatient households' share in total housing stock (%)	40.4
$N_B/(N_B + N_S)$	Impatient households' share in total labor force (%)	76.8
$LTV_{B,H}$	Borrowers' LTV ratio on housing loans (%)	73.0
DTI_B	Borrowers' debt-to-income ratio (%)	50.0
δ_H	Housing depreciation (% per annum)	4.0
ν_G	Domestic goods share in government goods production	0.99
ν_{IK}	Domestic goods share in capital goods production	0.75
ν_{IH}	Domestic goods share in housing goods production	0.99
ν_X	Domestic goods share in export goods production	0.90
γ_{YMC}	Adjust. costs of imports to produce consumption goods	0.76
γ_{YMG}	Adjust. costs of imports to produce government consumption goods	0.76
γ_{YMIH}	Adjust. costs of imports to produce housing goods	1.97
γ_{YMIK}	Adjust. costs of imports to produce capital goods	1.97
γ_{YMX}	Adjust. costs of imports to produce export goods	3.12
μ_W	Wage markup	1.1
μ_D	Domestic goods price markup	1.1
μ_M	Imported goods price markup	1.0
$\rho_{B,H}$	Housing loans persistence coefficient	0.95

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Table 1 – (cont.)

	Description	Value
β_{bank}	Bank's utility time discount factor	0.975
σ_{bank}	Bank's inverse elasticity of intertemporal substitution	1.00
$\tau_{\chi 1}$	Risk weight on consumption credit	1.50
$\tau_{\chi 2}$	Risk weight on investment credit	1.00
$\tau_{\chi 3}$	Risk weight on housing credit	0.90
$\tau_{\chi 4}$	Risk weight on open market positions	0.00
$\rho_{\gamma bankcap}$	Persist. of capital requirement	0.999
$\rho_{\tau_\chi 1}$	Persist. of risk weight on consumption credit	0.990
$\rho_{\tau_\chi 2}$	Persist. of risk weight on investment credit	0.990
$\rho_{\tau_\chi 3}$	Persist. of risk weight on housing credit	0.990
$\rho_{\tau RRD}$	Persistence of demand deposits RR ratio	0.999
$\rho_{\tau RRS}$	Persistence of savings deposits RR ratio	0.999
$\rho_{\tau RRT}$	Persistence of time deposits RR ratio	0.999
$\rho_{\tau RRadic}$	Persistence of additional RR ratio	0.999
$\mu_{B,H}$	Monitoring cost for housing credit	0.000
$\mu_{b,G}$	Gov. consumption coef. on total gov. debt	0.010
$\kappa^{\phi^*}_{B^{FPI}}$	Weight of FPI in risk premium equation	1.0
γ_{FDI}	Mean revertion parameter in FDI equation	0.01
ρ_{gL}	Time persistence of labor force growth rate	0.9961

Table 2: Estimated Parameters and Shocks

	Description	Prior Distribution			Posterior Distribution		
		Distribution	Mean	Std Dev	Mean	Credible set	
	Preference and Technology						
$\bar{h}_{C,S}$	Savers' Consumption Habit persistence	Beta	0.80	0.10	0.876	0.837	0.916
$\bar{h}_{C,B}$	Borrowers' Consumption Habit persistence	Beta	0.80	0.10	0.750	0.604	0.902
$\bar{h}_{N,S}$	Savers' Labor Habit persistence	Beta	0.50	0.25	0.136	0.002	0.271
$\bar{h}_{N,B}$	Borrowers' Labor Habit persistence	Beta	0.50	0.25	0.823	0.754	0.894
σ_L	Inverse Frisch elasticity of labor	Gamma	1.00	0.25	0.721	0.359	1.084
$\phi_{u,2}$	Capital utilization cost	Gamma	0.20	0.15	0.142	0.076	0.204
ξ_E	Adjustment cost of employment to hours	Beta	0.75	0.10	0.700	0.656	0.744
ϕ_K	Adjustment cost of capital investment	Gamma	3.00	1.00	2.664	1.261	4.006
ϕ_H	Adjustment cost of housing investment	Gamma	10.00	1.00	10.638	8.997	12.284
μ_C	EoS between domesti and imported goods	Gamma	1.00	0.99	1.324	0.806	1.833
γ_X	Adjustment cost of Exported goods	Gamma	35.00	10.00	35.730	21.543	49.250
	Nominal Rigidities						
ξ_D	Calvo - domestic goods price	Beta	0.80	0.03	0.865	0.829	0.902
ξ_W	Calvo - wages	Beta	0.80	0.10	0.898	0.873	0.924
ξ_M	Calvo - imported goods price	Beta	0.80	0.10	0.700	0.610	0.784
γ_D	Domestic Price indexation	Beta	0.50	0.20	0.139	0.021	0.248
γ_W	Wage indexation	Beta	0.50	0.20	0.063	0.017	0.106
γ_M	Imported goods price indexation	Beta	0.50	0.20	0.490	0.135	0.830
ξ^{R_E}	Calvo - investment credit interest rate	Beta	0.50	0.25	0.136	0.002	0.269
$\xi^{R_{B,c}}$	Calvo - consumption credit interest rate	Beta	0.50	0.25	0.303	0.027	0.547
	Policy rules						
ρ_R	Interest rate smoothing	Beta	0.70	0.10	0.825	0.791	0.862
γ_π	Taylor rule Inflation coefficient	Gamma	2.00	0.05	1.966	1.888	2.046
ρ_g	Government spending smoothing	Beta	0.80	0.10	0.829	0.729	0.938
	Financial Frictions						
$\chi_{bankK,2}$	Capital buffer deviation cost	Gamma	0.10	0.05	0.092	0.062	0.121
$\chi_{b_{bank}}$	Liquidity buffer deviation cost	Gamma	0.10	0.05	0.049	0.034	0.065
$\chi_{d,T}$	Time deposits to loans deviation cost	Gamma	0.10	0.05	0.119	0.064	0.174
ϕ_T	Adjustment cost of time deposits	Gamma	0.20	0.10	0.332	0.161	0.498
	Risk Premium and External Financial Flows						
$\kappa_{bf}^{\phi^*}$	Risk Premium debt coefficient	Gamma	0.05	0.00	0.050	0.048	0.051
$\kappa_{risk}^{\phi^*}$	Risk Premium risk coefficient	Gamma	0.01	0.00	0.002	0.001	0.004
$\gamma_{FER,S}$	FER REER coefficient	Normal	0.00	1.00	1.293	1.025	1.545
$\gamma_{FPI,R}$	FPI Interest Rate coefficient	Normal	0.00	2.00	0.703	-0.817	2.159
ϕ_{F,B^*}	UIP Foreign Debt coefficient	Gamma	1.00	0.90	0.216	0.126	0.301
	Autoregressive shocks						
$\rho_{\varepsilon^{I_K}}$	Adjustment cost of capital investment	Beta	0.50	0.20	0.250	0.105	0.396
$\rho_{\varepsilon^{I_H}}$	Adjustment cost of housing investment	Beta	0.50	0.20	0.546	0.269	0.796
$\rho_{\varepsilon^{B,S}}$	Savers' preference	Beta	0.50	0.25	0.189	0.030	0.327
$\rho_{\varepsilon^{B,B}}$	Borrowers' preference	Beta	0.50	0.25	0.997	0.993	1.000
ρ_{ε^A}	Temporary technology	Beta	0.50	0.20	0.874	0.801	0.949
ρ_{ε^u}	Capital utilization	Beta	0.50	0.10	0.719	0.620	0.813
$\rho_{\epsilon,X}$	Exporters adjust. cost	Beta	0.50	0.25	0.074	0.001	0.145
$\rho_{\epsilon,M}$	Importers adjust. cost	Beta	0.50	0.25	0.238	0.013	0.441
ρ_{μ_D}	Domestic Goods Price markup	Beta	0.50	0.20	0.542	0.297	0.797
ρ_{μ_W}	Wage markup	Beta	0.50	0.20	0.111	0.018	0.202
ρ_{μ_M}	Imported Goods Price markup	Beta	0.50	0.20	0.568	0.240	0.888
ρ_ϵ	Permanent technology	Beta	0.50	0.28	0.015	0.000	0.034
$\rho_{\bar{\pi}}$	Inflation target	Beta	0.70	0.10	0.797	0.701	0.896
ρ_{ϕ^*}	Risk Premium	Beta	0.50	0.28	0.812	0.679	0.954

Continued on next page

Table 2 – (cont.)

	Description	Prior Distribution			Posterior Distribution		
		Distribution	Mean	Std Dev	Mean	Credible set	
$\rho_{\epsilon UIP}$	UIP shock	Beta	0.50	0.25	0.861	0.819	0.904
	Autoregressive financial shocks						
$\rho_{\varepsilon^{S,S}}$	Preference for savings deposits	Beta	0.90	0.05	0.974	0.958	0.991
$\rho_{\mu^R_E}$	Markup on commercial loans	Beta	0.50	0.20	0.606	0.436	0.773
$\rho_{\mu^R_{B,C}}$	Markup on retail loans	Beta	0.50	0.20	0.916	0.857	0.977
$\rho_{\varepsilon^{bank\ cap}}$	Dividend distribution	Beta	0.50	0.25	0.049	0.000	0.103
ρ_{σ_B}	Risk distrib. s.d. in retail loans	Beta	0.50	0.20	0.637	0.329	0.940
ρ_{σ_E}	Risk distrib. s.d. in commercial loans	Beta	0.50	0.20	0.975	0.958	0.995
$\rho_{d,D}$	Preference for demand deposits	Beta	0.90	0.05	0.921	0.870	0.972
$\rho_{d,T}$	Adjustment cost in time deposits	Beta	0.50	0.25	0.684	0.539	0.834
$\rho_{\gamma_{B,H}}$	Debt-to-Income in housing loans	Beta	0.90	0.05	0.737	0.615	0.857
ρ_{γ_E}	LTV in commercial loans	Beta	0.90	0.05	0.911	0.842	0.983
$\rho_{\gamma_{B,C}}$	Debt-to-income in retail loans	Beta	0.90	0.05	0.988	0.980	0.997
$\rho_{IB^{rem}}$	Exogenous component in CAR	Beta	0.90	0.05	0.942	0.905	0.979
ρ_{R_S}	Savings Deposits interest rate	Beta	0.50	0.25	0.684	0.532	0.841
$\rho_{\varepsilon^{bank\ cap}}$	Dividend distribution	Beta	0.50	0.25	0.049	0.000	0.103
$\rho_{\tau_{B,E}}$	Credit taxes	Beta	0.90	0.05	0.941	0.903	0.981
$\rho_{s_{adm,B}}$	Bank admin. costs	Beta	0.90	0.05	0.928	0.882	0.976
ρ_{FER}	Foreign Exchange Reserves	Beta	0.50	0.25	0.956	0.920	0.994
ρ_{FPI}	Foreign Portfolio Investment	Beta	0.50	0.25	0.971	0.945	0.999
ρ_{FDI}	Foreign Direct Investment	Beta	0.50	0.25	0.740	0.633	0.852
	Traditional shocks						
ϵ^R	Monetary policy	Inv. Gamma	0.02	Inf	0.014	0.011	0.016
ϵ^G	Government spending	Inv. Gamma	0.01	Inf	0.007	0.006	0.008
ϵ_{I_K}	Capital invest. adjustment cost	Inv. Gamma	0.05	Inf	0.119	0.097	0.141
ϵ_{I_H}	Housing invest. adjustment cost	Inv. Gamma	0.05	Inf	0.090	0.064	0.114
ϵ_{β_S}	Savers' preference	Inv. Gamma	0.05	Inf	0.267	0.179	0.355
ϵ_{β_B}	Borrowers' preference	Inv. Gamma	0.05	Inf	1.661	0.646	2.669
ϵ^A	Temporary technology	Inv. Gamma	0.02	Inf	0.023	0.019	0.028
ϵ_u	Capital utilisation	Inv. Gamma	0.02	Inf	0.016	0.013	0.019
ϵ_X	Exporters adjust. cost	Inv. Gamma	0.10	Inf	0.061	0.052	0.071
ϵ_M	Importers adjust. cost	Inv. Gamma	0.10	Inf	0.081	0.061	0.100
ϵ_{μ_D}	Domestic Goods price markup	Inv. Gamma	0.10	Inf	0.064	0.045	0.082
ϵ_{μ_W}	Wage markup	Inv. Gamma	0.10	Inf	0.129	0.090	0.164
ϵ_{μ_M}	Importers markup	Inv. Gamma	0.10	Inf	0.055	0.028	0.081
ϵ^Z	Permanent technology	Inv. Gamma	0.10	Inf	0.044	0.037	0.051
ϵ_{g_L}	Labor force growth rate	Inv. Gamma	0.00	Inf	0.000	0.000	0.000
$\epsilon_{\bar{\pi}}$	Inflation target	Inv. Gamma	0.01	Inf	0.005	0.004	0.006
ϵ_{ϕ^*}	Risk Premium	Inv. Gamma	0.01	Inf	0.004	0.003	0.004
ϵ_{UIP}	UIP shock	Inv. Gamma	0.10	Inf	0.017	0.014	0.020
$\epsilon_{Y,me}$	GDP share meas. error	Inv. Gamma	0.01	Inf	0.003	0.002	0.003
ϵ_{risk}	Foreign Risk aversion index	Inv. Gamma	1.00	Inf	0.601	0.514	0.689
ϵ_{π^*}	Foreign inflation	Inv. Gamma	0.02	Inf	0.008	0.006	0.009
$\epsilon_{P^{M^*}}$	Foreign imported goods price	Inv. Gamma	0.05	Inf	0.030	0.025	0.034
$\epsilon_{\phi^{R^L_X}}$	Exported goods IR markup	Inv. Gamma	0.01	Inf	0.004	0.003	0.004
ϵ_{ω^X}	Share of Financed Exports	Inv. Gamma	0.15	Inf	0.072	0.061	0.083
ϵ_{ZF^*}	World demand	Inv. Gamma	0.01	Inf	0.005	0.004	0.005
	Financial shocks						
$\epsilon_{S,S}$	Preference for savings deposits	Inv. Gamma	0.02	Inf	0.023	0.019	0.026
$\epsilon_{\mu^{R_E}}$	Markup on commercial loans	Inv. Gamma	0.02	Inf	0.004	0.003	0.004
$\epsilon_{\mu^{R_{B,C}}}$	Markup on retail loans	Inv. Gamma	0.02	Inf	0.005	0.004	0.006
ϵ_{bankK}	Dividend distribution	Inv. Gamma	0.02	Inf	0.090	0.076	0.105

Continued on next page

Table 2 – (cont.)

	Description	Prior Distribution			Posterior Distribution		
		Distribution	Mean	Std Dev	Mean	Credible set	
ϵ_{σ_B}	Risk shock to retail loans	Inv. Gamma	0.10	Inf	0.049	0.028	0.068
ϵ_{σ_E}	Risk shock to commercial loans	Inv. Gamma	0.10	Inf	0.035	0.027	0.042
$\epsilon_{D,S}$	Preference for demand deposits	Inv. Gamma	0.05	Inf	0.037	0.031	0.042
$\epsilon_{d,T}$	Time deposit adjustment cost	Inv. Gamma	0.05	Inf	0.042	0.029	0.055
$\epsilon_{\gamma_{B,H}}$	Housing debt-to-income	Inv. Gamma	0.05	Inf	1.241	1.048	1.431
ϵ_{γ_E}	Collateral in commercial loans	Inv. Gamma	0.05	Inf	0.023	0.012	0.034
$\epsilon_{\gamma_{B,C}}$	Retail debt-to-income	Inv. Gamma	0.05	Inf	0.045	0.037	0.053
$\epsilon_{IB,rem}$	Exogenous component in CAR	Inv. Gamma	0.10	Inf	0.117	0.098	0.136
ϵ_{R_S}	Savings Deposits interest rate	Inv. Gamma	0.01	Inf	0.001	0.001	0.002
$\epsilon_{\tau_{B,E}}$	Credit taxes	Inv. Gamma	0.00	Inf	0.000	0.000	0.000
$\epsilon_{S_{adm,B}}$	Bank admin. costs	Inv. Gamma	0.00	Inf	0.001	0.001	0.002
ϵ_{FER}	Foreign Exchange Reserves	Inv. Gamma	0.10	Inf	0.087	0.074	0.100
$\epsilon_{FER,me}$	FER	Inv. Gamma	0.20	Inf	0.094	0.080	0.107
ϵ_{FDI}	Foreign Direct Investment	Inv. Gamma	0.02	Inf	0.012	0.010	0.014
ϵ_{FPI}	Foreign Portfolio Investment	Inv. Gamma	0.10	Inf	0.074	0.062	0.085
ϵ_{ULT}	Unilateral Transfers	Inv. Gamma	0.50	Inf	0.340	0.287	0.390

Table 3: Standard Deviations of Observable Series

Observable Variable	Sample Std. Dev.	Model Std. Dev.
Nominal GDP (HP filtered)	0.020	0.099
Private Consumption Share in Nominal GDP	0.019	0.038
Government Consumption Share in Nominal GDP	0.010	0.028
Investment Share in Nominal GDP	0.017	0.030
Exports Share in Nominal GDP	0.022	0.037
Imports Share in Nominal GDP	0.013	0.023
Housing Investment Growth Rate	0.025	0.107
Unemployment	0.030	0.076
Capacity Utilization	0.027	0.057
CPI Inflation	0.010	0.015
Nominal Wage Growth Rate	0.015	0.021
Base Interest Rate	0.013	0.016
Interest Rate on Savings Deposits	0.004	0.004
Nominal Exchange Rate Variation	0.103	0.099
Country Risk Premium (bps)	398.984	830.318
Retail Loans to GDP ratio	0.173	0.332
Housing Loans to GDP ratio	0.068	0.238
Commercial Loans to GDP ratio	0.119	0.151
Commercial Loans Interest Rate	0.010	0.015
Retail Loans Interest Rate	0.022	0.023
Default Rate on Commercial Loans	0.010	0.037
Default Rate on Retail Loans	0.008	0.063
Time Deposits to GDP	0.188	0.181
Savings Deposits to GDP	0.046	0.061
Demand Deposits to GDP	0.013	0.018
Bank Capital to GDP	0.087	0.192
Capital Adequacy Ratio	0.013	0.050
Unilateral Transfers to GDP	0.001	0.002
Variation of Net Foreign Exchange Reserves to GDP	0.031	0.079
Net Foreign Exchange Reserves to GDP	0.153	0.151
Net Foreign Direct Investment to GDP	0.019	0.022
Net Foreign Portfolio Investment to GDP	0.024	0.031
Reserve Requirement Ratio on Time Deposits	0.053	0.053
Additional Reserve Requirement Ratio	0.036	0.036
Reserve Requirement Ratio on Savings Deposits	0.042	0.041
Reserve Requirement Ratio on Demand Deposits	0.069	0.068
Inflation Target	0.008	0.009
Growth rate of Labor	0.001	0.001
Administrative Costs on Loans	3.609	6.349
Indirect taxes on Loans	0.815	1.481
Capacity Utilization	0.006	0.006
Foreign Interest Rate	0.005	0.006
VIX	8.785	19.444
Foreign Inflation	0.007	0.007
Imported Goods Inflation	0.036	0.032
Exported Goods Inflation	0.048	0.043
Interest Rate on Exports Loans	0.003	0.023
Financed Share of Exports	0.160	0.151

Table 4: Variance Decomposition of Selected Variables

Shock	Output Gap	Inflation	Interest Rate	Private Consumption	Government Consumption	Capital Investment
ϵ_{g_L}	2.72	1.37	3.44	1.53	5.70	0.04
ϵ^A	1.04	21.09	22.81	1.31	1.30	1.41
ϵ^Z	14.26	3.23	4.02	21.30	5.28	2.24
ϵ_u	0.08	0.16	0.17	0.01	0.01	0.22
ϵ_{I_K}	6.43	0.36	0.29	0.71	0.61	39.06
ϵ_{I_H}	1.20	0.31	0.87	0.15	0.01	0.19
ϵ^G	2.39	0.38	0.90	0.15	15.13	0.34
ϵ^R	1.57	0.79	9.19	0.82	2.48	1.10
ϵ_{μ_W}	0.08	2.68	3.05	0.11	0.15	0.21
ϵ_{μ_D}	1.89	34.84	3.41	0.64	0.14	2.58
ϵ_{μ_M}	0.18	1.54	0.21	0.06	0.11	0.10
ϵ_{UIP}	0.69	5.08	12.57	2.42	2.34	1.75
ϵ_{β_S}	12.85	5.07	11.13	16.38	0.06	1.98
ϵ_{β_B}	19.94	1.88	2.17	10.70	29.75	2.22
ϵ_{σ_E}	0.21	0.02	0.03	0.03	0.02	0.87
ϵ_{σ_B}	0.00	0.00	0.00	0.00	0.00	0.00
$\epsilon_{\mu^{R_E}}$	0.02	0.00	0.00	0.00	0.00	0.14
$\epsilon_{\mu^{R_{B,C}}}$	0.07	0.05	0.14	0.20	0.10	0.08
$\epsilon_{\gamma_{B,C}}$	7.48	1.02	1.50	3.62	8.50	1.27
$\epsilon_{\gamma_{B,H}}$	0.31	0.25	0.62	0.15	0.77	0.58
ϵ_{γ_E}	0.02	0.00	0.00	0.00	0.00	0.09
$\epsilon_{IB,rem}$	0.08	0.01	0.01	0.03	0.01	0.14
ϵ_{bankK}	0.66	0.05	0.08	0.22	0.16	1.08
$\epsilon_{D,S}$	0.00	0.00	0.00	0.00	0.00	0.00
$\epsilon_{S,S}$	0.00	0.00	0.00	0.00	0.00	0.01
$\epsilon_{d,T}$	0.01	0.00	0.00	0.00	0.00	0.05
$\epsilon_{\tau_{RR,T}}$	0.01	0.00	0.00	0.00	0.00	0.01
$\epsilon_{\tau_{RR,add}}$	0.01	0.00	0.00	0.00	0.00	0.01
$\epsilon_{\tau_{RR,S}}$	0.00	0.00	0.00	0.00	0.00	0.00
$\epsilon_{\tau_{RR,D}}$	0.00	0.00	0.00	0.00	0.01	0.00
$\epsilon_{s_{adm,B}}$	0.13	0.01	0.02	0.05	0.02	0.21
$\epsilon_{\tau_{B,E}}$	0.01	0.00	0.00	0.00	0.01	0.01
$\epsilon_{\overline{\pi}}$	1.15	0.87	0.41	0.56	0.98	0.66
ϵ_{R_S}	0.00	0.00	0.00	0.00	0.00	0.00
ϵ_M	0.68	0.05	0.12	0.09	0.03	0.22
$\epsilon_{P^{M*}}$	3.13	6.23	6.45	7.77	3.91	10.36
ϵ_X	4.84	0.37	0.73	1.64	0.44	4.39
$\epsilon_{Z^*_X}$	14.62	6.22	6.13	26.30	14.81	23.93
ϵ_{ZF^*}	0.14	1.35	1.37	0.96	0.36	1.38
ϵ_{ω^X}	0.00	0.00	0.00	0.00	0.00	0.00
$\epsilon_{\phi^{R^L_X}}$	0.01	0.00	0.00	0.00	0.00	0.01
ϵ_{R^*}	0.05	0.20	0.37	0.08	1.49	0.04
ϵ_{π^*}	0.00	0.00	0.00	0.00	0.01	0.00
ϵ_{risk}	0.08	0.28	0.34	0.04	0.01	0.08
ϵ_{ϕ^*}	0.15	0.47	0.27	0.02	0.00	0.10
ϵ_{FDI}	0.38	1.41	2.47	1.06	0.75	0.25
ϵ_{FER}	0.01	0.14	0.47	0.06	0.42	0.02
ϵ_{FPI}	0.00	0.04	0.12	0.01	0.04	0.00
ϵ_{ULT}	0.00	0.01	0.02	0.02	0.00	0.01
$\epsilon_{FER,me}$	0.41	2.15	4.08	0.77	4.06	0.55
$\epsilon_{Y,me}$	0.00	0.00	0.00	0.00	0.00	0.00

Table 4 - (cont.)

Shock	Commercial Loans	Retail Loans	Housing Loans	Commercial Lending Rate	Retail Lending Rate	Housing Lending Rate
ϵ_{g_L}	2.70	0.00	0.43	3.95	1.69	2.85
ϵ^{A}	8.46	0.16	0.10	5.00	6.56	18.90
ϵ^{Z}	15.42	0.14	3.68	23.09	4.35	3.33
ϵ_{u}	0.15	0.01	0.00	0.02	0.02	0.14
ϵ_{I_K}	7.57	0.04	0.06	10.20	0.25	0.24
ϵ_{I_H}	0.25	0.05	0.02	0.29	0.34	0.72
ϵ^{G}	0.40	0.02	0.00	0.08	0.18	0.75
ϵ^{R}	0.59	0.03	0.02	7.41	4.20	7.62
ϵ_{μ_W}	0.95	0.06	0.00	0.71	0.65	2.52
ϵ_{μ_D}	0.97	0.17	0.27	2.47	1.49	2.83
ϵ_{μ_M}	0.09	0.00	0.00	0.33	0.10	0.18
ϵ_{UIP}	3.45	0.09	0.19	5.29	4.76	10.41
ϵ_{β_S}	3.22	0.17	0.02	1.91	2.29	9.22
ϵ_{β_B}	1.65	30.04	21.00	2.11	17.36	1.80
ϵ_{σ_E}	17.06	0.00	0.00	10.02	0.11	0.02
ϵ_{σ_B}	0.00	0.05	0.00	0.03	0.90	0.00
$\epsilon_{\mu^{R_E}}$	0.18	0.00	0.00	10.24	0.02	0.00
$\epsilon_{\mu^{R_{B,C}}}$	2.50	0.16	0.03	0.17	14.89	0.12
$\epsilon_{\gamma_{B,C}}$	4.19	45.54	0.16	2.49	3.82	1.24
$\epsilon_{\gamma_{B,H}}$	2.04	22.22	72.11	0.23	21.17	0.51
ϵ_{γ_E}	0.64	0.00	0.00	0.67	0.01	0.00
$\epsilon_{IB,rem}$	0.54	0.01	0.00	0.29	0.51	0.01
ϵ_{bankK}	6.85	0.07	0.02	0.95	2.68	0.06
$\epsilon_{D,S}$	0.01	0.00	0.00	0.00	0.00	0.00
$\epsilon_{S,S}$	0.05	0.00	0.00	0.00	0.01	0.00
$\epsilon_{d,T}$	0.09	0.00	0.00	0.19	0.09	0.00
$\epsilon_{\tau_{RR,T}}$	0.15	0.00	0.00	0.00	0.02	0.00
$\epsilon_{\tau_{RR,add}}$	0.20	0.00	0.00	0.00	0.03	0.00
$\epsilon_{\tau_{RR,S}}$	0.03	0.00	0.00	0.00	0.00	0.00
$\epsilon_{\tau_{RR,D}}$	0.01	0.00	0.00	0.00	0.00	0.00
$\epsilon_{s_{adm,B}}$	0.79	0.02	0.01	0.40	1.19	0.02
$\epsilon_{\tau_{B,E}}$	0.04	0.00	0.00	0.01	0.05	0.00
$\epsilon_{\overline{\pi}}$	0.29	0.04	0.00	0.13	0.09	0.34
ϵ_{R_S}	0.00	0.00	0.00	0.00	0.00	17.15
ϵ_{M}	0.10	0.00	0.01	0.16	0.07	0.10
$\epsilon_{P^{M*}}$	5.29	0.12	0.48	2.88	2.73	5.34
ϵ_{X}	0.74	0.08	0.11	0.54	0.30	0.61
$\epsilon_{Z_X^*}$	8.49	0.60	1.12	4.55	2.81	5.08
ϵ_{ZF^*}	0.87	0.01	0.06	0.50	0.68	1.14
ϵ_{ω^X}	0.00	0.00	0.00	0.00	0.00	0.00
$\epsilon_{\phi^{R_X^L}}$	0.04	0.00	0.00	0.00	0.02	0.00
ϵ_{R^*}	0.14	0.00	0.00	0.13	0.12	0.31
ϵ_{π^*}	0.00	0.00	0.00	0.00	0.00	0.00
ϵ_{risk}	0.14	0.00	0.00	0.13	0.13	0.28
ϵ_{ϕ^*}	0.14	0.00	0.00	0.13	0.15	0.22
ϵ_{FDI}	0.86	0.02	0.02	0.85	0.98	2.05
ϵ_{FER}	0.14	0.01	0.01	0.16	0.40	0.39
ϵ_{FPI}	0.03	0.01	0.00	0.04	0.13	0.10
ϵ_{ULT}	0.01	0.00	0.00	0.01	0.01	0.02
$\epsilon_{FER,me}$	1.50	0.02	0.05	1.24	1.64	3.38
$\epsilon_{Y,me}$	0.00	0.00	0.00	0.00	0.00	0.00

11 Observable Variables

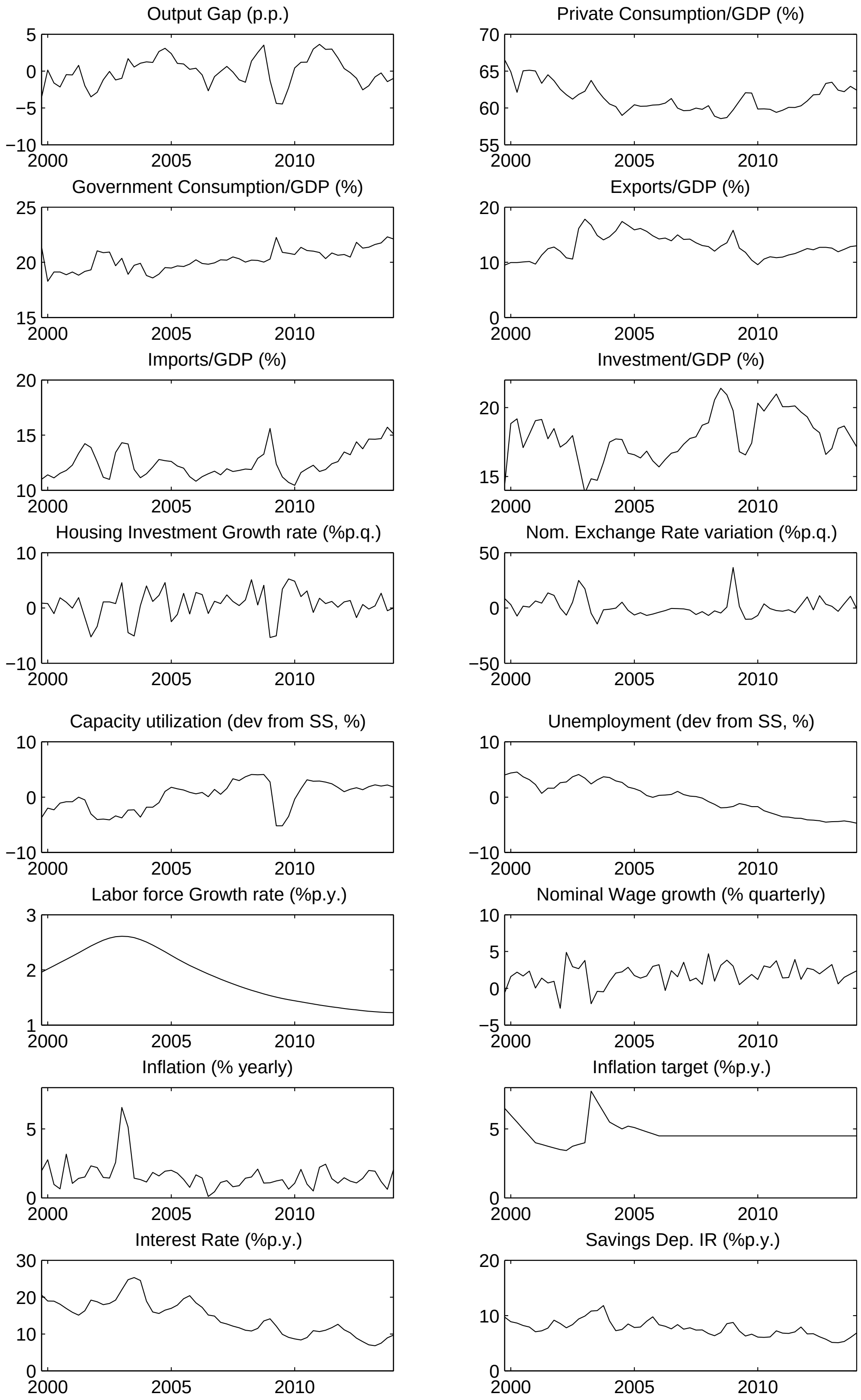

Figure 1: Observable Variables

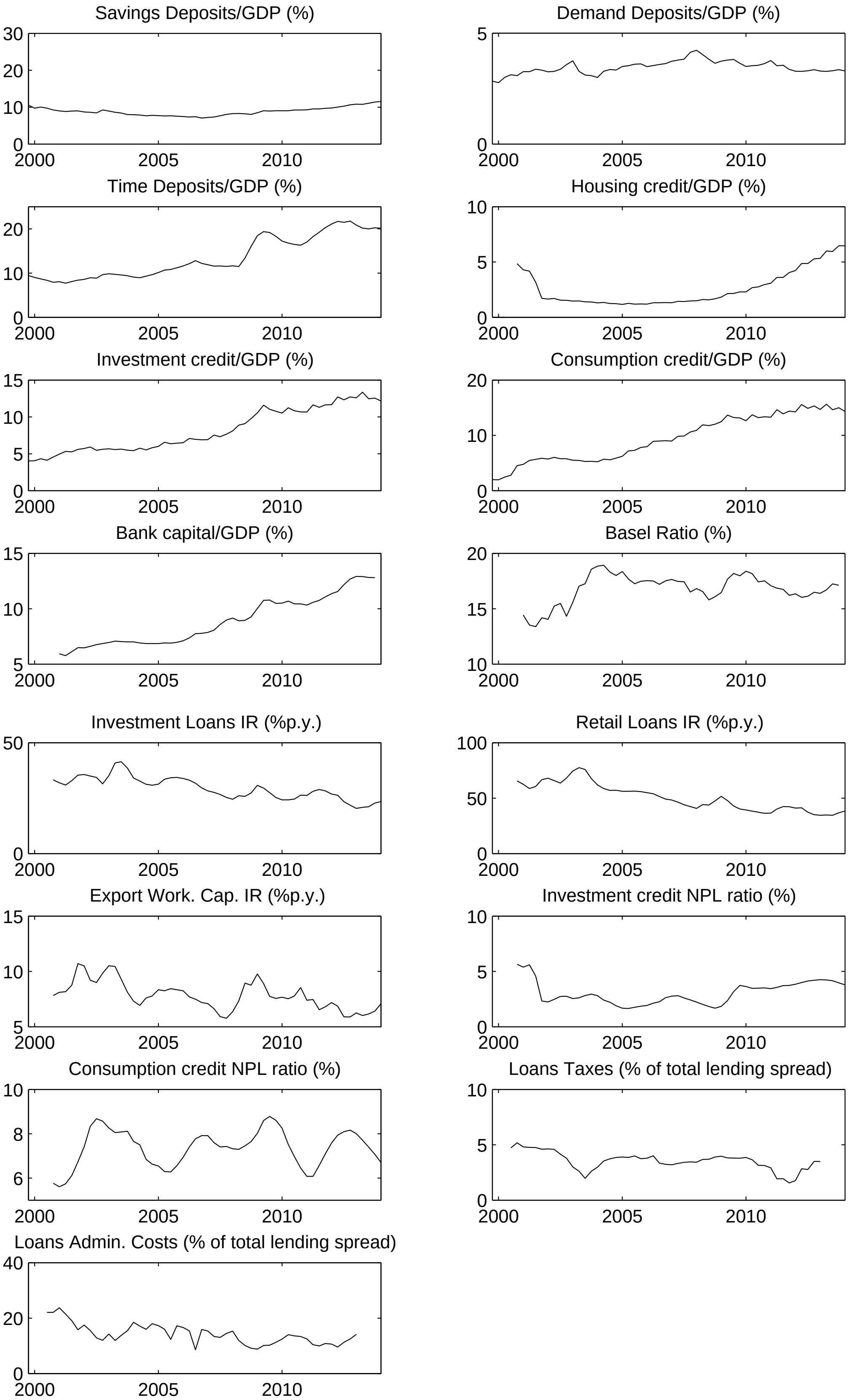

Figure 2: Observable Variables

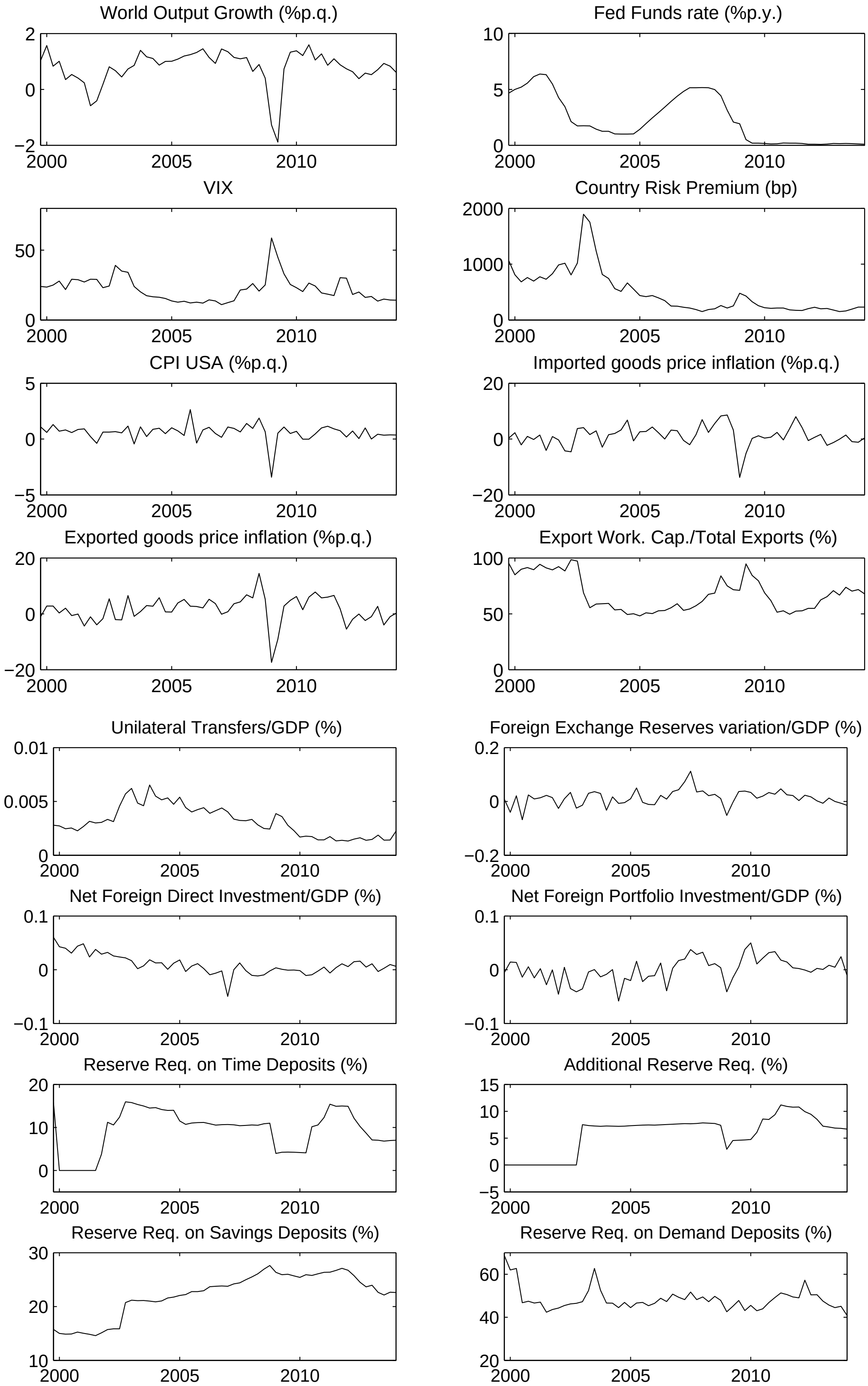

Figure 3: Observable Variables

12 Priors and Posteriors

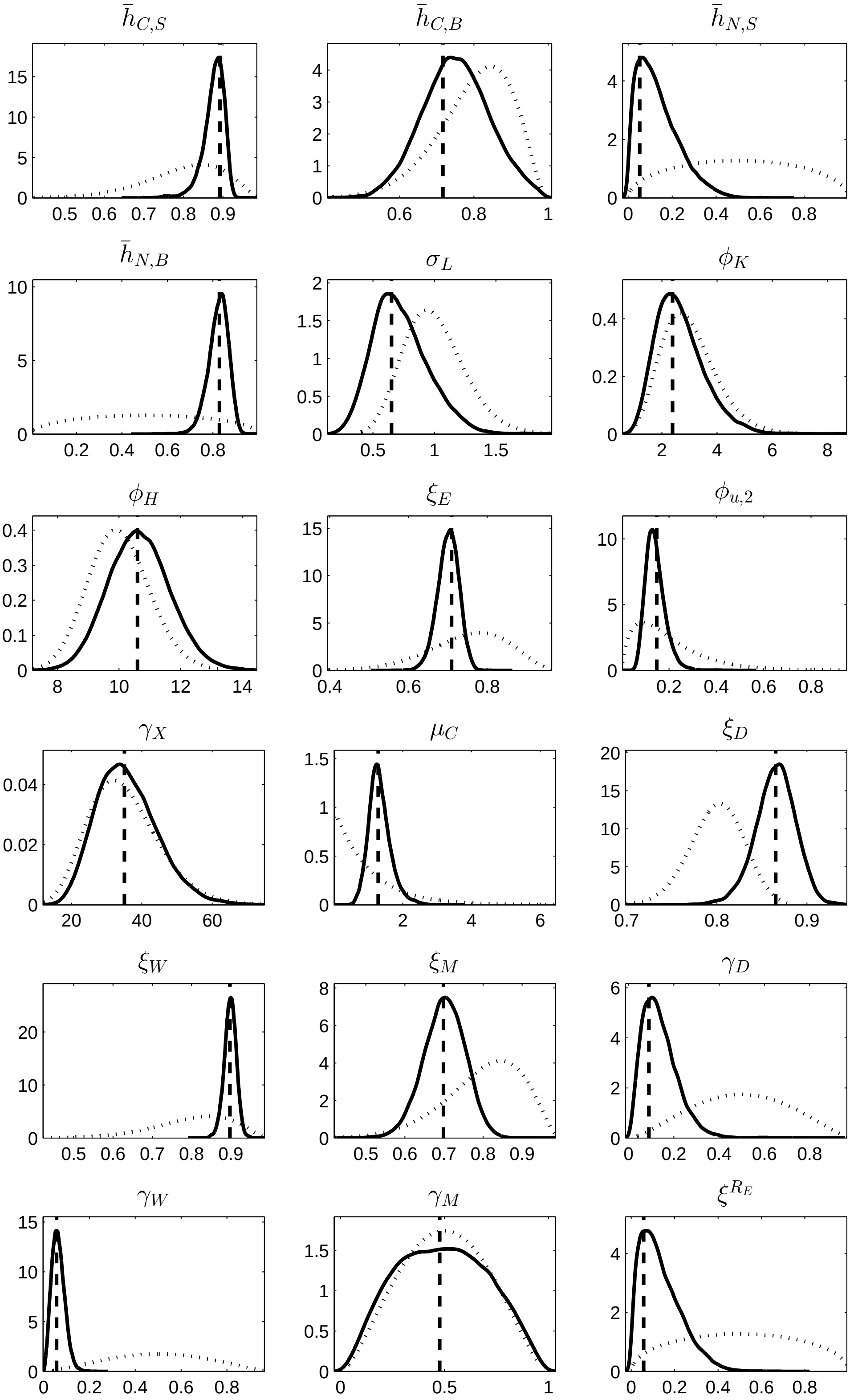

Figure 4: Priors and Posteriors

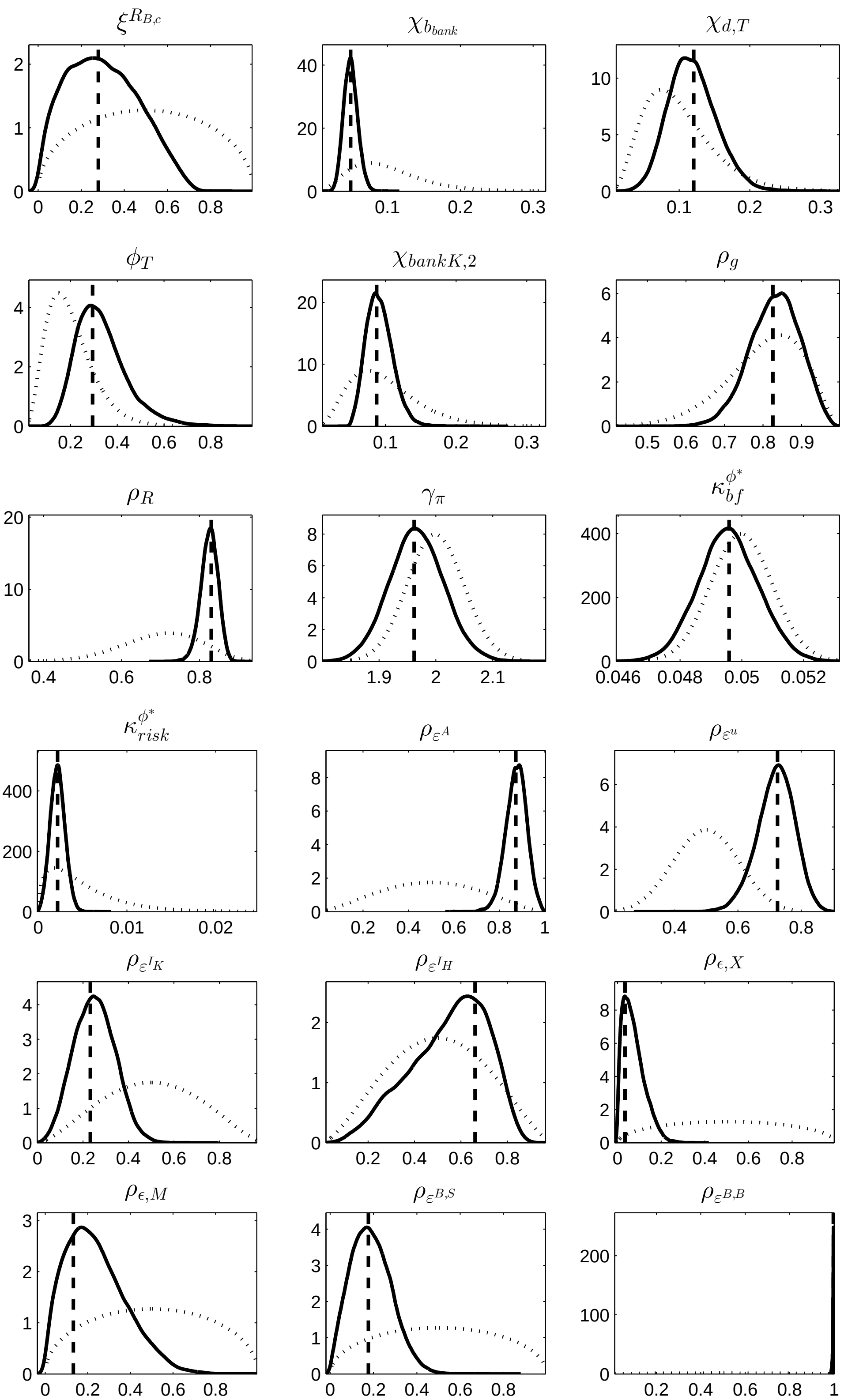

Figure 5: Priors and Posteriors

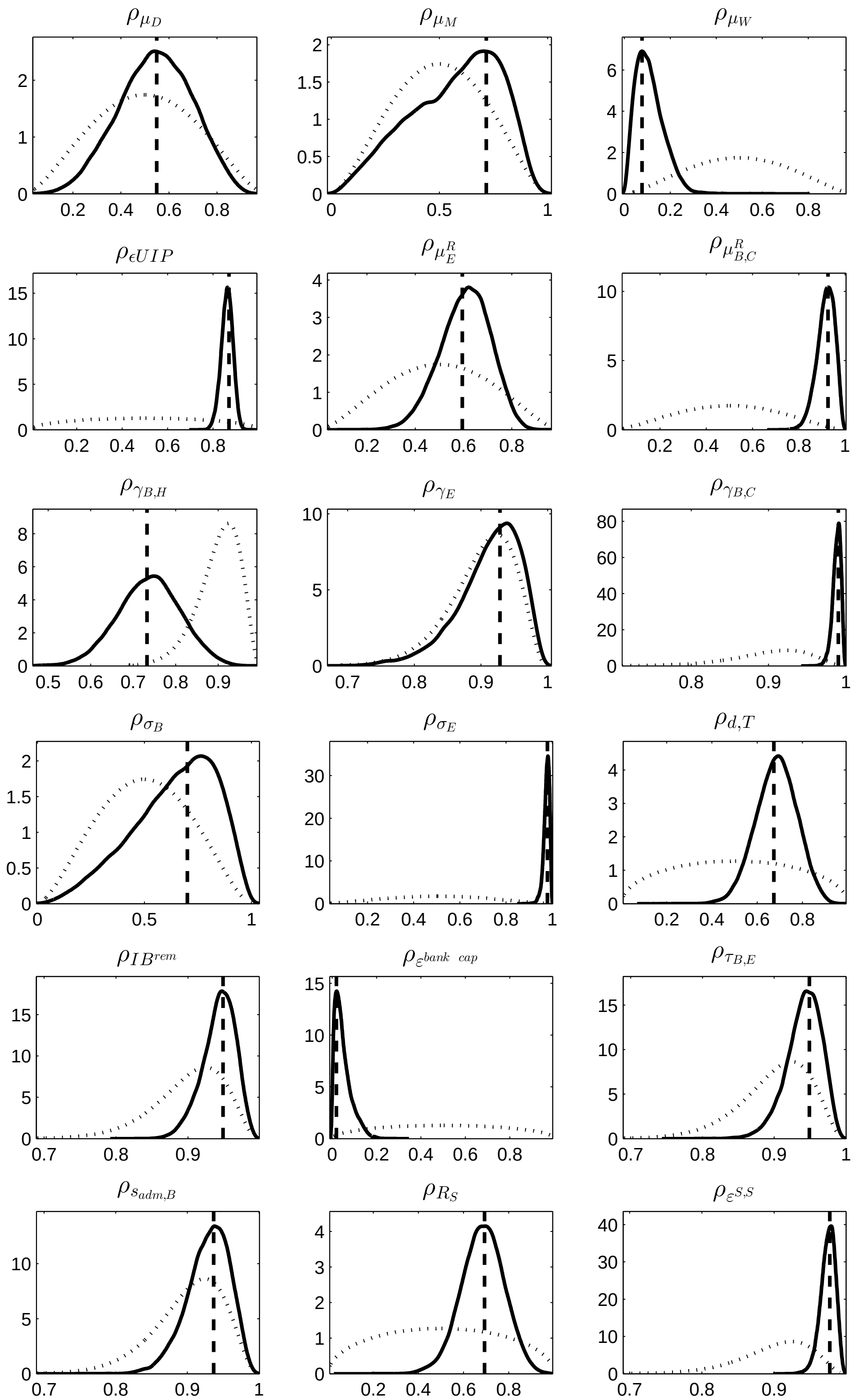

Figure 6: Priors and Posteriors

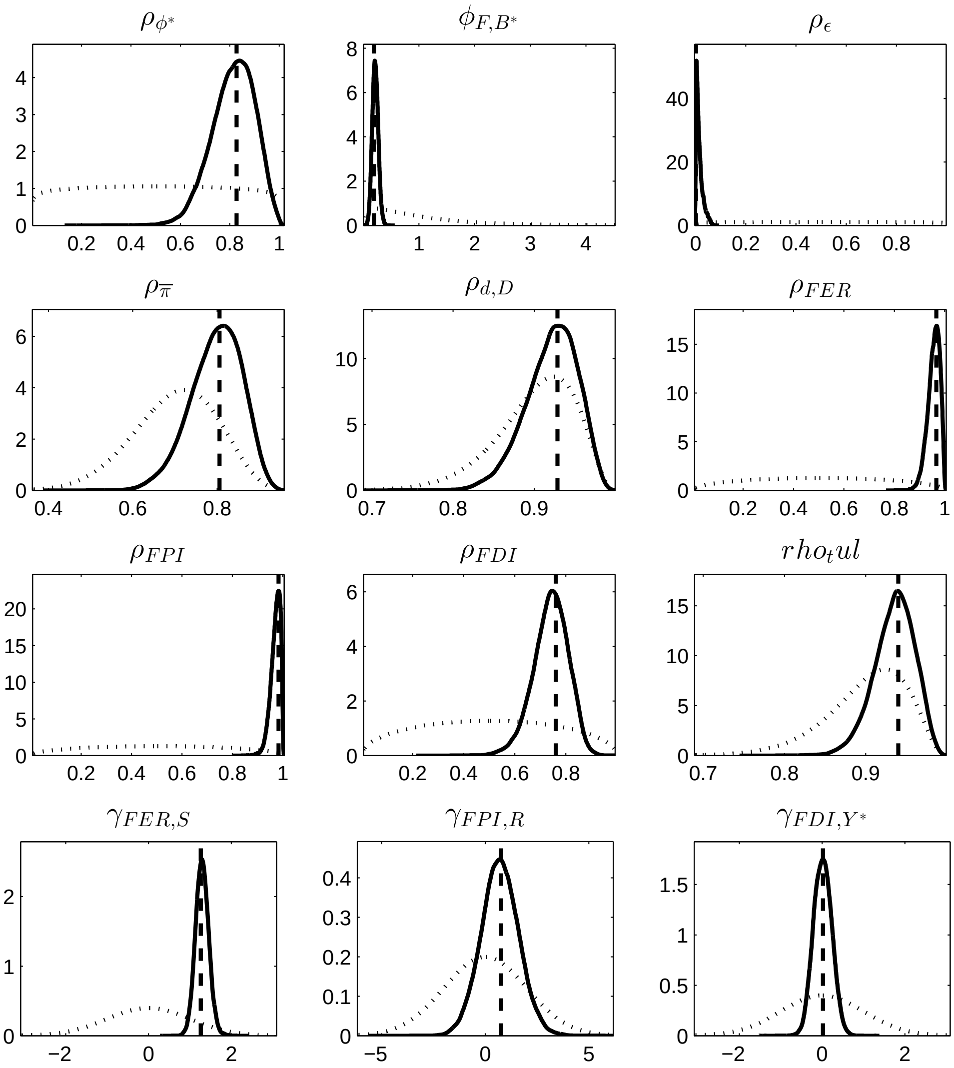

Figure 7: Priors and Posteriors

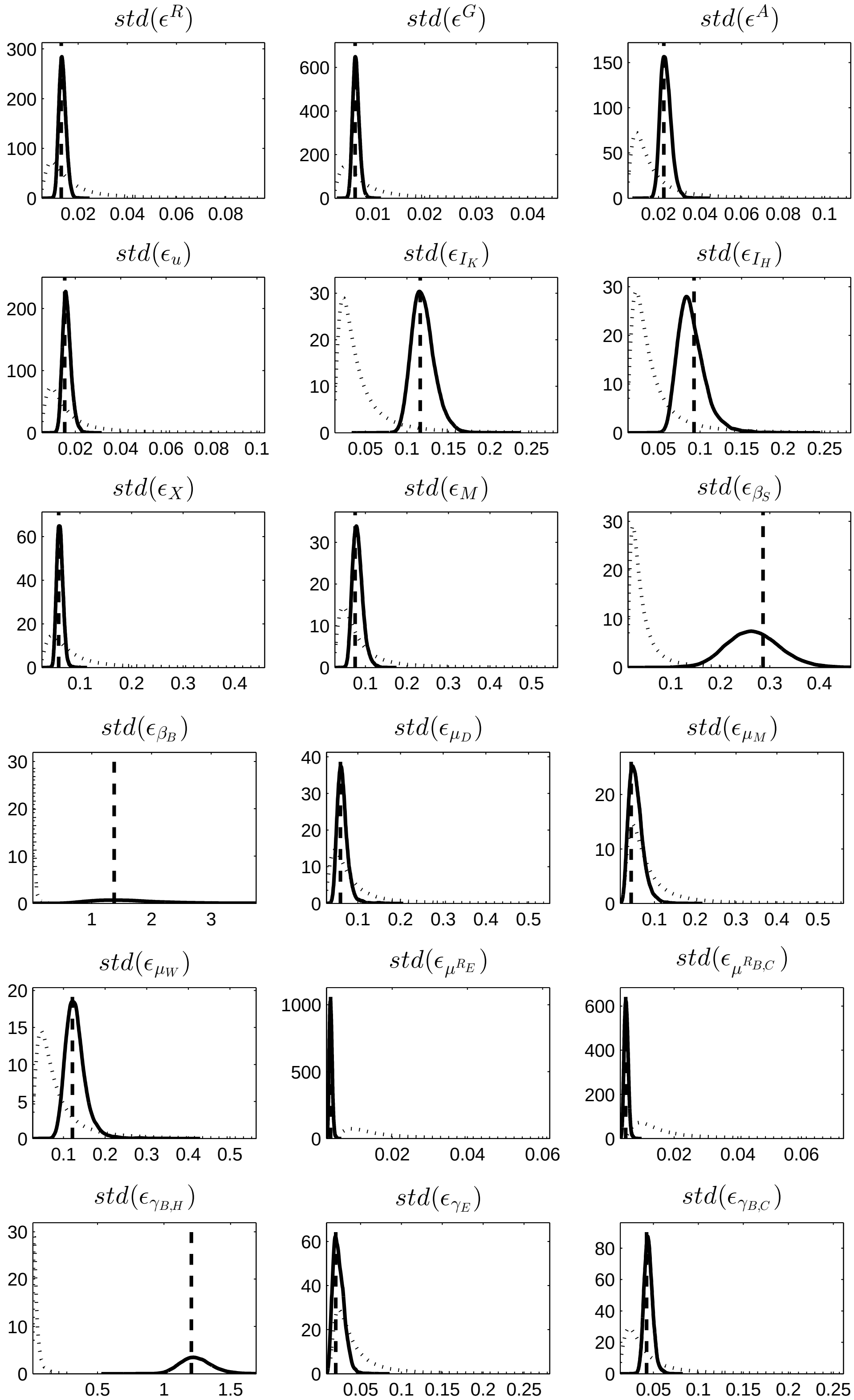

Figure 8: Priors and Posteriors

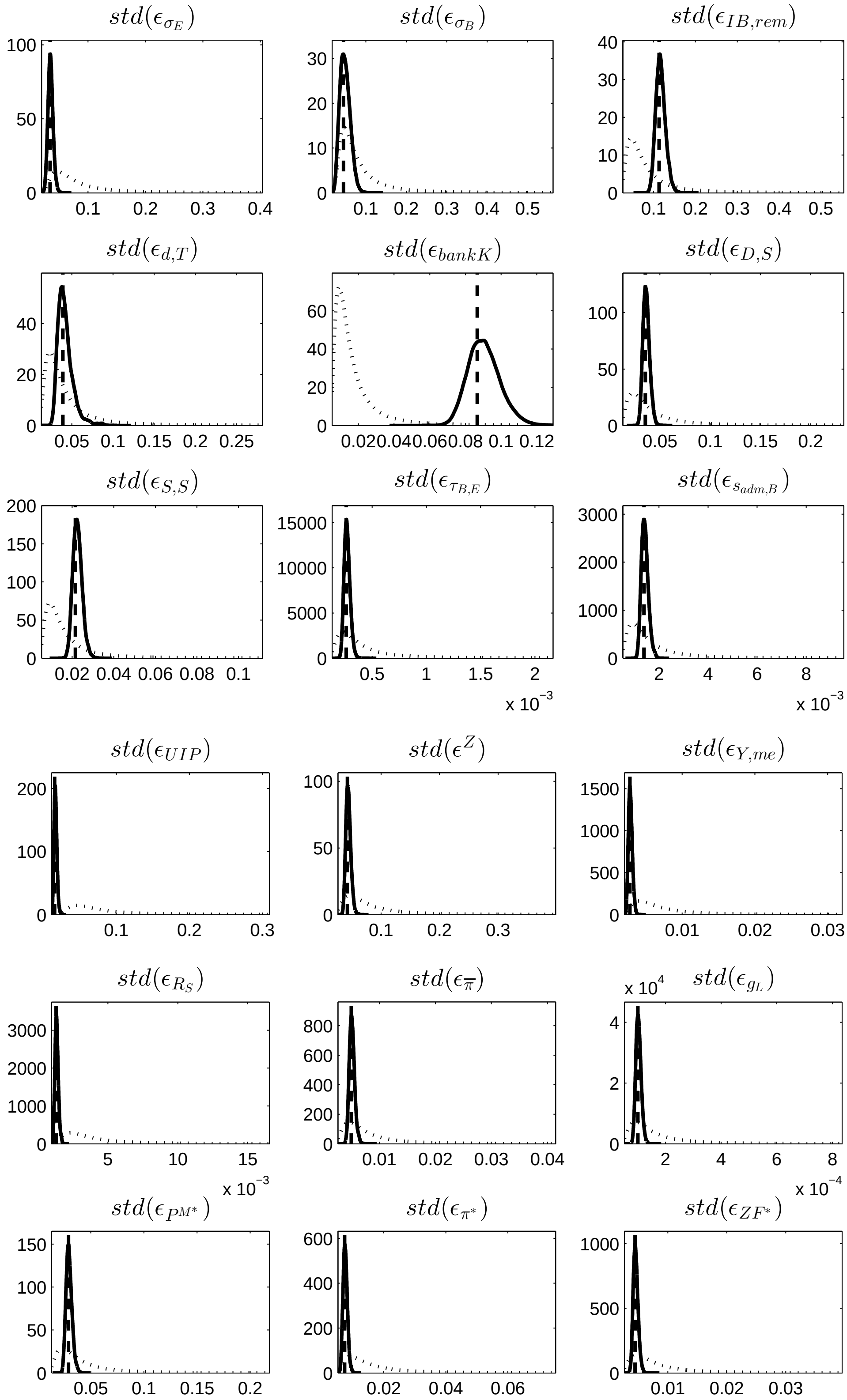

Figure 9: Priors and Posteriors

13 The transmission of macroprudential and monetary policies

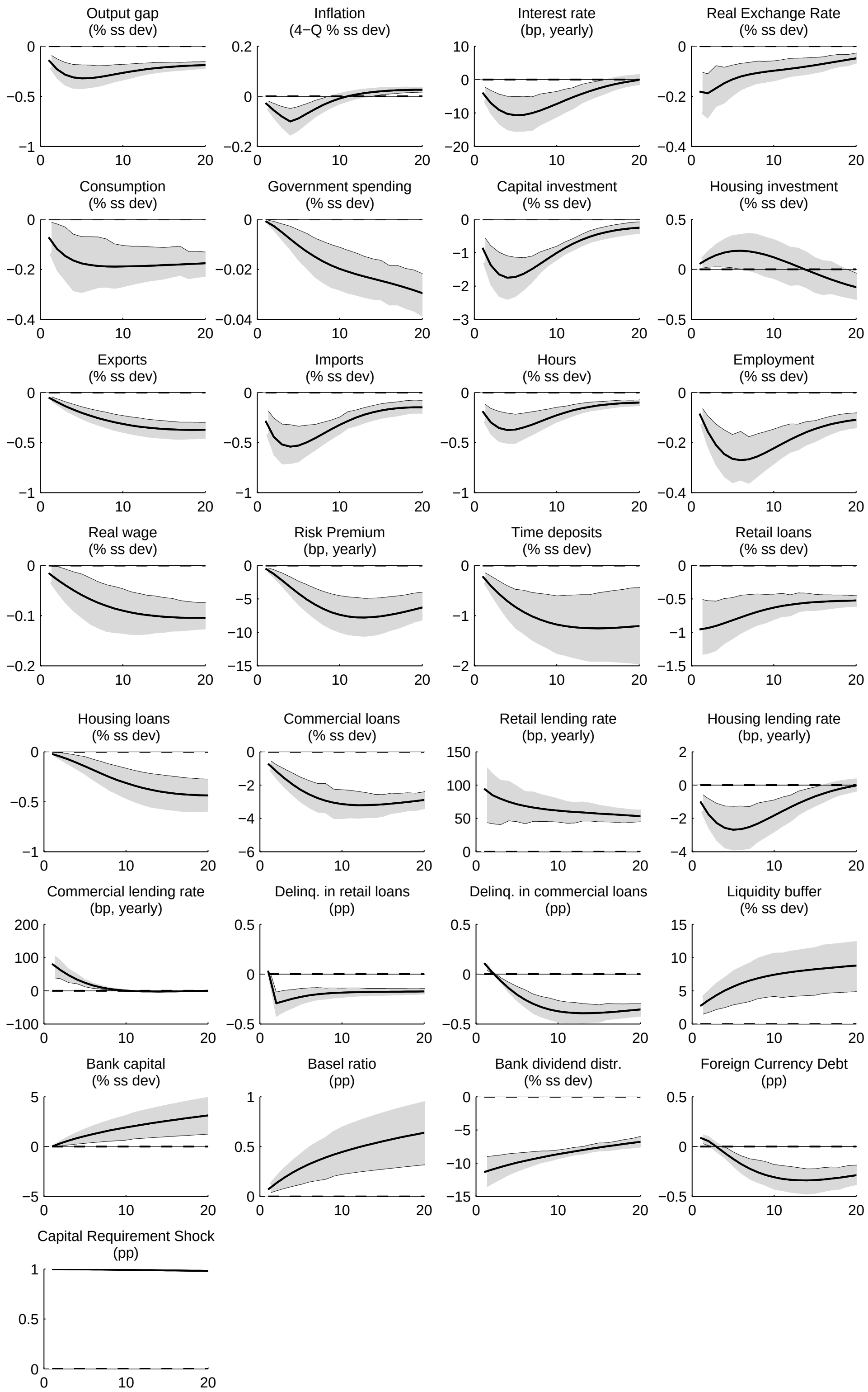

Figure 10: Bank Capital Requirement Shock

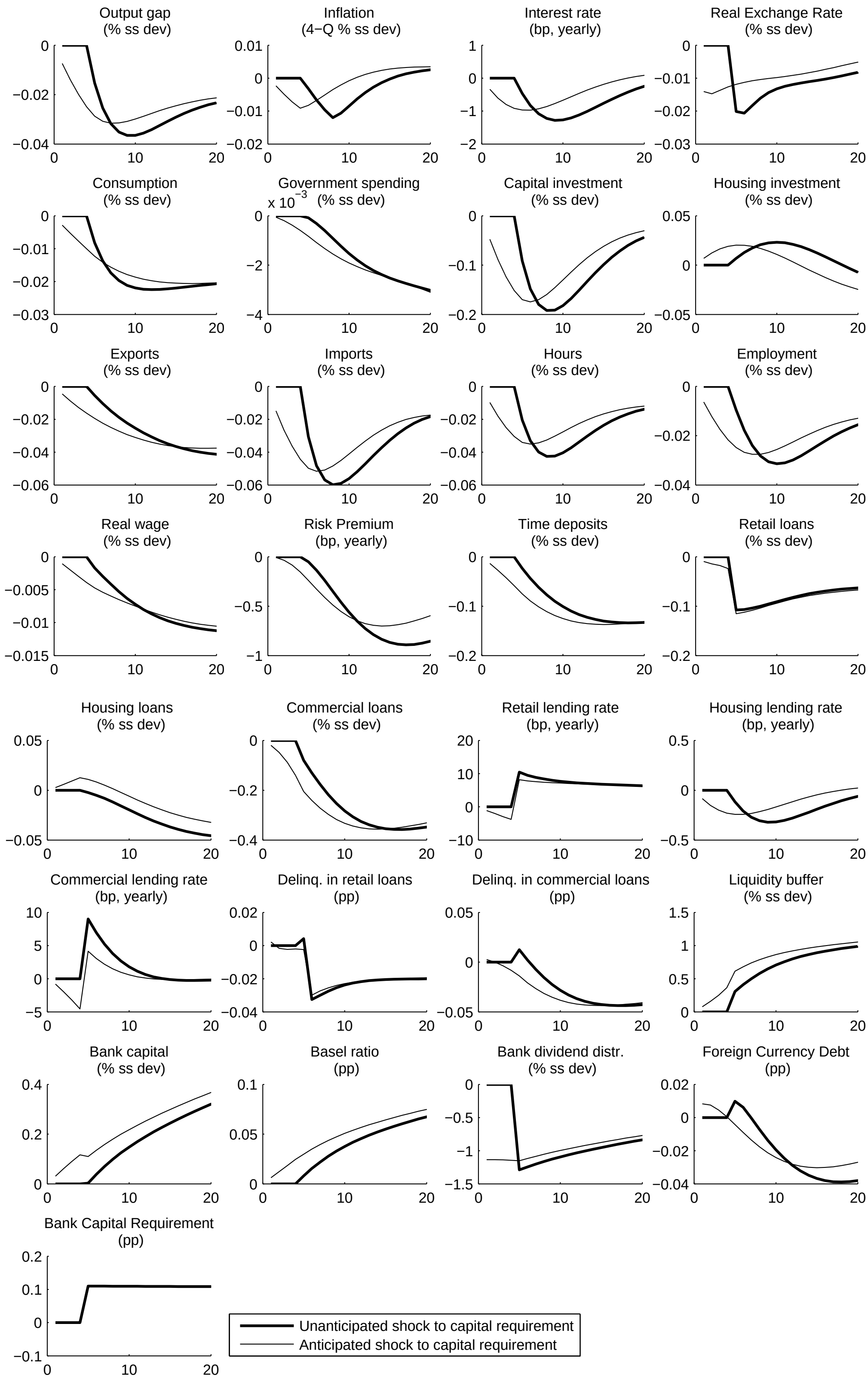

Figure 11: Anticipated x Non-anticipated capital requirement shocks

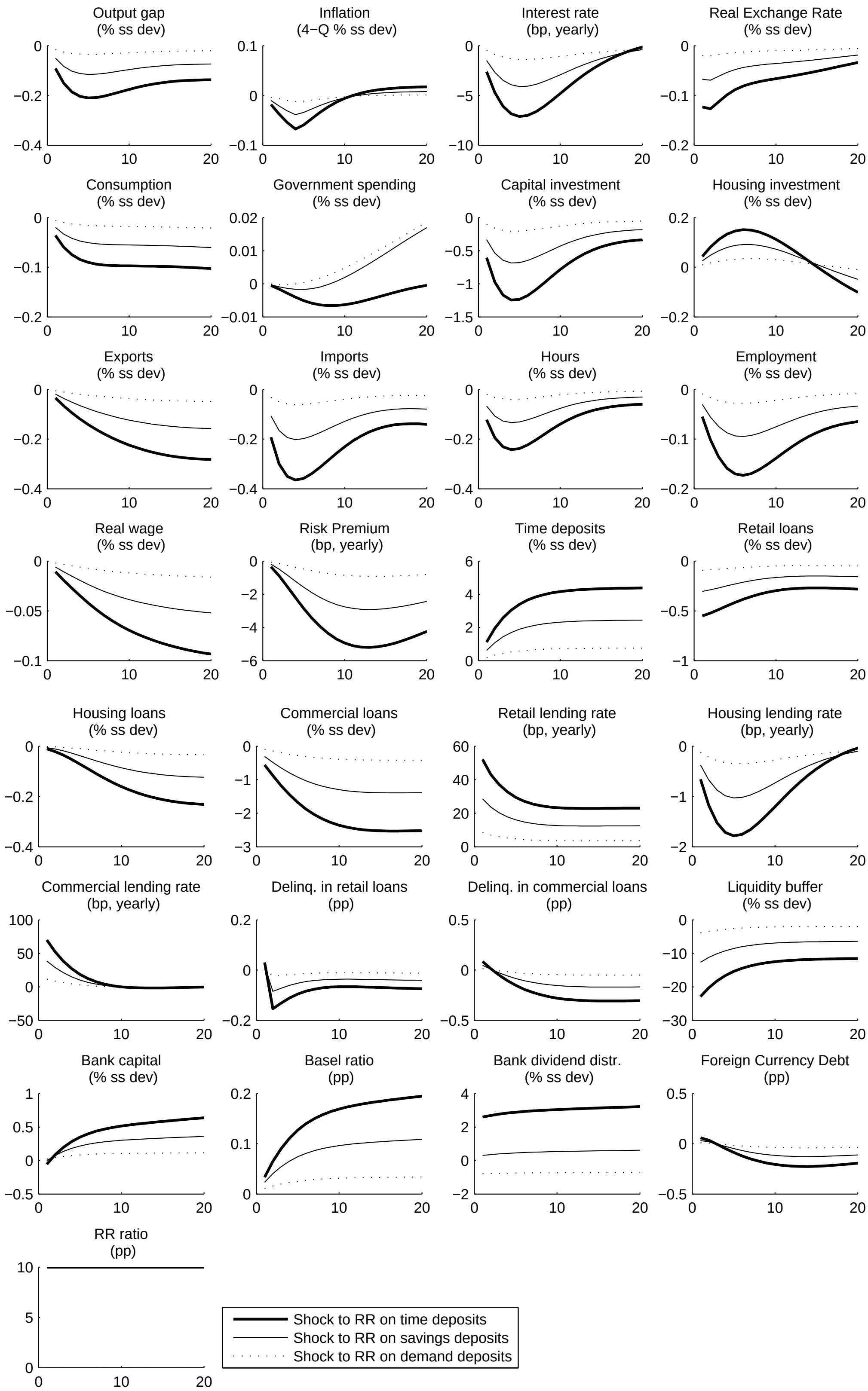

Figure 12: 10 p.p. Shock to Reserve Requirement Ratios

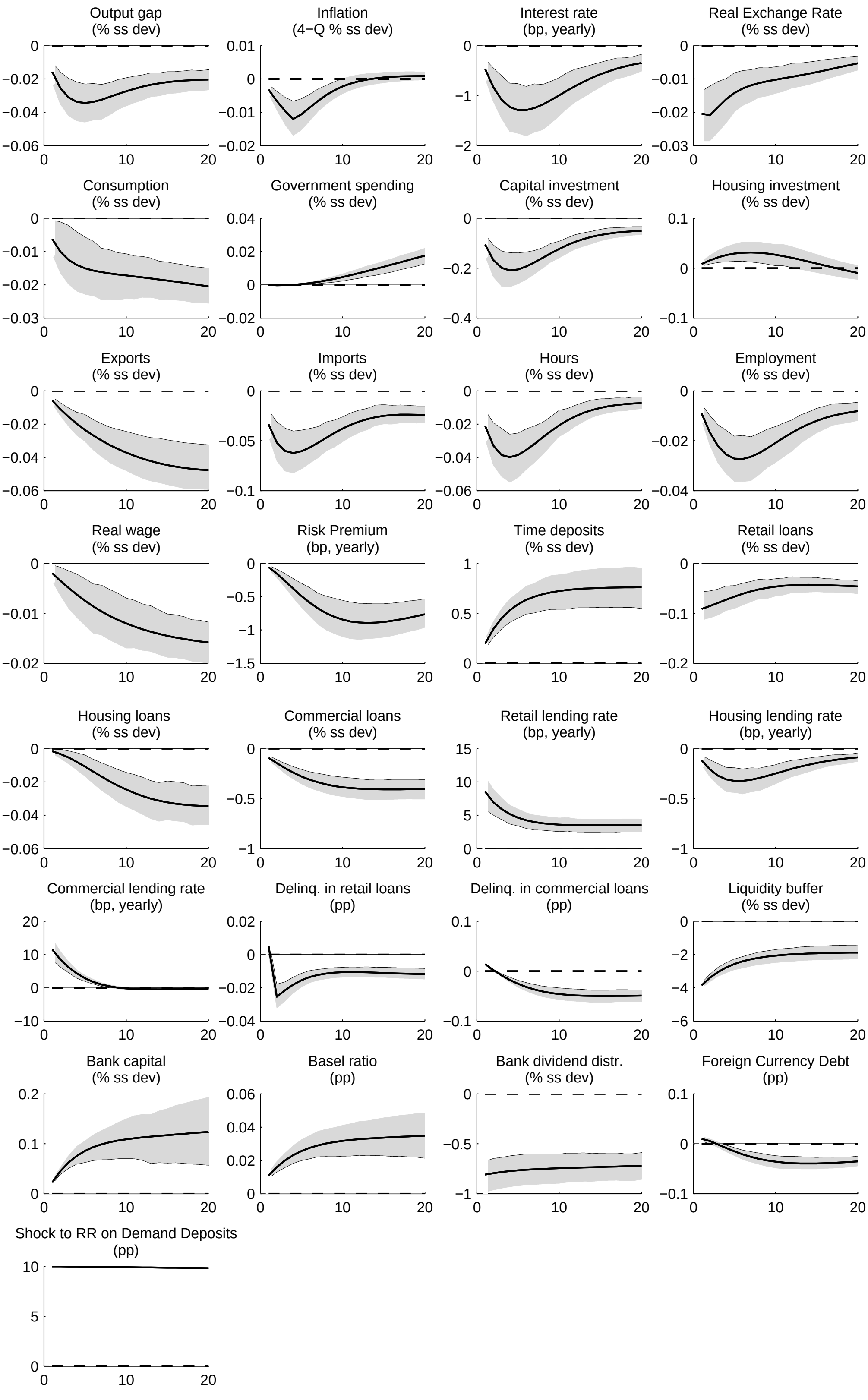

Figure 13: Shock to Reserve Requirement Ratio on Demand Deposits

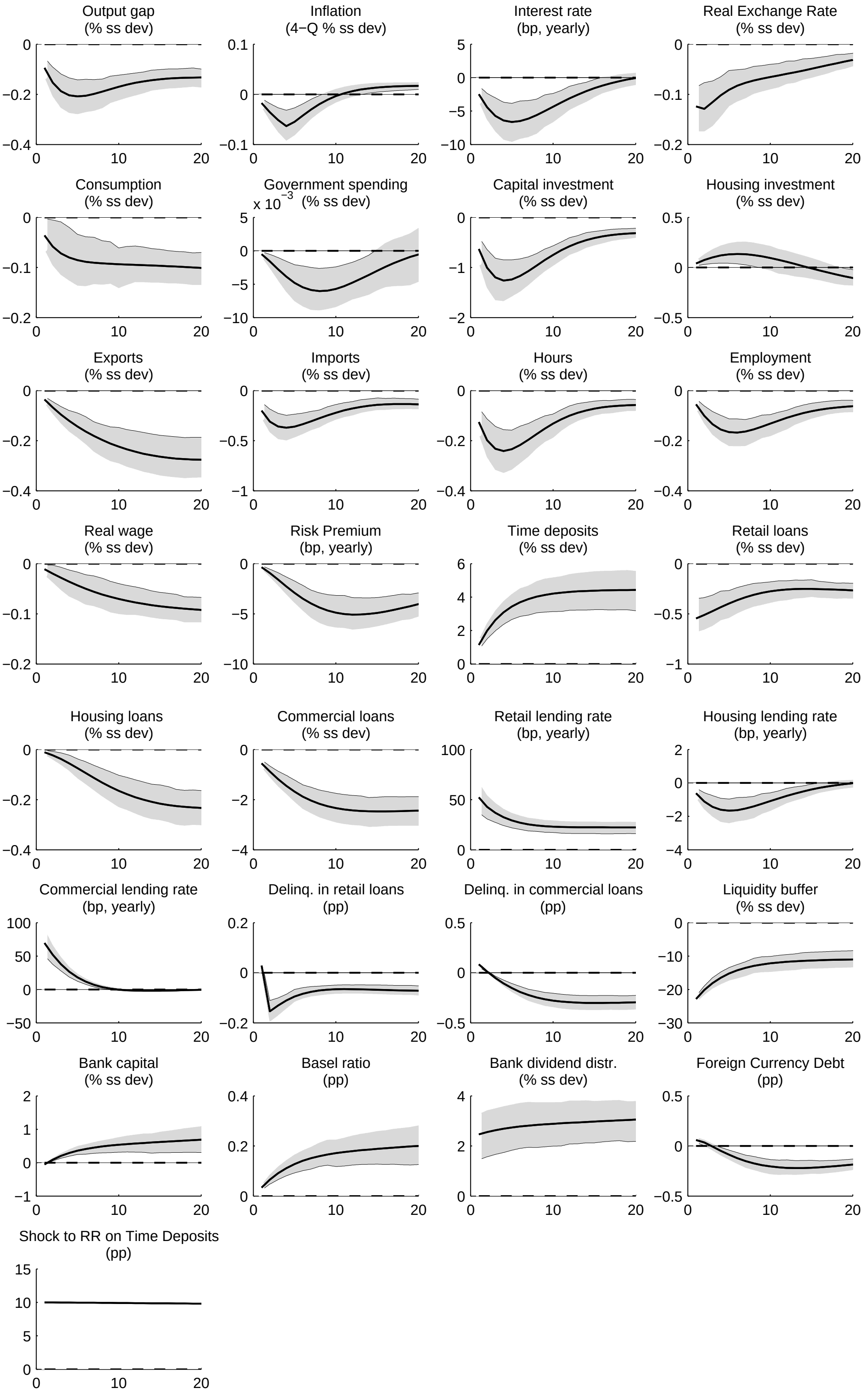

Figure 14: Shock to Reserve Requirement Ratio on Time Deposits

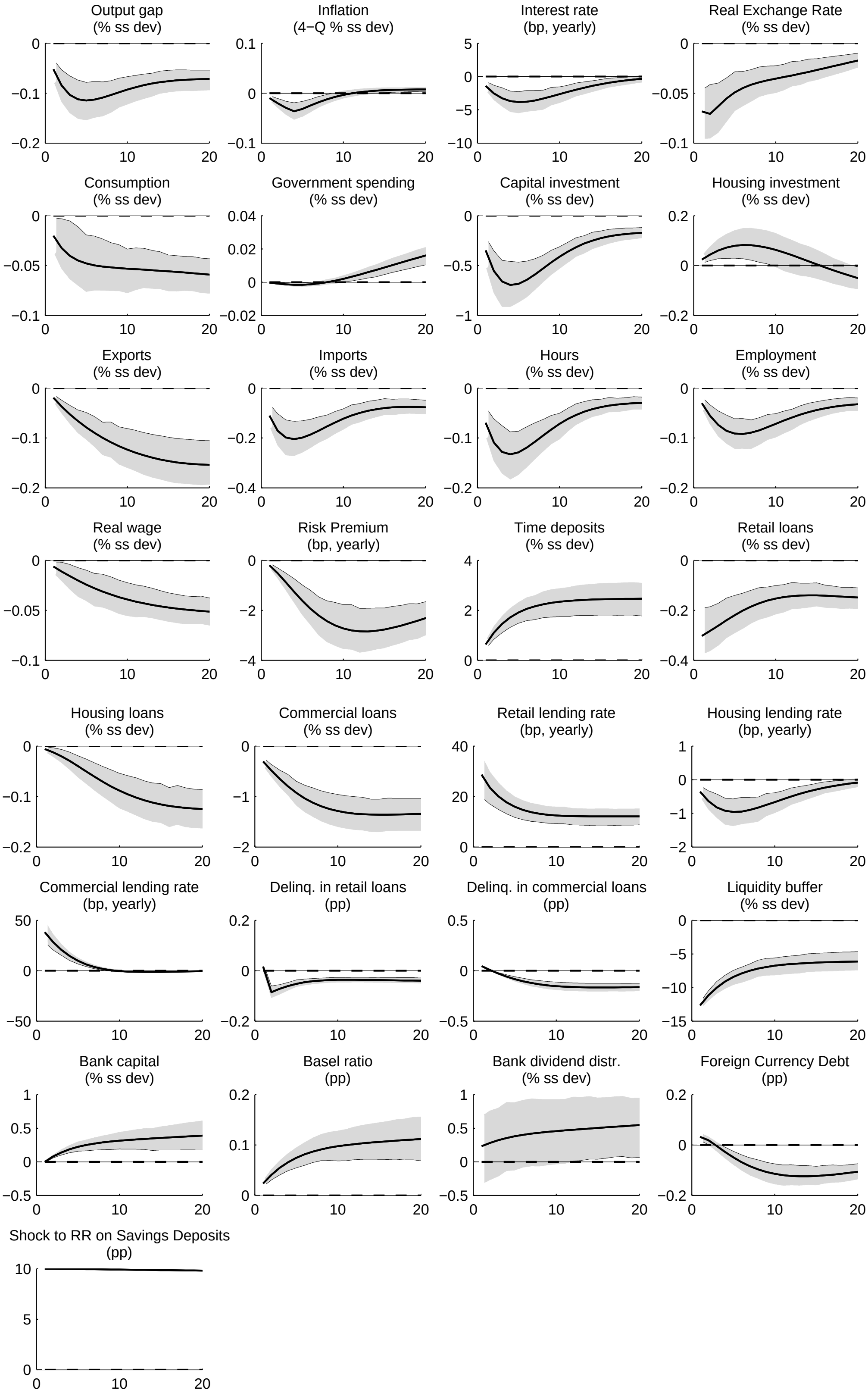

Figure 15: Shock to Reserve Requirement Ratio on Savings Deposits

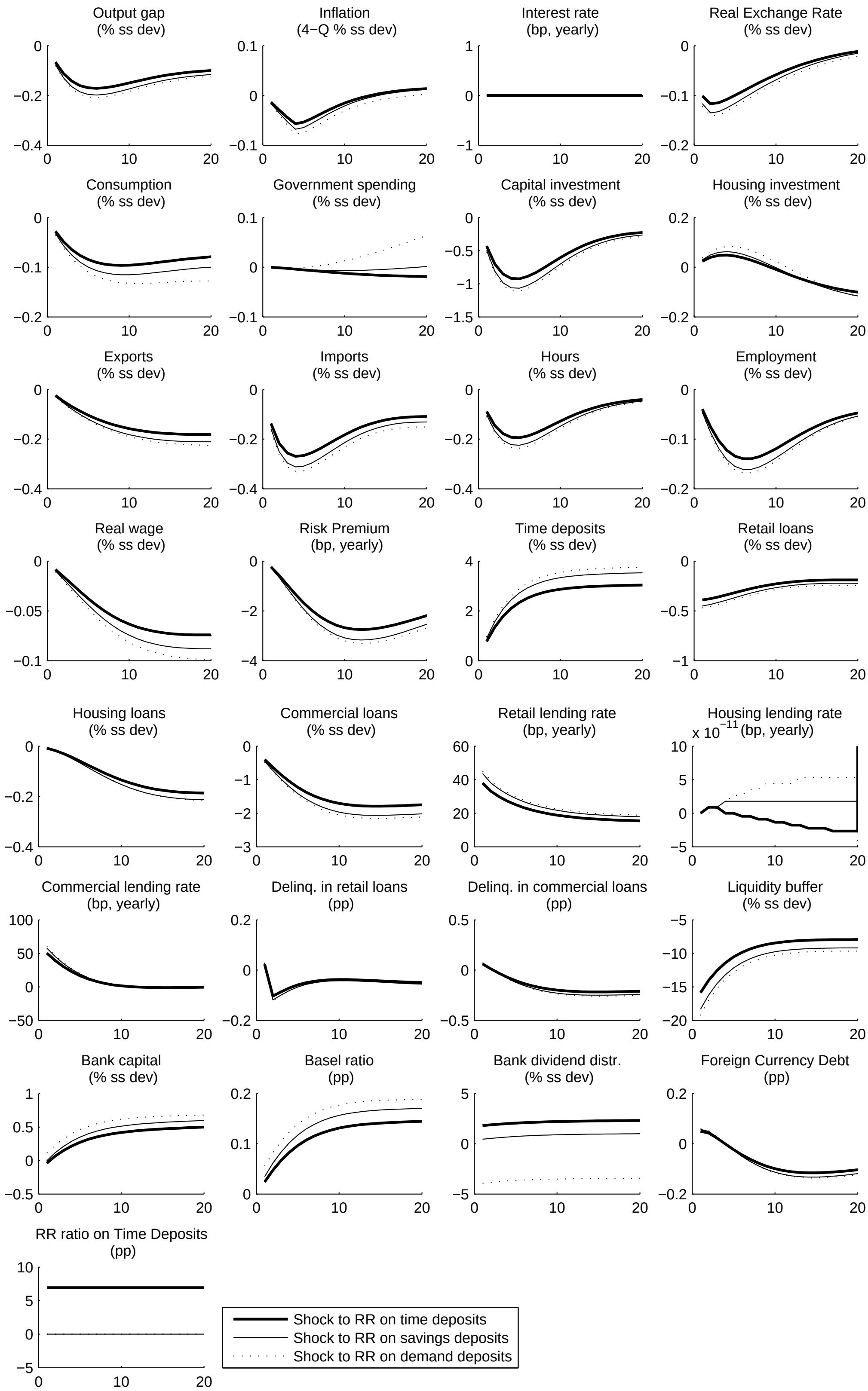

Figure 16: Comparing same scale shocks to Reserve Requirement Ratios

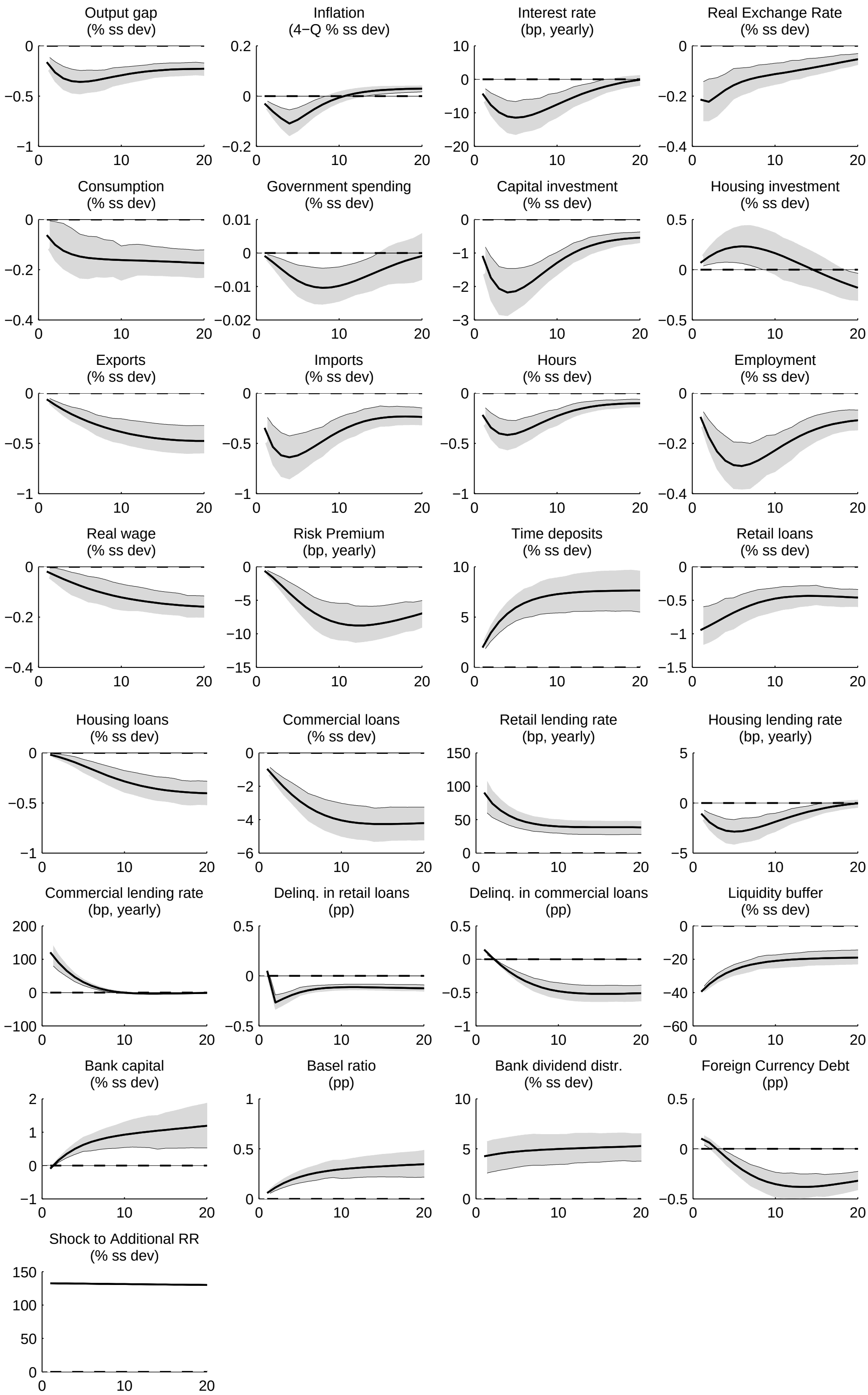

Figure 17: Shock to Additional Requirement Ratio

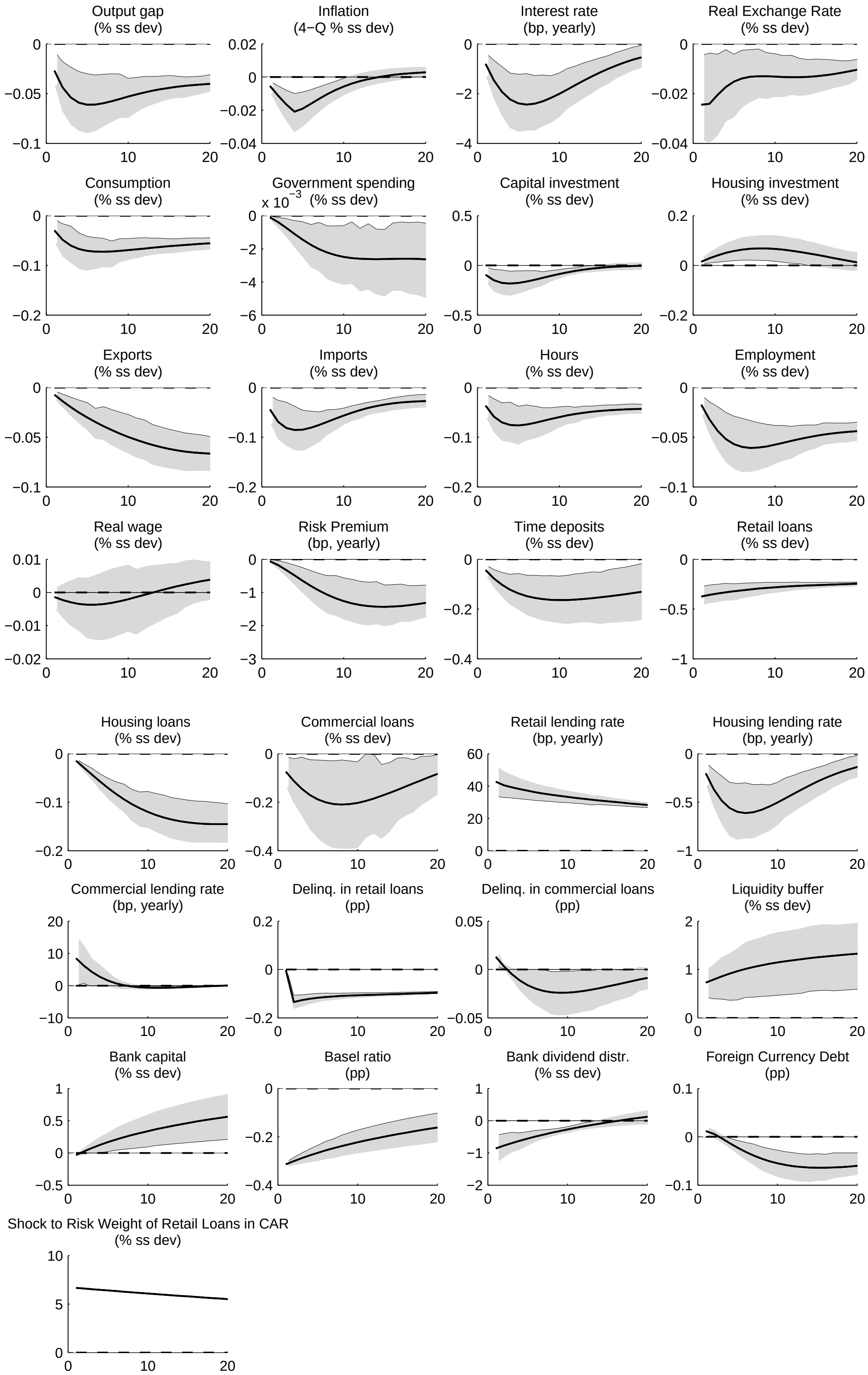

Figure 18: Sectoral Risk Weight Shock to Retail Credit

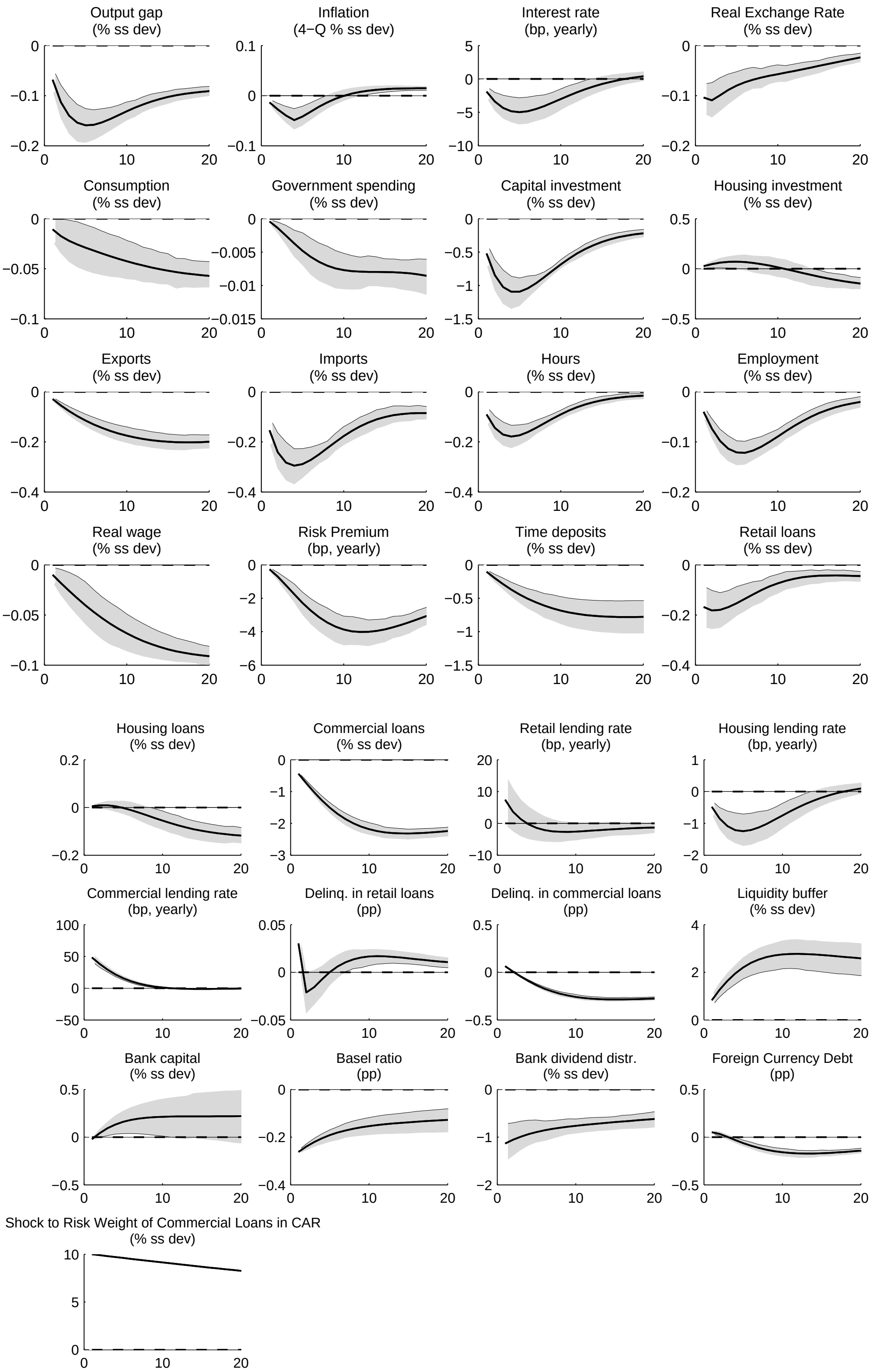

Figure 19: Sectoral Risk Weight Shock to Commercial Credit

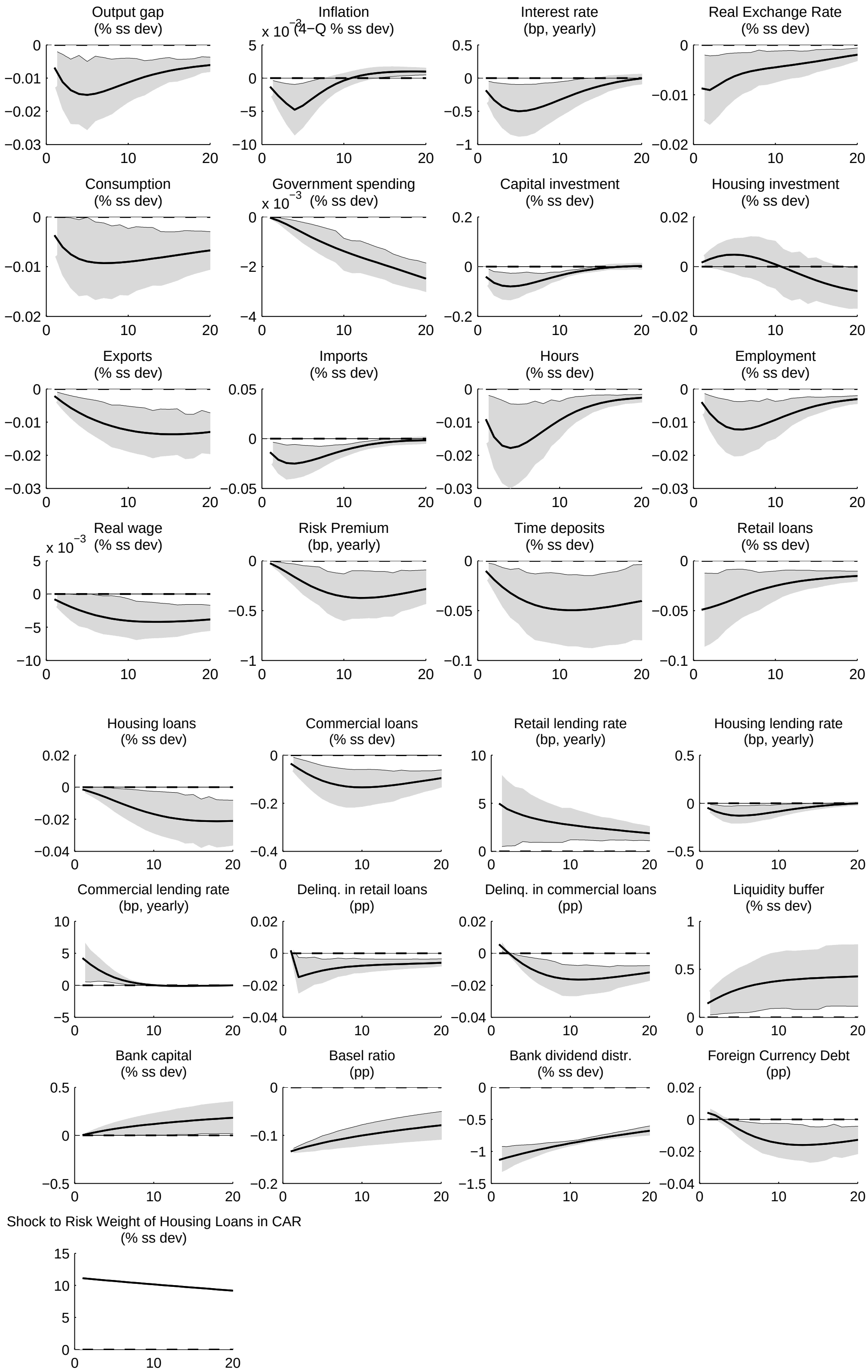

Figure 20: Sectoral Risk Weight Shock to Housing Credit

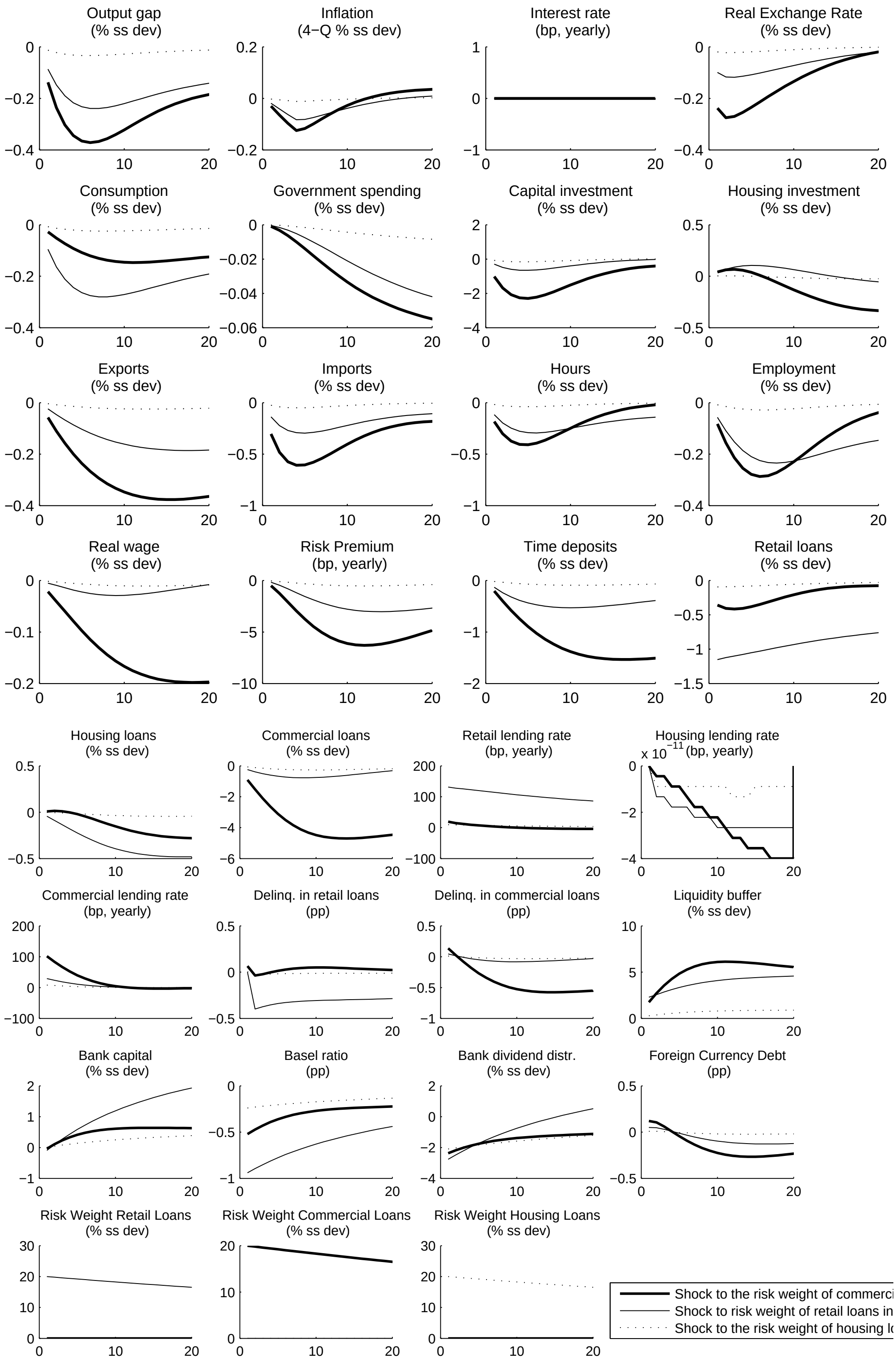

Figure 21: Shock to Risk Weights of Bank Assets in CAR

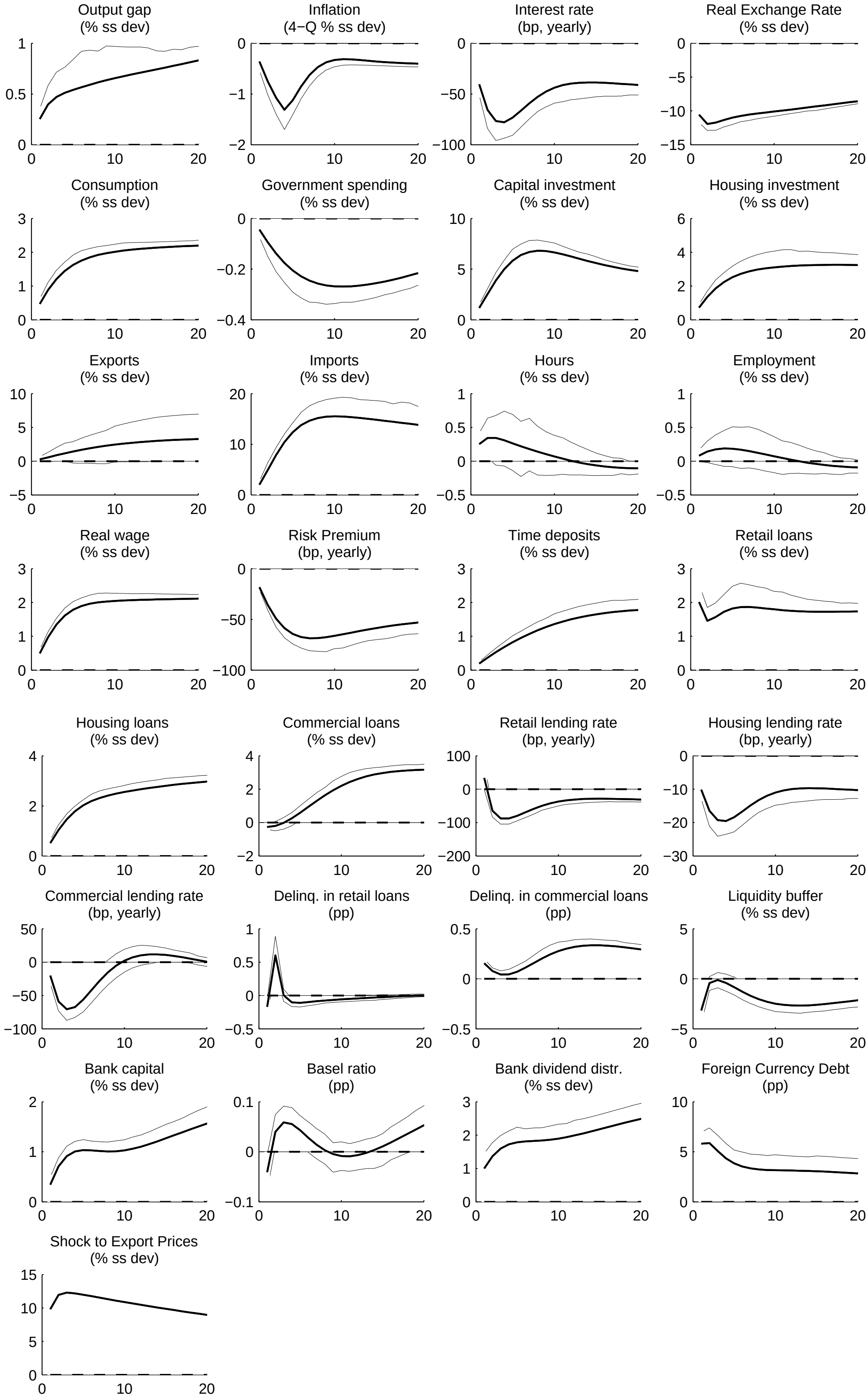

Figure 22: Shock to Export Prices

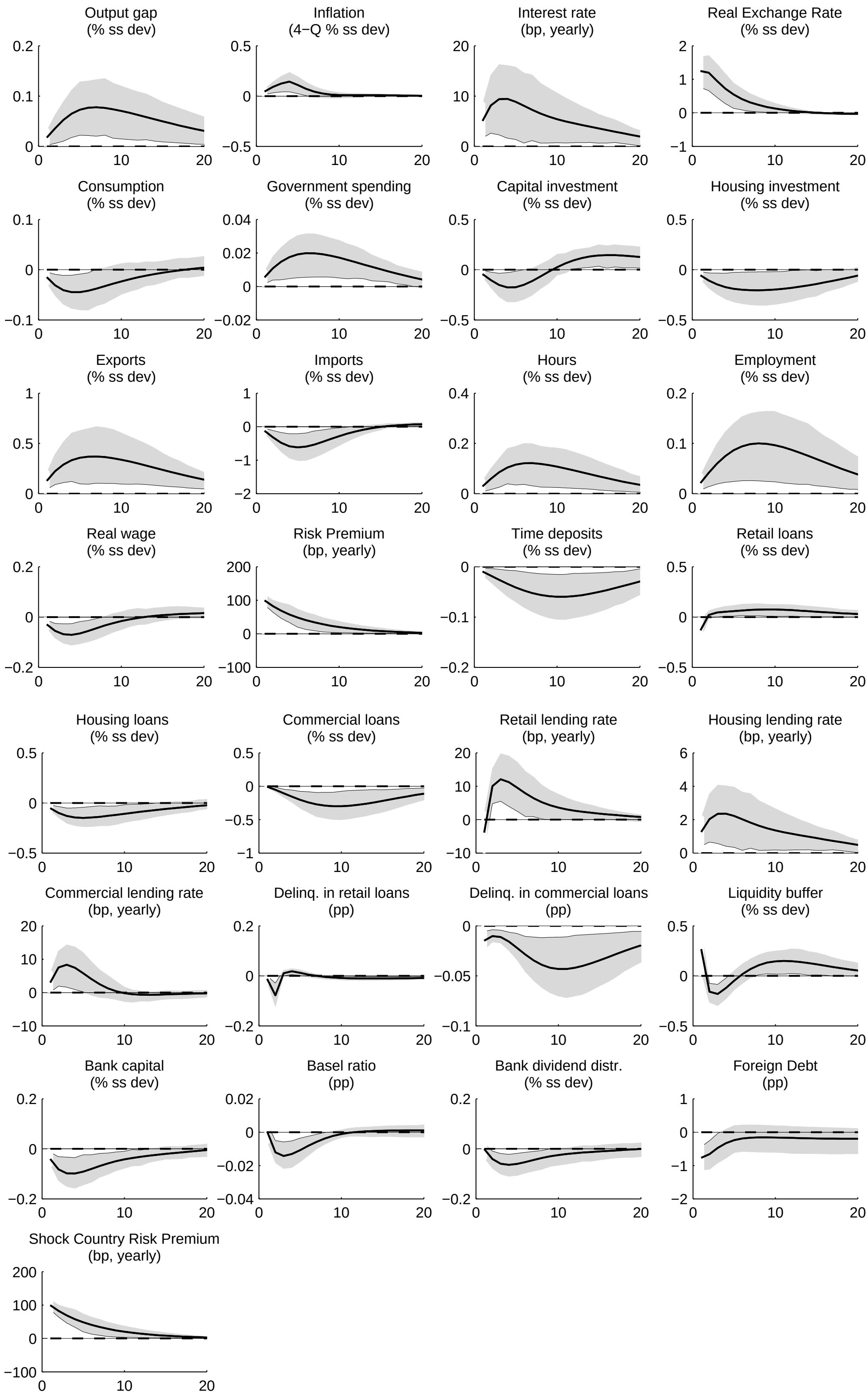

Figure 23: Shock to Country Risk Premium

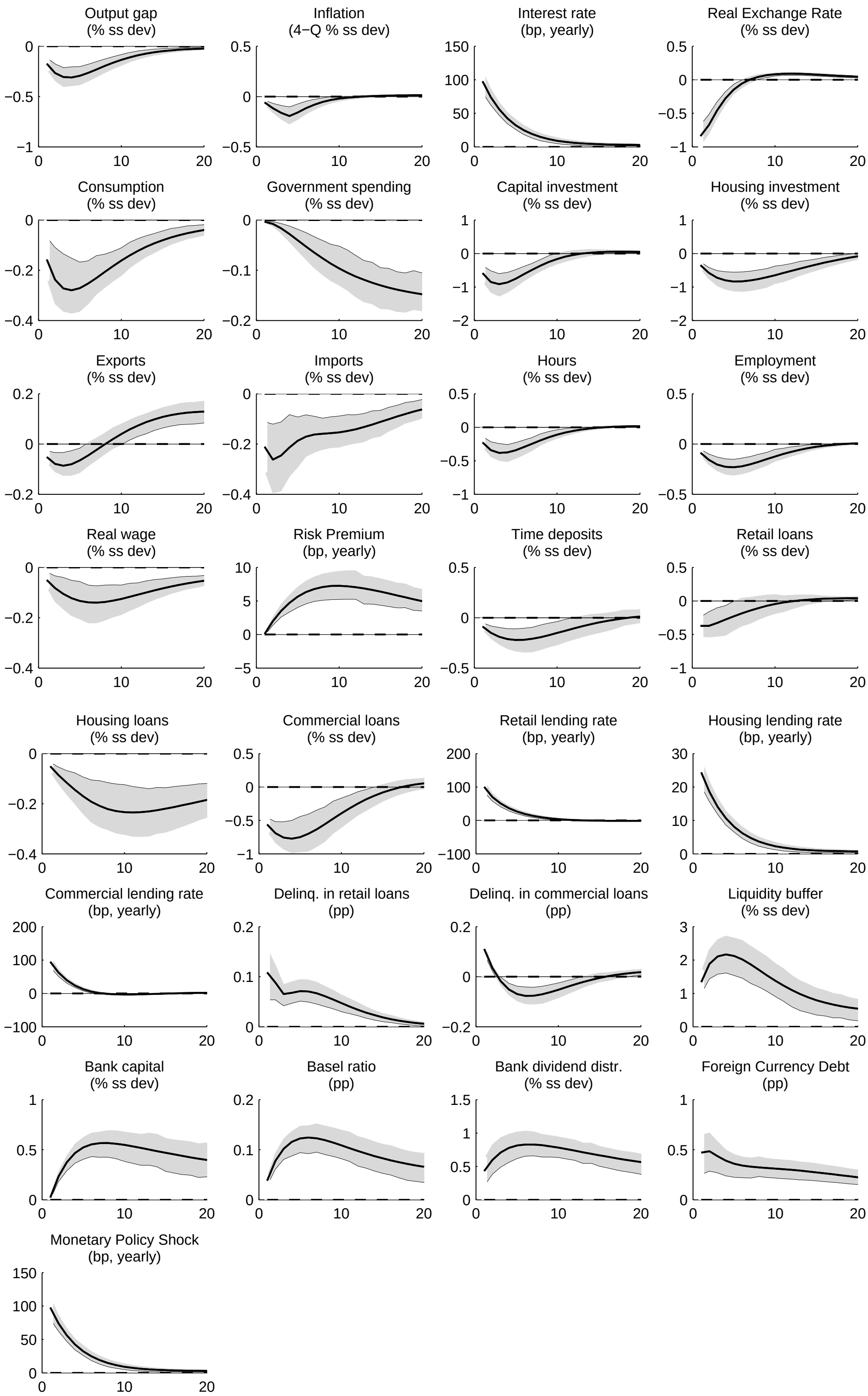

Figure 24: Monetary Policy Shock

14 Capital Requirement exercises

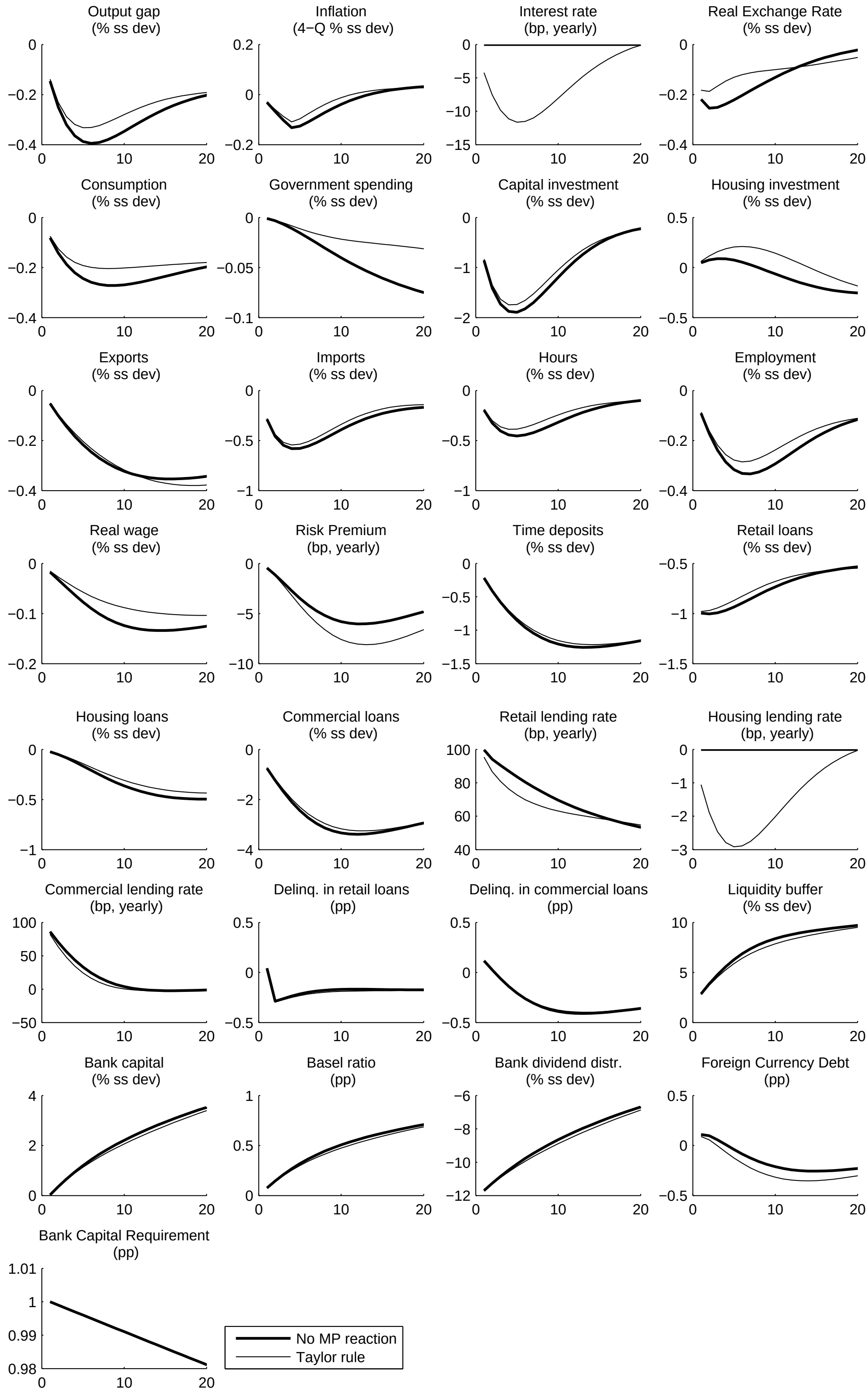

Figure 25: The role of Monetary Policy behavior on the transmission mechanisms of a Capital Requirement Shock

15 Comparative Effects of Policy Instruments

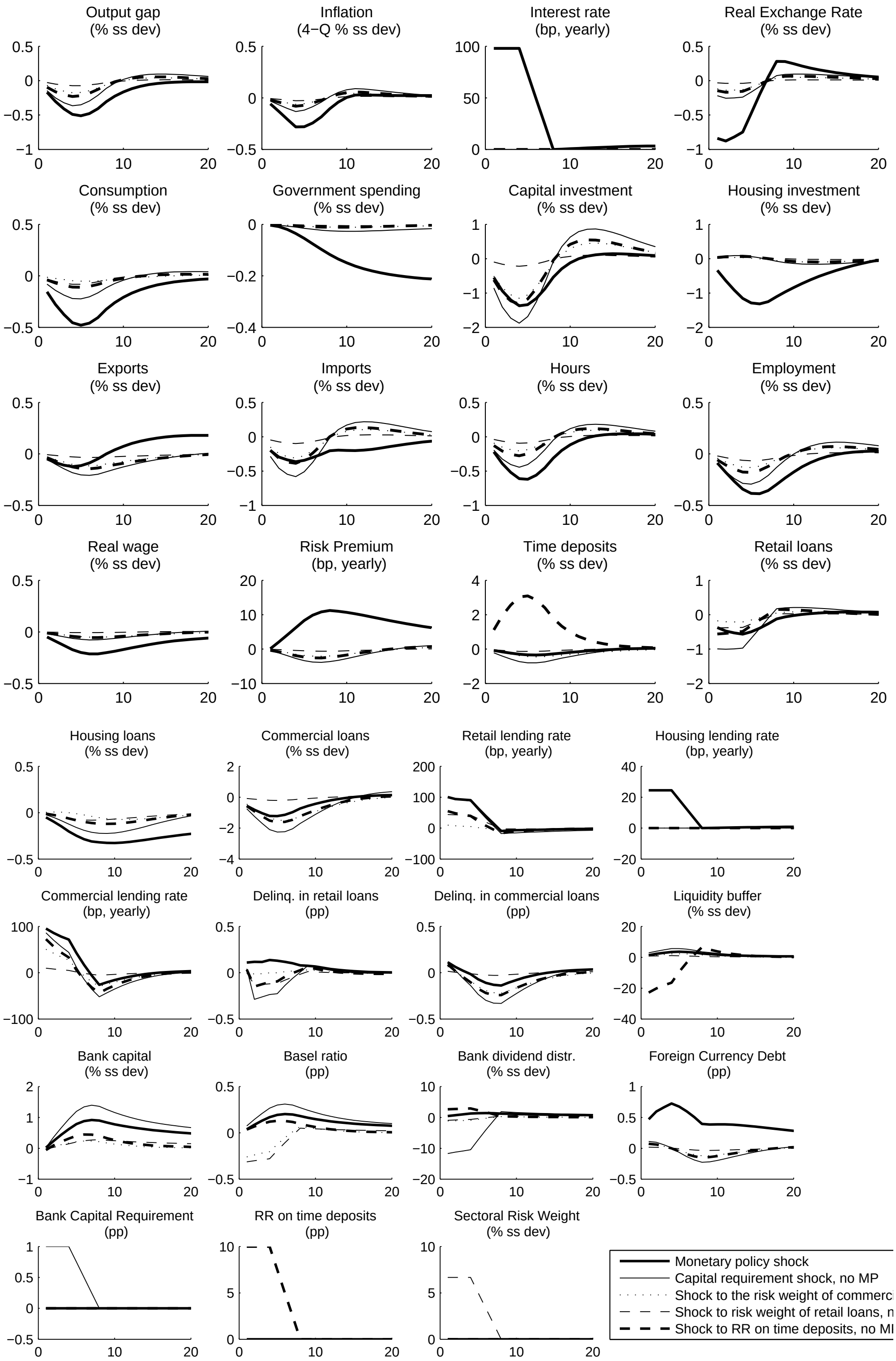

Figure 26: Comparative Effects of Policy Instruments

16 External Shocks and Foreign Currency Flows

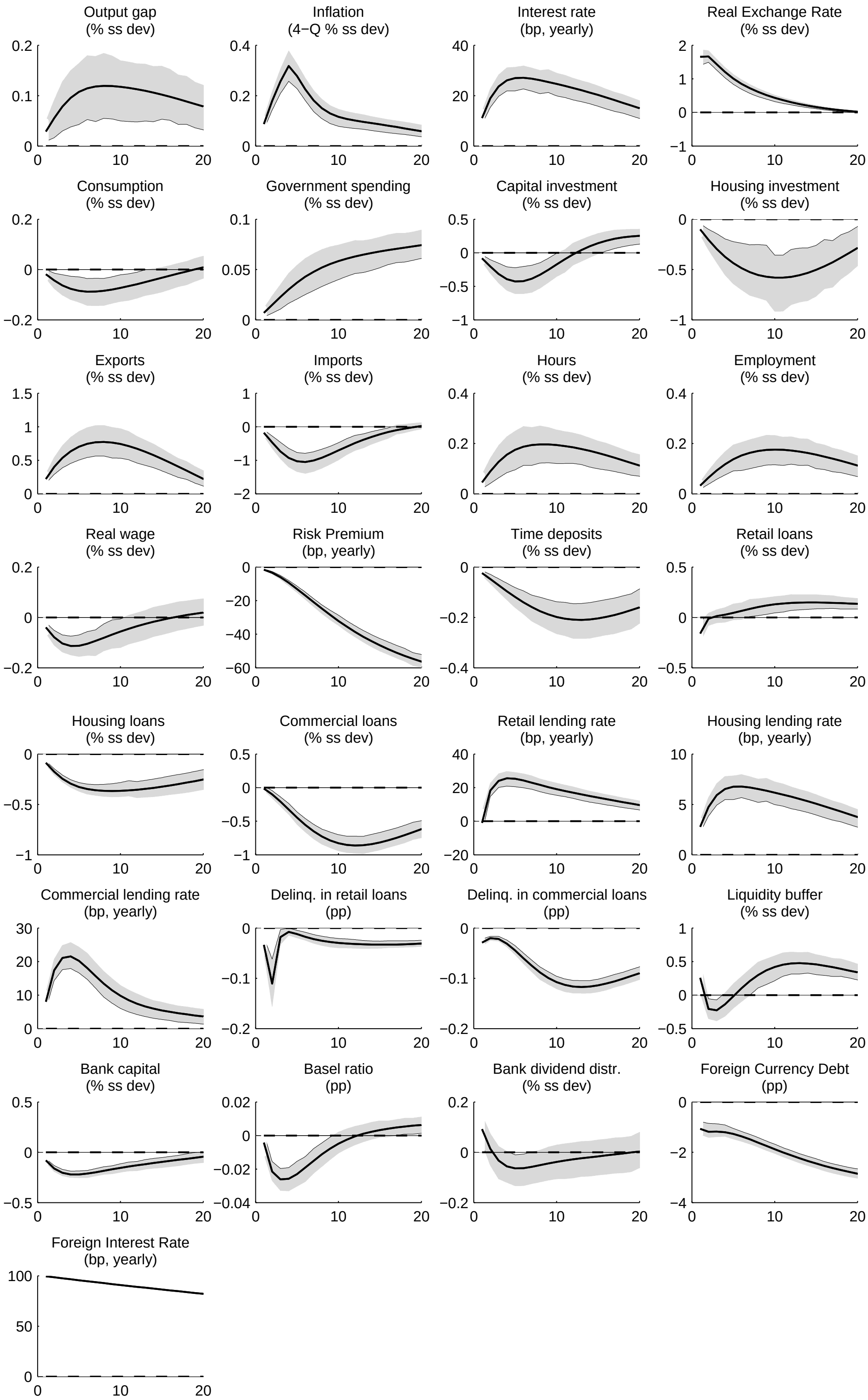

Figure 27: Foreign Interest Rate Shock

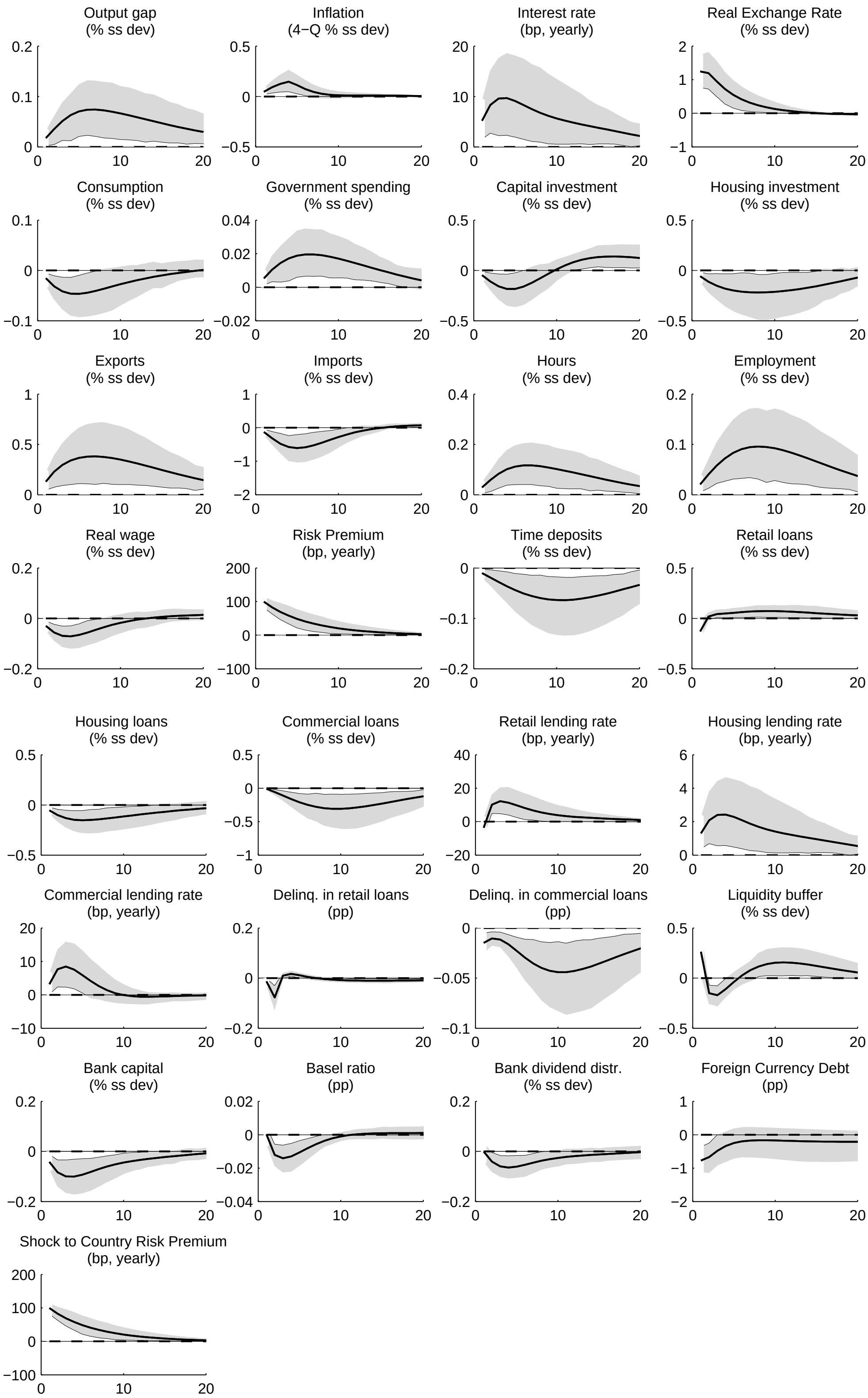

Figure 28: Country Risk Premium Shock

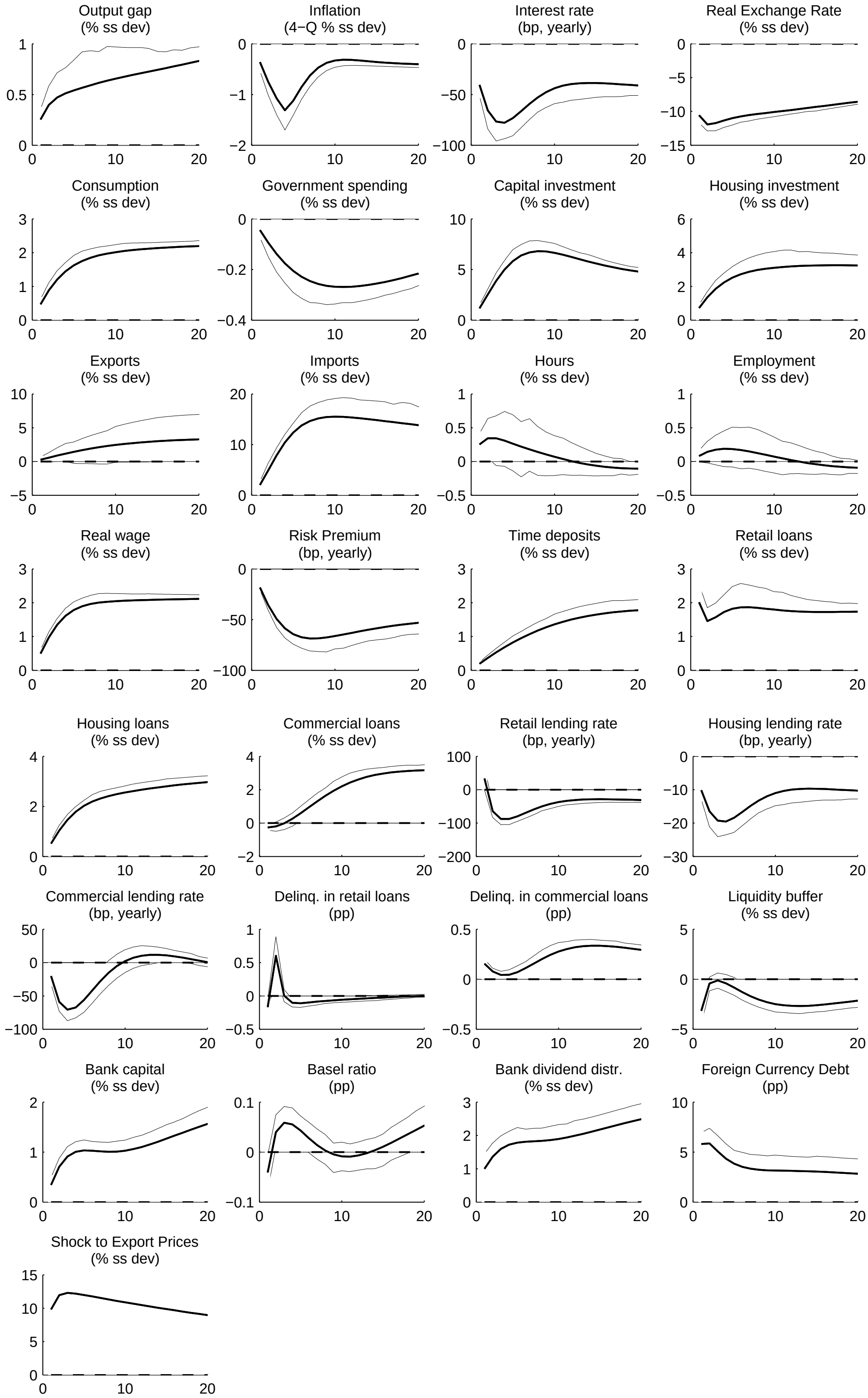

Figure 29: Exports Price Shock

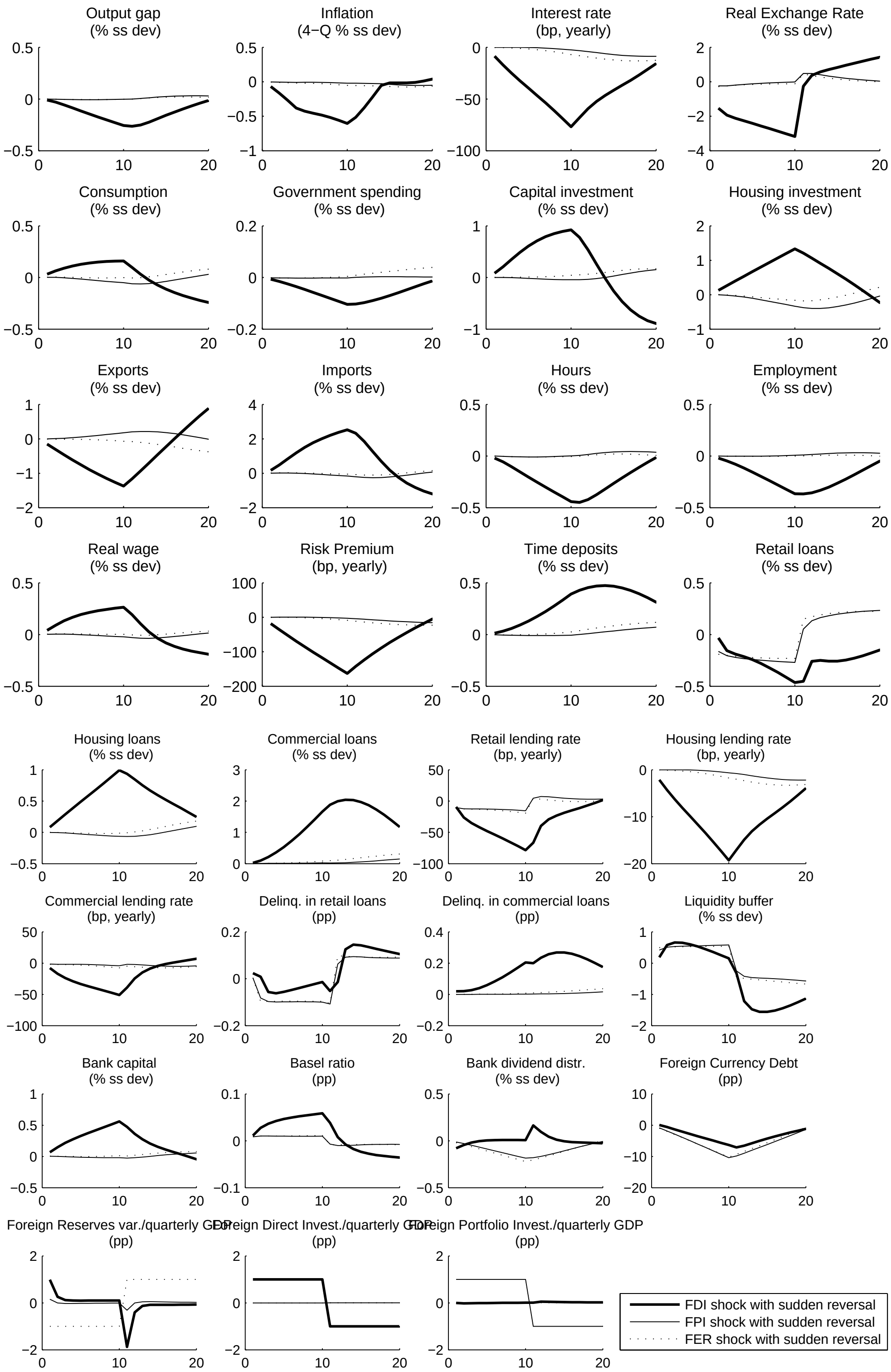

Figure 30: Comparative Effects of Foreign Currency Flows

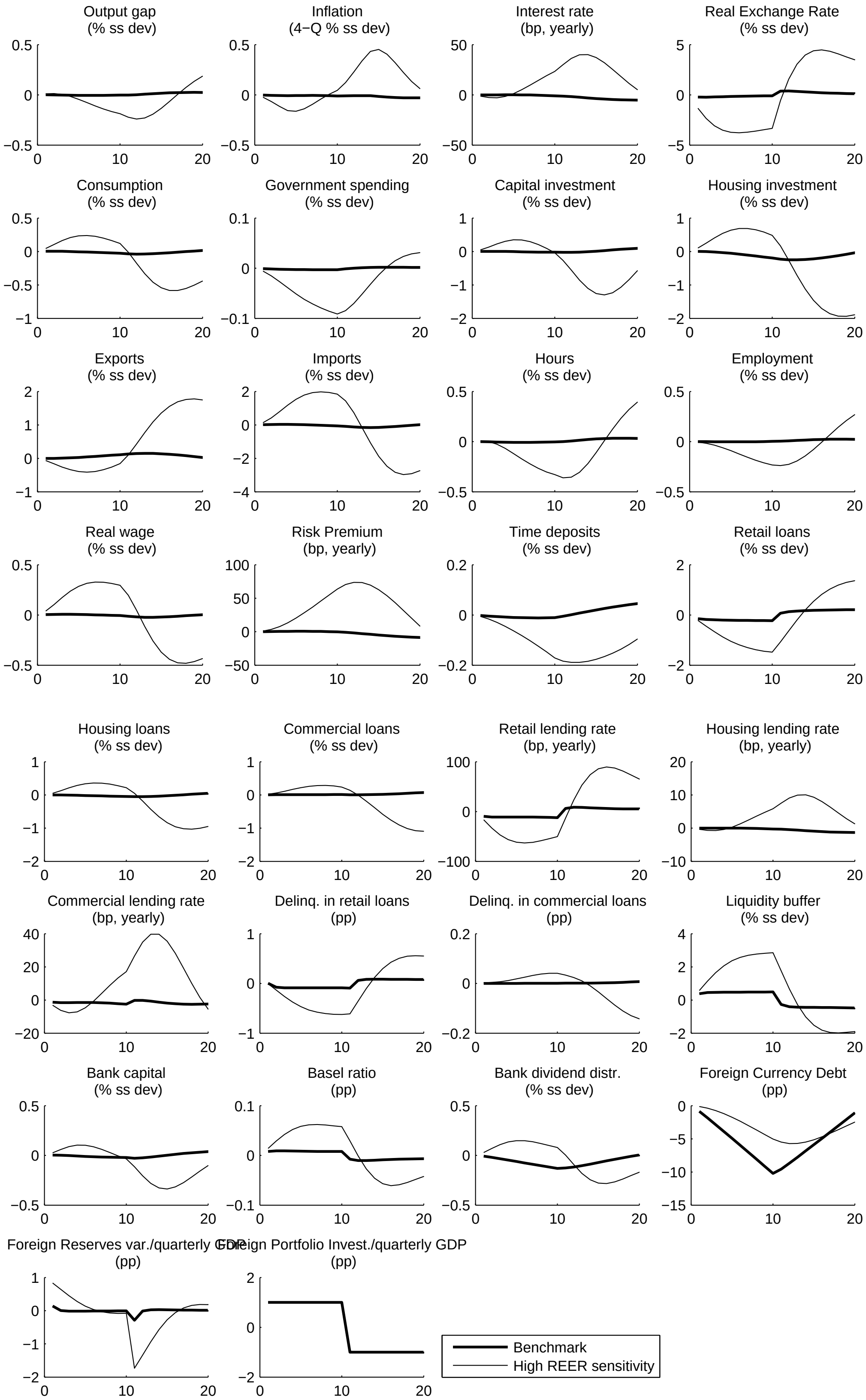

Figure 31: Counterfactual Exercise: FPI in a model with larger sensitivity of exchange rate to external financial flows

17 Countercyclical Capital Buffer exercises

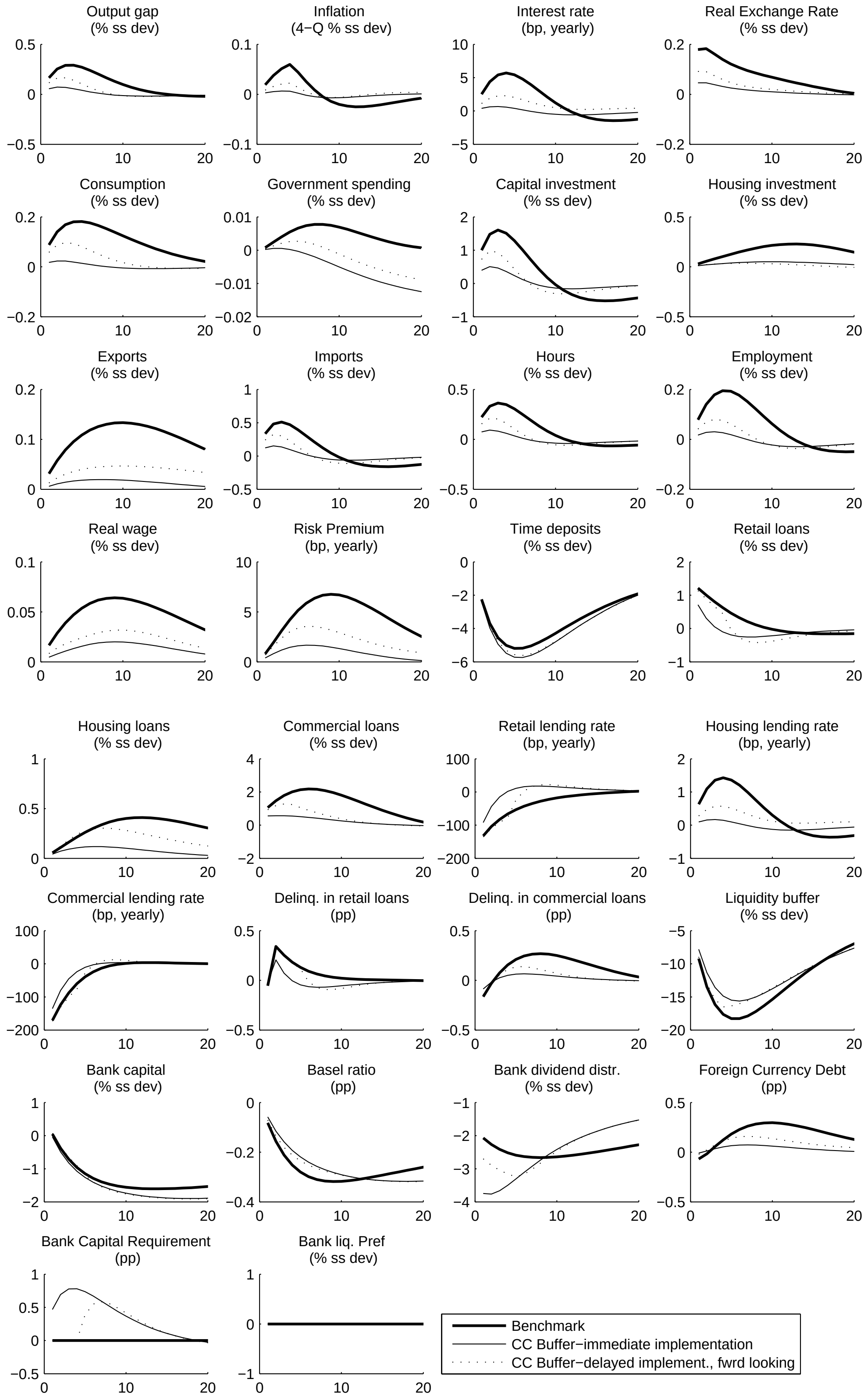

Figure 32: Bank Liq. Preference Shock and the Countercyclical Capital Buffer

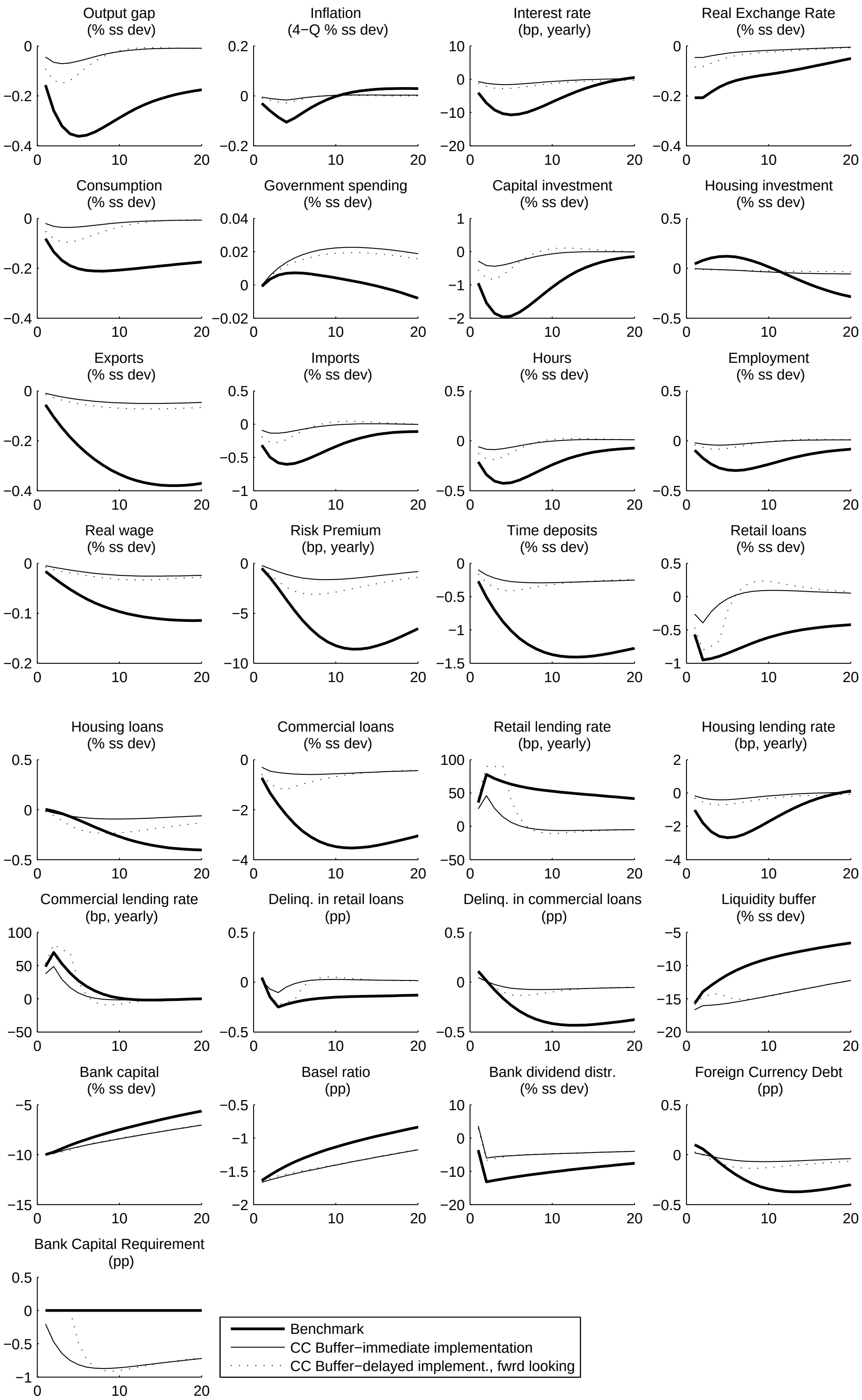

Figure 33: Bank Capital Shock and the Countercyclical Capital Buffer

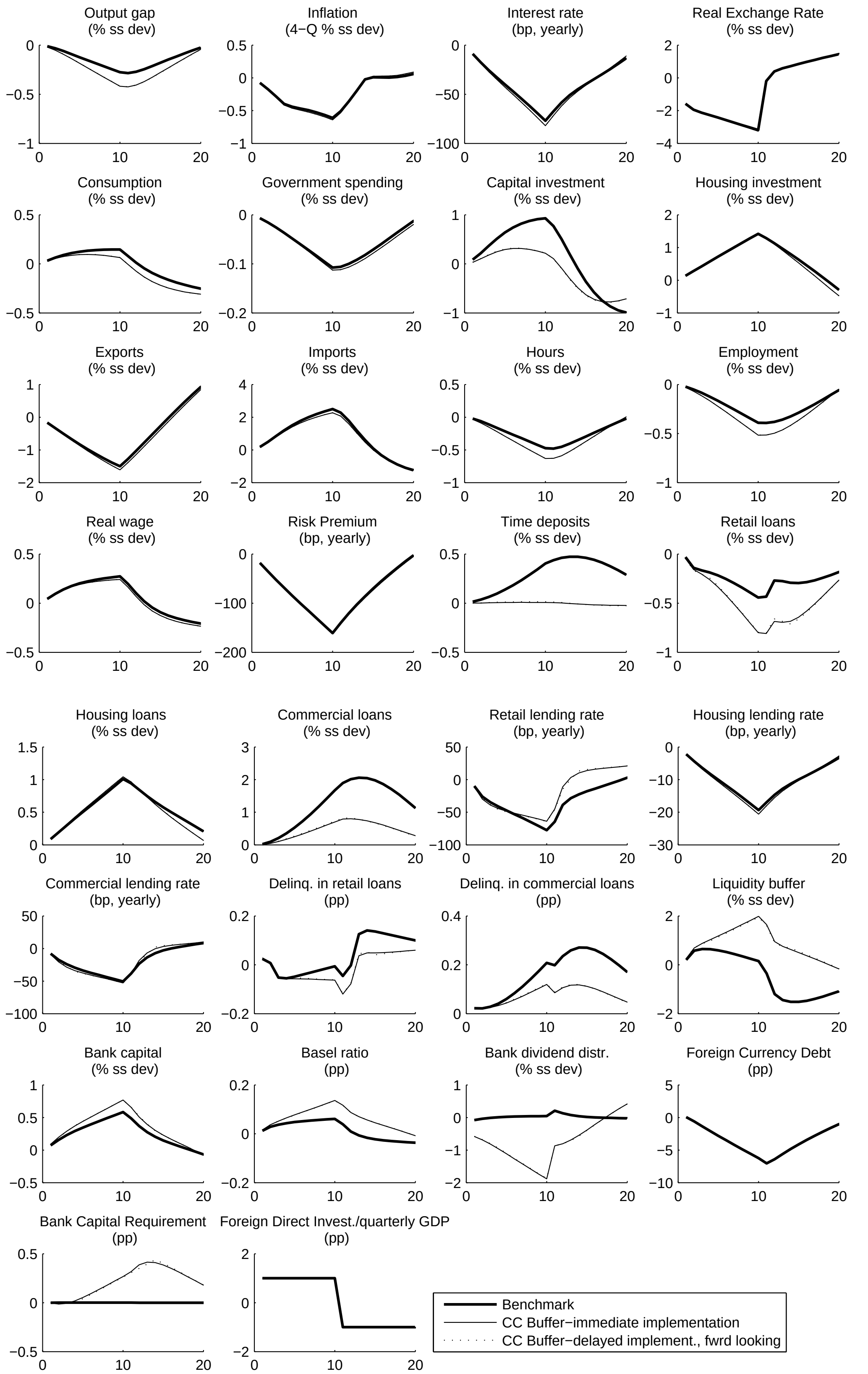

Figure 34: Foreign Direct Investment and the Countercyclical Capital Buffer

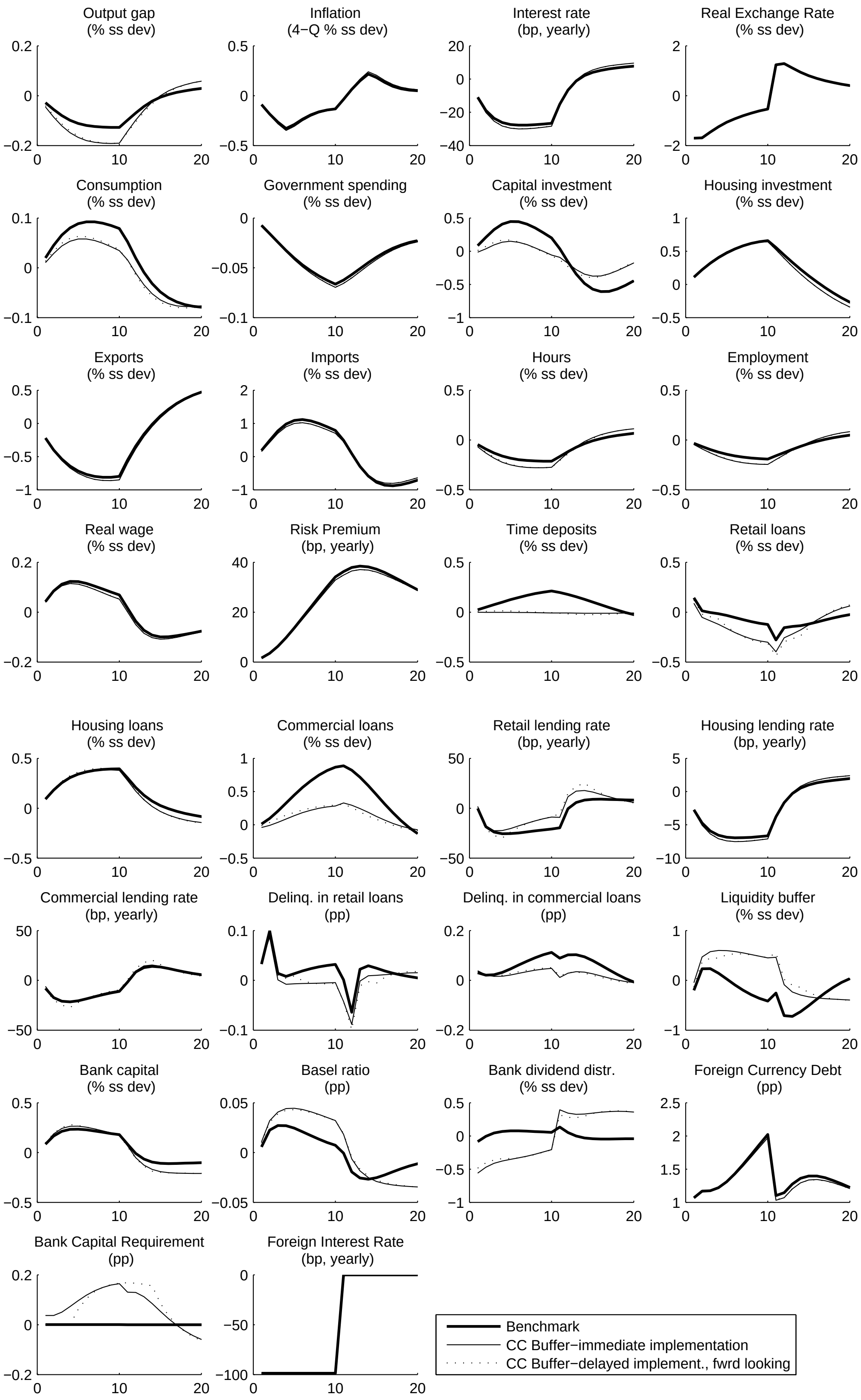

Figure 35: Foreign Interest Rate Shock and the Countercyclical Capital Buffer