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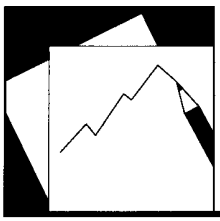

IMF Working Paper

Modeling with Macro-Financial Linkages: Credit and Policy Shocks in Emerging Markets

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Modeling with Macro-Financial Linkages: Credit and Policy Shocks in Emerging Markets

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Abstract

This paper develops a stylized, small, open economy macro model that incorporates an explicit and non-trivial role for financial intermediation. It illustrates how such a model could be used for policy analysis in an emerging market economy where policymakers are concerned about risks associated with rapid credit growth, financial dollarization, and foreign borrowing, while lacking traditional tools to effect monetary policy transmission, and hence could resort to more direct instruments, such as foreign exchange market intervention and regulatory and administrative measures. Calibrating the model to a stylized emerging European economy, the paper simulates real and financial sector implications of various external and policy-related shocks that could be used as input for monetary policy making.

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I. INTRODUCTION AND MOTIVATION

1. Central banks need a consistent framework to anchor policy decisions to address shocks to the economy that raise macro-prudential concerns, in some cases with dramatic discontinuities and adjustments. A model-based forecasting and policy analysis system (FPAS) provides such a framework, but its role is often underestimated in a country with no independent interest rate policy. While tailor made FPASs have become cornerstones of decision making in inflation targeting regimes,[2] their role in formulating policy has been questioned in highly dollarized economies with tightly managed exchange rates. Where room for interest rate policy is limited, policymakers often rely on administrative/direct monetary tools when addressing policy concerns, such as rapid credit growth or a buildup of external debt.[3] Such tools often have complex and distortionary effects on private sector activity, and their effects may change as the private sector seeks to get around the measures. Policymakers need a reliable system to assess the tools that may have potentially important implications.

2. Arguably, active monetary policies implemented through direct instruments increase the need to anchor decision making on the basis of a systematic model. In fact, where country authorities consider administrative measures with the hope to achieve a desirable outcome in terms of a multi-faceted objective function, policy-setting process benefits from a better understanding of the transmission of macro and financial shocks to the economy and possible trade-offs. Although there may be better alternative regimes and measures to bring first order effects or achieve tangible objectives in the longer-term, it is still preferable for policymakers to take these decisions on the basis of a structured and comprehensive discussion.

3. This paper provides a practical guide for establishing and using such a model-based policy analysis framework in an economy where financial sector issues play an important role, while policymakers typically lack traditional policy tools to influence the economy. Such a system could be designed as a general tool to describe the main channels and workings of the economy; help better understand the transmission of macro and financial shocks to the economy and possible trade-offs; and help formalize policymaking, by providing a practical toolkit to analyze the implications of monetary policy measures in a more systematic and internally consistent framework. Although there is growing emphasis on understanding the linkages between the real and financial sectors from a policymaking point of view, there are very few central banks that have a policy analysis framework with a financial sector incorporated in it. Any such existing FPASs are for developed economies (e.g., Canada, United Kingdom), and not for emerging economies with specific features.[4]

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[2] In IT regimes, where the main instrument is the key policy interest rate, the FPAS plays a pivotal role, since medium-term forecasts serve as the intermediate target—the main vehicle for shaping inflation expectations.

[3] Šošic and Kraft (2006), for example, discusses the challenges policy-makers face in highly dollarized financial systems, the measures they can take, and theory-based justification for their concerns.

[4] More recently, such models with an explicit financial sector are being built in a number of emerging market country central banks (e.g., in Bulgaria and Croatia) along the lines of the model described in this paper, with a view to using them as input in formal monetary policy decision making process.

4. The kind of environment the paper focuses on is characterized by (i) a high degree of openness; (ii) high levels of financial dollarization that limit the scope for traditional monetary policy transmission; and (iii) a dominant role for banks to intermediate foreign or domestic financial flows in the form of loans to households and corporates, while corporates can also borrow directly from abroad, in addition to loans from domestic banks.

5. In such an environment, policymakers are concerned about a number of risks. Typical examples of such risks are: persistent current account deficits and fast accumulation of private and banking sector indebtedness, exposure of non-financial firms and households to currency mismatch and their implications for financial stability, and exposure to a sudden decline in the availability of funds to the economy. Since the traditional channels of monetary transmission through domestic interest rates are weak, policymakers rely more on direct instruments to address such risks (e.g., exchange rate management, various regulatory requirements, or limits on bank lending or borrowing). Policymakers' efforts to make banks internalize the risks and reduce the pace of their lending may increase the effective cost of funds sufficiently to prompt the private sector to switch to borrowing directly from abroad.

6. As a key component of such an FPAS, the paper develops below a stylized dynamic stochastic general equilibrium (DSGE) model of monetary policy transmission for an economy with the above characteristics. The model is based on a standard sticky-price business cycle framework, extended to include an explicit financial intermediation sector. The model also flexibly combines a variety of direct and indirect monetary policy tools. The real side of the model has three production sectors, utility-maximizing households consuming tradable and nontradable goods, and profit-maximizing firms producing domestic goods (produced and sold domestically), and exports (produced domestically and sold abroad).

7. The financial sector is the most distinct feature of the model. It is built around the following four building blocks: (i) an important role for financial intermediation, as opposed to just "internal financing;" (ii) costly banking activities, with costs associated with producing loans and deposits; (iii) the existence of two imperfectly substitutable sources of intermediated funds for firms: domestic bank loans and funds borrowed directly from abroad; and (iv) full financial dollarization.

8. Within this framework, domestic banks collect deposits from households; extend loans to households and non-bank financial intermediaries; maintain required reserves with the monetary authority; and clear the net surplus or deficit of funds with the world financial market. Producing bank loans and deposits is costly, giving rise to time-varying lending and deposit spreads, and thereby an external finance premia, all of which responding to the economy's conditions. Non-bank intermediaries combine bank loans and funds obtained directly from abroad (with the proportion of each component depending on their relative interest costs), and extend this bundle of funds to domestic firms. The monetary authority uses two types of instruments to control the economy over the business cycle: a variety of reserve requirements or other direct controls imposed on domestic banks and foreign exchange interventions to manage the nominal exchange rate.

9. The model is then used to analyze the linkages between the real and financial sectors of the model economy and how various policy measures and shocks affect the key economic

and financial aggregates. The explicit modeling of financial intermediation makes it possible to analyze the main financial-real sector links within a conceptual framework and to capture important financial sector issues that have been affecting the countries in emerging Europe. The shocks analyzed include, in particular, policymakers' efforts to slow rapid growth of bank lending and borrowing, and domestic credit crunch associated with the spillover effects of the ongoing global financial crisis.

10. The rest of the paper is organized as follows. Section II provides an overview of the model. Section III explains how to parameterize the model to match certain properties of a stylized emerging market economy. Section IV conducts various experiments and analyzes the transmission and implications of externally induced credit crunch, as well of policy-induced credit supply shocks (as a result, e.g., of changes in direct monetary policy instruments). Section V concludes.

II. The Model with Financial Intermediation and Frictions

11. This section summarizes the basic structure of the model and its agents and markets, describes some of its most important microeconomic foundations, including the objective functions and constraints of individual agents, and clarifies some of the modeling choices made when designing the analytical forms of these functions.

A. The Basic Structure of the Model

12. The model extends a standard sticky-price business cycle framework to include a financial sector and a policy environment characteristic of many emerging market economies in the Central, Eastern, and Southeastern Europe. The structure of the real side of the economy is similar to the DSGE model developed for inflation targeting regimes in Beneš, Castello-Branco, and Vávra (2007). The financial sector block is built drawing mainly on Edwards and Vegh (1997).

13. On the real side, the model includes households and two production sectors: domestic goods and exports. Domestic firms use imports, a (fixed) stock of capital, and labor in producing the domestic goods, differentiate them costlessly and sell them to households as consumption. Domestic firms are monopolistically competitive with each firm having a certain degree of control over its own prices. This allows us to introduce price stickiness and, hence, interactions between real and nominal variables in the medium term. Domestic firms use loans to cover their expenditures and hold deposits in proportion to the required loans. Exports are an exogenous endowment, and are not demanded domestically. Moreover, the terms of trade are exogenous to the country's exporting industries, suggesting that they are sufficiently small not to have any power over their own price.

14. Households consume domestic goods and supply differentiated labor to production. The labor differentiation is costless and individual household labor types are monopolistically competitive in supplying labor, allowing them to have a degree of control over the wage setting process. Households borrow to finance their consumption and hold deposits in proportion to loans. They also own and internally finance all domestic firms (or receive dividends, for that matter), including financial sector firms, and the central bank.

15. The fully dollarized financial sector has two types of institutions: banks and non-bank financial intermediaries.[5] The existence of non-bank financial intermediaries is a novel feature of the model, and helps in dealing with the existence of two sources of intermediated funds (i.e., bank loans and direct foreign borrowing) in a tractable way. The roles of banks and non-bank intermediaries are specified as the following:

- Banks collect deposits from households and firms, and extend loans to households and non-bank intermediaries. Banks incur real costs in producing loans and deposits. Consequently, they face upward sloping marginal costs in the loan-to-deposit ratio, resulting in an upward (downward) sloping loan supply (deposit demand) curve, and in endogenous lending and deposit spreads. The net surplus of, or need for, funds is cleared with the world financial market. Banks' deposits and foreign liabilities are subject to unremunerated reserve requirements set by the monetary authority.

- Nonbank intermediaries are an auxiliary type of agents (in fact, they are part of banks), whose only business is to do a bundling of funds for firms. While households have access only to domestic bank loans, the corporate sector can choose between bank loans and funds obtained directly from abroad. These two sources of funds are, for various reasons, not perfect substitutes, and are, consequently, demanded in a proportion determined by their relative interest costs. Such a mechanism, however, adds to the complexity of the model. To keep it tractable, we do not let firms determine the sources of their financing. Instead, we introduce the nonbank intermediaries to take bank loans and foreign funds and combine them into a bundle with a constant elasticity of substitution.

- When combining the two sources of funds, the nonbank intermediaries seek to minimize the total cost. As the two sources are imperfect substitutes, the demand for each of them becomes downward-sloping in the respective interest rate. The bundle of bank loans and foreign funds is then lent to firms at a rate that is effectively (up to first order) a weighted average of the bank lending rate and the foreign interest rate.

16. Finally, the demand for loans and supply of deposits by households and firms, and the demand for the bundle of funds by the corporate sector are motivated as follows:

- Households cannot directly enter the world financial market or issue or buy bonds: The only saving instrument available to them is bank deposits. On the other hand, they are required to finance their consumption through bank loans. This constraint increases the cost of today's consumption relative to future consumption, and affects

[5] Our setup assumes full financial dollarization, but no payments dollarization. While an extreme assumption, it fits reasonably well the situation in many countries in emerging Europe. Banks' balance sheets are fully exposed to an indirect FX risk of their clients, which is not realized as long as the exchange rate remains stable. However, the setup can also handle various modifications, including different currency denominations of assets and liabilities on bank balance sheets. In these modifications the expected exchange rate change is passed onto the pricing of bank products. Extending the model to include capital as collateral for loans is also straight-forward, allowing to analyze the effect of capital denomination (hence, of hedged versus unhedged borrowers).

the interest rate channel of monetary transmission, also by introducing a lending-deposit spread.

- Domestic firms are required to obtain funds from nonbank intermediaries (i.e. a bundle of loans from domestic banks and abroad) to finance their working capital (input bill). This constraint increases the marginal cost of production, and hence affects interactions between prices and real economic activity over the business cycle. The firms also hold deposits in proportion to their input bill.

17. The policy environment is characterized by a central bank that uses three types of instruments to conduct monetary policy and influence the economic activity: (i) foreign exchange interventions to manage the nominal exchange rate, (ii) a range of reserve requirements that banks must keep with the central bank, and (iii) controls to limit/regulate the volume (or growth) of bank loans.

B. Description of the Model's Micro Foundations

18. In this model, **households** derive their utility from consumption of domestic goods, c_t and disutility from supplying labor, h_t. The one-period utility function is given by

$$\mathrm{E}_0 \sum \tilde{\beta}^t \left[(1-\chi) \log(c_t - \chi C_{t-1}) - \tfrac{1}{1+\eta} h_t^{1+\eta} \right]$$

where χ is the degree to which consumption decisions of today are affected by external habit (i.e., the past). Without habit formation, the utility function would imply a unit elasticity of substitution between today's and tomorrow's consumption. This is a convenient modeling option. Including habit formation helps reduce the elasticity to more realistic values in the short run, and makes consumption more auto-correlated.

19. Households maximize the expected value of the discounted sum of these one-period utility functions from now to infinity, subject to a budget constraint, balancing their receipts and expenditures over time, and a liquidity constraint. The liquidity constraint requires that the household borrow a certain amount, $d_{H,t}$, proportional to consumption expenditures, on top of its long-term debt position, and hold this amount in the form of liquid assets. In this model, low-interest deposits represent such liquid assets. The liquidity constraint is given by:

$$d_{H,t} = P_{Q,t}\, c_t$$

where $d_{H,t}$ is the required level of deposits.

20. **Domestic producers** produce differentiated goods and sell them in monopolistically competitive market to households. Because each firm is facing its own downward-sloping demand curve, we need to distinguish between individual prices and quantities (denoted by lower-case letters and indices *i*) and market-wide prices and quantities (denoted by upper-case letters). The production function is given by:

$$q_{t,i} = A_t^{1-\gamma_M} (h_t)^{\gamma_H} (m_t)^{\gamma_M} (k_{t'})^{1-\gamma_H-\gamma_M}$$

Where $q^n_{t,i}$ is firm *i*'s output, A_t is the level of productivity (common to all producers in the sector), m_t and k_t are imports and capital used in production.

21. Furthermore, each producer faces Rotemberg's (1982) quadratic costs of price adjustments with backward indexation. The fact that it is costly for firms to deviate from the last period's market-wide inflation can be viewed as a short-cut for costs associated with frequent price re-optimization, and is the source of nominal rigidities in our model.

22. Similar to the households, each domestic firm must borrow a certain amount, $d_{F,t}$, proportional to its working capital (i.e., input factor bill), and hold this amount in the form'of liquid assets—low-interest deposits. Formally, the liquidity constraint is given by,

$$d_{F,t} = W_t\, h_t + Z_t\, k_{t'} + P_{M,t}\, m_t$$

which is a constraint analogous to the one introduced for households. W_t, Z_t and $P_{M,t}$ refer to prices of the three input factors: labor, capital, and imports respectively.

23. **Banks** produce deposits, D_t, and loans, L_t, hold reserves, R_t, with the central bank, get refinancing from the central bank, B_t, and the rest of the world, F_t to maximize profits:

$$\mathrm{E}_t\left[\left(1+i_{L,t}\right)L_t + R_t - \left(1+i_{D,t}\right)D_t - \left(1+i_{B,t}\right)B_t - \left(1+i^*_t\right)F_t - h\left(L_t, D_t\right)\right]$$

where the balance sheet constraint is $L_t + R_t = D_t + B_T + F_t$, and the required reserves, $R_t = r^d_t D_t + (r^d_t + r^f_t)F^b_t$, apply to both deposits and foreign liabilities, with the two required reserve ratios, r^d_t on deposits and r^f on foreign liabilities, set by the central bank.[6] Furthermore, $i_{L,t}$, $i_{D,t}$, and $i_{B,t}$ are interest rates on loans, deposits, and central bank refinancing respectively, i^*_t is the interest rate on foreign funds, and $\mathrm{E}_t\left[S_{t+1}/S_t\right]$ is the expected rate of depreciation (or appreciation when negative). The depreciation appears in the profit function because loans, deposits, and foreign funds are denominated in foreign currency whereas reserves are held in domestic currency and the objective of banks is to maximize profits expressed in domestic currency.

24. The profits of banks are affected by costs of producing loans and deposits. The cost function, $h(L_t, D_t)$, is constructed so that the marginal costs (with respect to both loans and deposits) are functions of the ratio L_t/D_t only. This means that the resulting lending and deposit rates will also react to this ratio: the higher L_t/D_t the higher both the lending rate and the deposit rate, and vice versa. Finally, the lending and deposit rates will also be influenced by the setting of the two required reserve ratios, r^r_t and r^m_t, by the central bank: (i) an increase

[6] Note that the resulting interest rate setting equations would, strictly speaking, depend on the currency in which the required reserves are held. However, given the assumption of fixed exchange rate expectations (determined by the central bank's behavior), we would not observe any differences in the model's responses in the simulations. Moreover, even when we simulated unexpected changes in the central parity, the ex-post disparity facing the banks would be ultimately absorbed by the households' budget, and there would be no wealth or income effect at the aggregate (i.e., economy-wide) level.

in r_t^r will see the lending rate rise with the deposit rate unchanged, whereas (ii) an increase in r_t^m will see both rates rise, and vice versa.

25. **The financial intermediaries** (formally, part of banks) use a CES technology to combine bank loans and funds borrowed directly from abroad, and lend the bundle of these two types of sources of funds to domestic firms. Again, loans, foreign funds and the bundle are all denominated in foreign currency. The rate intermediaries charge to firms is approximately the weighted average of the bank lending rate and the foreign rate. Since these sources of funds are not perfect substitutes, the demand for each of them is interest cost elastic. The demand functions up to first order can be approximated as:

26. **The central bank** uses three types of instruments. First it manages the nominal exchange rate of the currency, and sets the two required reserve ratios. Due to foreign exchange interventions, the nominal exchange rate is a process reverting to a central parity,

$$\log S_t = \rho_s \log S_{t-1} + (1-\rho_s)\log \overline{S} + e_t^s$$

where, the innovation term, e_t^s, is not a forecast error, but rather a tool the central bank uses to manipulate the path for the nominal exchange rate. Because central banks usually tend to do so in response to changing economic conditions, the innovation term can be effectively a function of other macroeconomic indicators.

27. Second, the central bank sets the required reserve ratios, which may also respond to various economic conditions. To simplify the use of the model, we introduce them as autoregressive processes with potentially non-zero unconditional means:

$$r_t^d = \rho_{rd}\, r_t^d + (1-\rho_{rd})\, r_d + e_t^{rd}$$
$$r_t^f = \rho_{rf}\, r_t^f + (1-\rho_{rf})\, r_f + e_t^{rf}$$

where, r_d and r_f are the unconditional means (steady state). The two innovation terms, e_t^{rd} and e_t^{rf} can again be functions of the state of the economy, or used to manipulate the reserve ratios at the central bank's discretion.

28. Third, the central bank may impose temporary credit volume restrictions on banks, in the form of a maximum period-on-period rate of growth in the total volume of loans granted. To this end, we introduce an additional constraint for banks:

$$L_t \le \overline{L} \text{ or } L_t \le (1+\phi)L_{t-1},$$

where ϕ is the growth rate set by the central bank. We assume that one of the above constraints is binding as an equality at all times when the credit controls are in place.[7] The

[7] This is a realistic assumption given the fact that the credit controls are usually introduced at times when the actual credit growth significantly exceeds the one desired by policymakers. In other words, the equilibrium volume of loans without controls would be systematically above the levels prescribed by the central bank.

shadow value of this constraint will, in general, increase the marginal cost of lending, and hence the bank lending rate.

29. The aggregated **balance of payments** equation describes the change in the country's net position with the rest of the world as a function of the current account (i.e., the sum of debt service and trade balance). Note that full dollarization entails the dependence of investment income on the actual change in the nominal exchange rate:

$$F_t = \left[\omega_F (1 + i^{\text{å}}_{t-1}) \frac{S_t}{S_{t-1}} + (1 - \omega_F)(1 + i_{B,t-1}) \right] F_{t-1} - (P_{X,t} X_t - P_{M,t} M_t)$$

where $P_{X,t} X_t - P_{M,t} M_t$ is the trade balance, and $(1 + i^*_{t-1}) S_t / S_{t-1}$ is the ex-post investment income rate paid abroad.

30. In solving the model, we proceed as follows: we derive the first-order optimality conditions for the optimization problems of all agents, impose market clearing conditions, and re-write the conditions for the aggregate variables. Then we find the model's non-stochastic steady state (i.e., a balanced growth path along which all shocks are deterministic zeros), calculate Taylor's first-order expansion of the optimality conditions around such a steady-state, integrate future expectations out using the Schur generalized decomposition, and find the state-space representation of the model, as described in Klein (2000).[8]

C. Main Characteristics of Policy Transmission

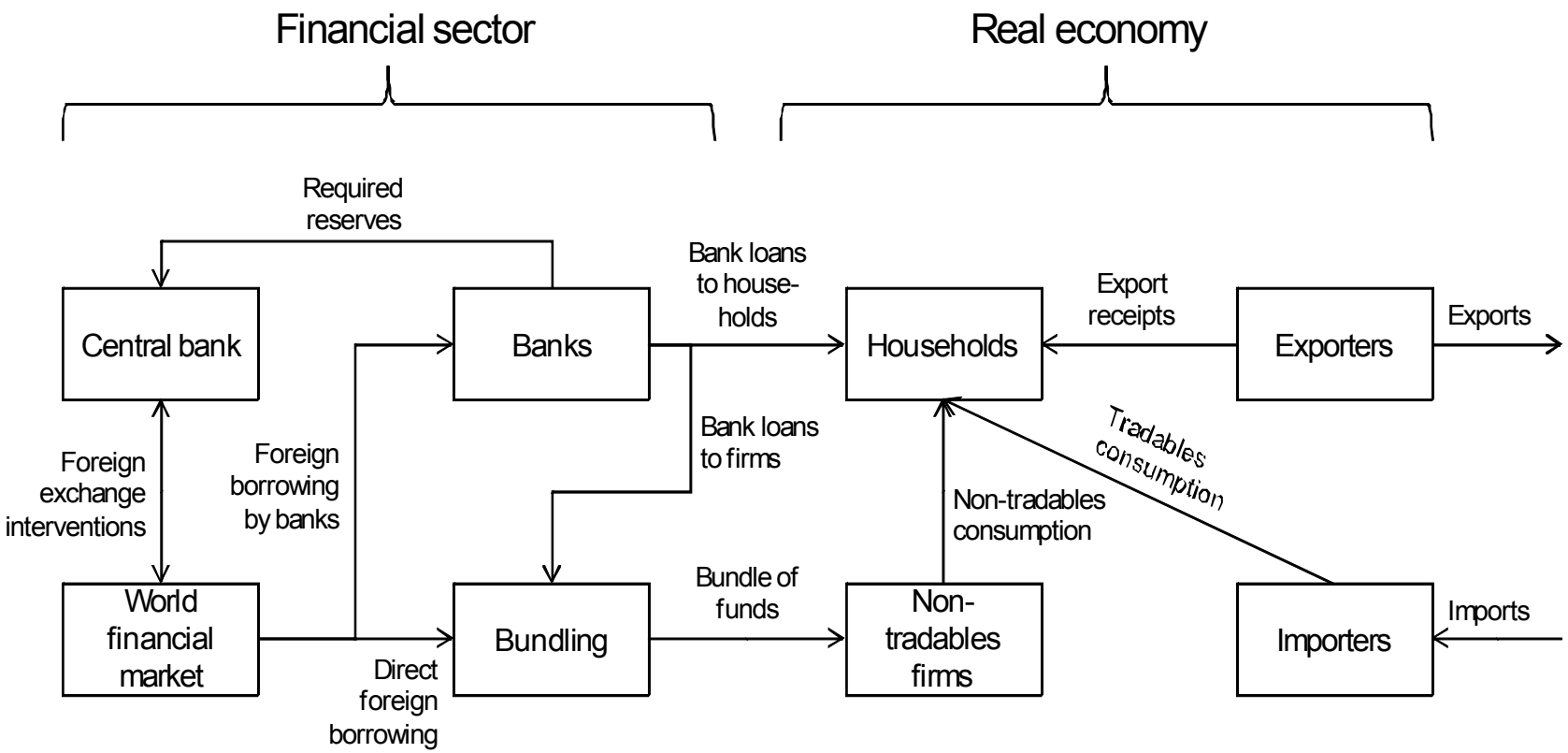
31. The model can be used to analyze the main linkages between the real and financial sectors (Diagram 1). It can then be used to analyze the impact of various domestic and external shocks, as well as to show how the various policy measures affect the rest of the economy. For example, it can help gauge the extent to which policy measures such as reserve requirements or limits on credit by financial intermediaries affect long-run trends and business cycles, helping to assess their monetary and financial sector implications over a medium-term horizon. The model can also be used to analyze the impact of external shocks, such as shocks to foreign prices and interest rates, as well as of a credit crunch triggered by adverse external financial market conditions (see Section IV). Finally, the model can help draw predictions about the implications for business cycle fluctuations (dynamic response-to-shock simulations) and for the changes in the long-run characteristics of the economy (steady-state comparative statics).

32. The working of the main channels of transmission, distinct from a standard sticky-price business cycle framework, can be illustrated with a number of examples:

- **Required reserves** banks must hold affect the marginal costs of bank lending and deposits, and alter both the optimum levels of lending and deposit rates, and the

[8] We use The IRIS Toolbox (a Matlab based package for economic modelling) to perform all these steps as well as the experiments and simulations described in the rest of the paper.

Diagram 1. Main Macro-Financial Linkages in the Model



lending and deposit spreads. Because households and firms must finance part of their expenses by loans, the lending and deposit spreads enter the costs of households' consumption and firms' production. The interest rate channel and the cost channel of monetary policy transmission therefore work differently from an economy without such loan constraints and/or required reserves. On the firms' side, the impact of the policy measures is considerably mitigated because of the existence of an alternative source of funds: foreign direct borrowing. Obviously, the higher the elasticity of substitution between bank loans and direct foreign funds, the smaller effect the monetary policy measures have on the rest of the economy.

- **Controls on credit volumes** are a binding constraint imposed on the bank lending activities. Hence, they have a non-zero shadow value for banks, raising the marginal cost of bank lending. It is optimal for the banks to pass through the shadow value into the final lending rate. The effectiveness of credit controls is also weaker with the existence of alternative sources of funds. As bank lending rates increase with the shadow value of the credit controls, the bank loans are substituted for direct foreign funds whose cost is not affected. The impact on the total inflow of funds as well as on the effective costs of borrowing is, therefore less pronounced.

- **A managed exchange rate regime** is to shelter the fully dollarized balance sheets of real economy firms and households from the risks associated with currency mismatch. This is because all revenues and expenses are paid in domestic currency whereas deposits and loans are in foreign currency. The potential effect of large movements in the nominal exchange rate is realized through the aggregated balance of payments equation discussed above.

- **Risk-premium-like shocks**, which are viewed as one of the main sources of uncertainty in countries under consideration, can be analyzed with the model. The model can experiment with at least three different types of such shocks and can be used to analyze the effect of each shock on the real sector: (i) a shock hitting the cost of foreign funds facing both banks and non-bank borrowers; (ii) a shock hitting the domestic bank lending rate, and (iii) a shock hitting the country's net position.

III. Model Calibration and Properties

33. This section presents the calibration of the model parameters and examines the deterministic and stochastic properties of the model. The model is calibrated using the data for Croatia—a country exhibiting many of the features described in the introduction. The objective of the calibration exercise is two-fold: to explain how the model's various parameters determine the main multipliers and affect the transmission channels, and to provide a parameterization that is sufficiently realistic to help interpret the results of the simulations and policy experiments in a sensible way.

34. The model's parameters can be divided into three groups: (i) parameters that determine the non-stochastic steady state of the model, (ii) parameters that may or may not have affect on the steady state but have been introduced to control the short-run dynamics of

the model, and (iii) parameters that determine only the stochastic properties of the model (i.e. only second moments of model-induced distributions).

A. Parameterizing Steady State

35. When parameterizing the steady state, we proceed in four basic steps. First, we determine the growth, inflation, and interest rate characteristics of the economy. We then use these values, and calibrate the financial block together with the balance of payments. Third, we determine the parameters and other characteristics of the real economy block. Last, we set the model's two numeraires (the world price level and the central parity) to arbitrary values, and determine the steady-state values for all model variables.

Growth, inflation, and interest rate characteristics

36. In this step, we calibrate the steady-state growth, inflation and interest rate characteristics and related parameters (see Table 1 for a description of these parameters):

- We start with assumptions about the rate of growth of domestic real economic activity, world prices, and world nominal interest rate; based on the observed historical averages, these characteristics directly determine α, π_* and i_*.

- We then proceed as follows: Given an assumption about the long-run domestic lending rate, we can use the Euler equation to obtain the discount factor, β, and the adjusted discount factor, $\tilde{\beta}$. The deposit rate is furthermore linked to the foreign rate through the optimum lending rate equation. We, must hence calibrate the steady state for the two required reserve ratios, r_d and r_f, and choose the long-run ratio of bank loans to deposits, L_{ss}/D_{ss}, and the parameter θ_{LD}, which controls the elasticity of the deposit and lending rates to *L/D* ratio (see section III.B on parameterizing transitory dynamics).

- With these characteristics pinned down, we can infer about the value of θ_D, the fixed component of the lending spread. Analogously, using the optimum deposit rate equation we obtain the fixed component of the lending spread, θ_L. The two last values should be checked against the elasticity θ_{LD} to see if they satisfy the general restrictions on cost functions (that is, increasing and convex).

The financial block

37. When calibrating the financial and real economy blocks, we extensively use various nominal expenditure ratios as guidance.[9] In addition to the loan-to-deposits ratio imposed in the previous step, we need three more inputs at this stage: first, the desired steady state for the net foreign liabilities position (NFL), or alternatively the trade surplus (TS) or deficit;

[9] Note also that most of the steady-state equations employed in these two steps are expressed in such nominal expenditure ratios.

second, the proportion in which non-bank intermediaries combine bank loans and funds obtained directly from abroad; and third, the ratio of bank loans granted to firms to bank loans granted to households.

Table 1. List of Main Behavioral Parameters and Their Baseline Calibration

Parameter	Description	Baseline value
α	Steady state rate of growth of real economy	$1.04^{1/4} - 1$
π_*	Steady state rate of inflation, world economy	$1.02^{1/4} - 1$
i_*	Steady state nominal rate of interest, world economy	$1.04^{1/4} - 1$
β	Discount factor	0.96^(1/4)
r_d	Steady state required reserve ratio on deposits	0.05
r_f	Steady state required reserve ratio on foreign liabilities	0
θ_D	Fixed component in deposit spread	2.5/400
θ_L	Fixed component in lending spread	1/400
θ_{LD}	Banking cost function parameter	100
ν	Determines share of bank loans in bundle borrowed by firms	0.30
Eta	Long-run elasticity of labor supply	0
γ_M	Import share of gross production	0.34
ò	Elasticity of substitution in monopolistically competitive markets	6
χ	Habit in consumption	0.85
ξ_W	Wage adjustment costs	1/0.05
ξ_P	Price adjustment costs	1/0.07
ε	Elasticity of substitution between bank loans and foreign funds	2

38. We first use the balance of payments equation to link the net liabilities (or assets) position, NFL, of the country with the trade surplus (or deficit), TS. One can, in fact, use the equation either way: assuming a certain ratio of NFL to GDP, we can obtain TS to GDP, or vice versa, depending on which indicator we put more emphasis on in a long-run perspective. In either case, the consistency of the implied net investment income (i.e. debt service paid on NFL) should be subsequently checked with the observed data. Large deviations of the model's long-run predictions from reality may indicate that the calibration of the world interest rate, domestic real growth, or inflation may need to be reconsidered.

39. Next, based on our assumption about the bank loans to foreign funds ratio and the optimality conditions for nonbank intermediaries we can pinpoint the share parameter ν consistent with the above assumption, and calculate the implied interest rate on the bundle of funds, i_t^b . Finally, using the three remaining identities from the balance sheets of banks and nonbank intermediaries, we can pin down the ratios of all financial categories to GDP.

Real economy

40. Because we already know the ratios of all financial categories and net exports to GDP, we can use the optimality conditions from the real economy sector to calculate the ratios of the two types of consumption, output, exports and imports to GDP, as well as the values for the two parameters that control the portion of consumption and input bill financed through borrowing from banks and non-bank intermediaries, κ_h and κ_n.

41. The elasticity of substitution in monopolistically competitive markets, ε (or the corresponding mark-up μ) can be used to fine-tune the share of exports (or imports) in domestic value added. The elasticity of real marginal costs to output, γ, need not be calibrated, and we can set it to a convenient value 1 (without loss of generality). The reason is that although it contributes to determining the ratio of funds firms need to borrow from non-bank intermediaries, we fully control this characteristic through the parameter κ_n. Moreover, over the business cycle, the effect of output on marginal costs and inflation is given by yet another parameter, ξ_n. Finally, given the calibration of λ_h and λ_n (see below), these two parameters are uniquely determined by the assumptions made above.

Steady-state values for individual variables

42. With all nominal expenditure ratios determined, and the values for all numeraires, we can pinpoint the steady state for each individual variable. Recalling that we normalize the level of productivity, A_t, exports, X_t, and the nominal exchange rate central parity, $\overline{S}$, to 1, the only remaining numeraire is the world price, P_t^* for which we allow for a unit root in the law of motion, meaning that the model's nominal variables are non-stationary and the model does not have a fixed steady state. Its steady state is, instead, a balanced growth path.

43. We approximate the dynamics of the model by Taylor's first-order expansion. This expansion is still valid even though the model has a balanced growth path (provided we take into account that nominal variables grow over time, and have thus different values at times $t-1$, t, and $t+1$), and the coefficients of Taylor's expansion are, in fact, independent of where exactly we are on the balanced growth path. To compute Taylor's expansion numerically, we, need a particular point around which we approximate the model's equations; This point can be determined arbitrarily by choosing a particular level of the world price, and the model's other equation can be used to calculate the corresponding steady states for all remaining variables.[10]

[10] More specifically, given the world price we can first express the import price (as the product of the nominal exchange rate and the world price). Knowing the nominal exports to imports ratio, we can determine real imports. Real consumption follows, on the other hand, from our assumptions about the production function, together with the optimality condition for price setting. Finally, we only need to express nominal GDP, and find out the values of all financial categories based on their proportions to nominal GDP.

B. Parameterizing Transitory Dynamics and Stochastic Properties

44. There are seven behavioral parameters that have been introduced to help produce realistic dynamics in the short run: the habit parameter, χ, the two parameters controlling the elasticity of loan demands to real consumption or real costs, λ_h and λ_n, the two price stickiness parameters, ξ_n and ξ_τ, the elasticity of substitution between bank loans and direct foreign funds, η, and the parameter of the bank cost function, θ_{LD}. These parameters need to be calibrated with respect to the system properties of the model as a whole, such as responses to external, policy, and domestic shocks, or implied autocorrelations (degrees of persistence) as compared to the observed ones. However, we can find some general guidance for setting first-pass values for some of them.

45. The role of the habit parameter is three-fold. First, it reduces the short-run elasticity of substitution in consumption between tradables and domestic (which is unitary in the long run); second, it reduces the short-run elasticity of intertemporal substitution (i.e., the sensitivity of consumption to the real interest rate); third, it entails the dependence of consumption on its own lag. For most countries, realistic values lie between 0.70 and 0.90.

46. The two parameters in loan constraints, λ_h and λ_n, are to increase the elasticity of loans to consumption and funds borrowed from intermediaries to production costs (they both are unitary in the long run). From the two constraints, we can easily see that the elasticities are in both cases $1/(1-\lambda)$. These should be set according to the average magnitude of loan cycles relative to consumption cycles or output cycles.

47. The inverses of the two price stickiness parameters, $1/\xi_n$ and $1/\xi_\tau$, multiplied by four (to relate them to annualized inflation) compare well to the stylized parameters on the output gap in models with a New Keynesian Phillips curve or on the pass-through of nominal exchange rate or world price shocks to domestic inflation (the parameter in tradables).

48. The value of the parameter, θ_{LD}, which controls the elasticity of the deposit and lending rates to *L/D* ratio, needs to satisfy general conditions for a well-behaved cost function. Besides, because this parameter serves to close the model, we keep its baseline calibration value low, which is the literature standard for parameters with such property. However, this parameter also controls the responsiveness of the banking sector to the credit cycle and the business cycle, in general, and as such is a subject of calibration experiments.

49. The elasticity of substitution between bank loans and direct foreign funds, η, was calibrated to achieve reasonable model properties in terms impulse responses. As a control experiment, in the calibration we used the episode of de facto credit growth controls in 2003 that saw a marked increase in direct foreign borrowing relative to domestic credit extended by banks.

50. In addition to these seven parameters with some behavioral interpretation, we have several other parameters that describe reduced-form autoregressive processes for exogenous and policy variables. The first-pass values can be usually obtained by running simple regressions.

51. Finally, to be able to describe the second moments of the model-induced distributions (which is a useful indicator of the match between the model and the observed data), we need to parameterize the standard errors of the various shocks introduced in the model. We use the following simple procedure. We run a Kalman filter with the same number of shocks as the number of observables (see the list of observables later in this section) with its initial condition treated as deterministic numbers. In such a case, the estimates of unobservables and historical shocks do not depend on the structure of relative standard errors, and we use them to estimate their sample standard errors.

IV. Using the Model-Based Framework for Policy Analysis—Implications of a Credit Crunch

52. This section presents various policy relevant experiments that illustrate how the model could be used in informing policymaking at the central bank, such as an analysis of transmission of most important external and domestic shocks. Special emphasis is put on investigating the impact of various direct policy measures over the business cycle and of domestic or external shocks that may affect the behavior of financial intermediaries and, in turn, the real sector of the economy. The experiments chosen closely relate to the ongoing events in the global financial markets.

53. Analyzing the implications of negative credit supply shocks has become highly relevant in the current juncture. The global financial markets have been in a state of turmoil since mid-2007, evolving from a crisis that was initially largely confined to sophisticated western financial systems to a "sudden stop" in international funding. The initial cut in wholesale sources of financing experienced by western banks (e.g., in the United Kingdom, United States, and Germany) has now spilled over to the emerging market economies, in the form of higher refinancing costs, limited access to funding, and slowdown in economic activity, changing the perceptions that most emerging market economies were immune to the global turmoil given the absence of direct exposures to the subprime crisis.

54. The extent and speed of the spillover has in general been the result of the growing degree of financial interlinkages between the western economies and emerging markets. In Europe, in particular, the degree of financial interlinkages among Western and emerging European countries has increased markedly with the growing foreign ownership of the banking systems. Most central, eastern, south eastern European (CESE) countries are heavily exposed to Western European banks, either through direct borrowing by their private sector or through their local banking sectors, and some western European countries are exposed to a range of CESE countries through their operations concentrated in the region.[11] The growing financial links has in turn increased susceptibility of host countries to financial contagion from home countries of parent banks or other hosts with exposure to home countries. They also increased vulnerability to the availability of, and cost of access to, external funding under tighter global liquidity conditions.

[11] See Árvai, Driessen, and Ötker-Robe (2009) who analyze these interlinkages and exposure to regional financial contagion.

55. Indeed, tighter global market conditions since mid-2007 have resulted in growing indications of a credit crunch in the euro area, where banks have started tightening credit standards.[12] Credit supply diminished due to banks' higher funding costs, uncertainty about funding availability, reassessment of risks, and as banks manage the size and composition of their balance sheets. Such tightening has implications for the euro area's economic growth dynamics through moderation of credit supply to fund consumption and investment, which is now more costly, and reduced expectations for growth of income and wealth.

56. Similar real economy effects of a credit crunch have started to become apparent in emerging Europe. Credit supply in the domestic economies has diminished as a result of: banks' reduced access to funds and/or higher funding costs from abroad (both due to tight liquidity conditions and higher risk premium sought by international markets; the latest BIS data indeed suggest a drop in cross border flows) and banks' increased risk aversion given the greater uncertainty about funding availability and the desire to manage their balance sheets. In turn, reduced credit supply is affecting economic growth through limited availability of funds for consumption, investment, and production. For emerging Europe, real economy effects of a credit crunch are expected to be even greater since credit growth has been funded increasingly by foreign borrowing. Diagram 2 illustrates the main transmission channels a credit supply shock could affect an emerging European economy.[13]

57. We explore below the implications of negative credit supply shocks that combine the various elements described in Diagram 2. In particular, we analyze credit crunch induced by external shocks, including (i) tighter lending by banks, as a result, for example, of increased risk aversion in lending to the private sector; (ii) reduced or costly access to external funding by banks and corporations; and (iii) tighter liquidity that raises the interest rate banks can borrow from the interbank market. We also analyze the implications of a policy induced credit crunch. In particular, we examine the effects of direct monetary policy tools aimed at reducing the rapid growth of bank loans (including, e.g., price based controls on bank lending and foreign borrowing or credit growth limits).

58. The shocks are assumed to last one year (i.e., a temporary shock), unexpected in the first period of the simulation, but expected thereafter. In general, the shocks affect real economic activity through three basic first-round channels: (i) the intertemporal channel, (ii) the cost channel, and (iii) the income channel.

A. Credit Crunch Induced by Exogenous Shocks

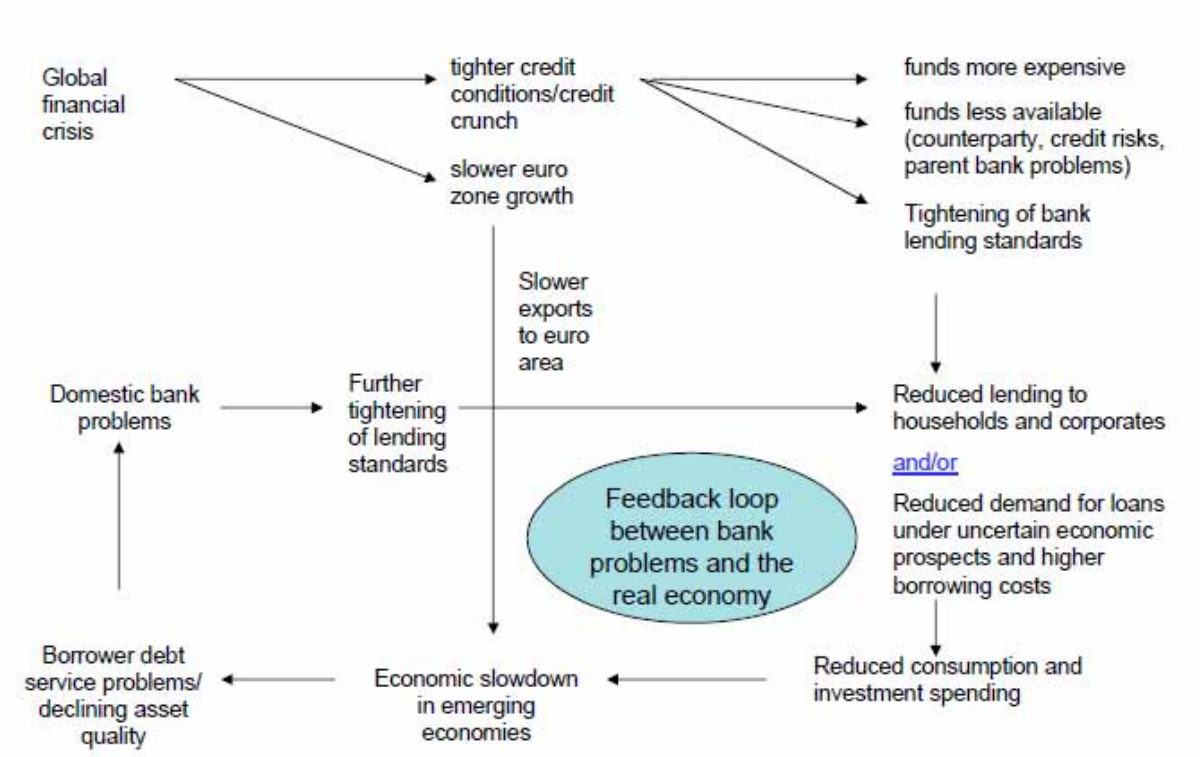
59. In this experiment, we examine the effects of the following financial intermediation shocks that are assumed to be triggered by some exogenous factor that affects the ability of banks and the non-bank private sector to borrow from abroad and of banks to lend. The

[12] See for example, ECB (2007-08); JP Morgan (2007); Morgan Stanley (2007); European Economic Focus (2008); and Schroders Talking Point (2008).

[13] The current version of the model, however, does not allow for the feedback loop from the real economy to banking sector problems.

nature of these shocks are similar to the difficulties that have been facing many emerging market economies in the context of the ongoing global financial crisis:

Diagram 2. Transmission Channels of an Exogenously Induced Credit Supply Shock



- Type 1 (a "**domestic lending shock**") is a shock to banks' optimal lending rate setting. It corresponds to a situation in which the banks wish to, for whatever reason (e.g., uncertainty about the economic situation or funding conditions, or tightening of lending standards with increased risk aversion), cut back loans to firms and households below the market equilibrium. Banks' cutting back their loans has a shadow value (forgone profits) associated with it, which increases the marginal cost of bank lending activity, and hence translates into higher lending rates.

- Type 2 (a "**country risk premium shock**") is a shock to the rate at which foreign funds are available to the domestic financial intermediation sector (both banking and non-banking). The implied reaction in lending and deposit rates is the result of banks' optimizing behavior in response to the higher foreign risk premium.[14]

[14] Such a shock may take the form of either a costlier access to foreign funds (thereby a higher foreign risk premium) or a reversal of, or a cut in the availability of, foreign funds for domestic banks and corporations, regardless of the interest rate. The implications of the second type of shock are similar to the one shown here, and, therefore, are not reported.

- Type 3 (an "**interbank shock**") is a shock to the rate at which banks can refinance from the interbank market (i.e., other banks or the central bank). Because the banks are in zero net position with each other under a symmetric equilibrium, this shock describes the effects of a shortage of liquidity provided by the central bank.

60. All three shocks involve a 10 percentage point increase in the relevant interest rate in the first period, gradually brought back to zero at an autoregressive rate of 0.80 (the autoregressive rate is set so that the effect of the shocks dies out in 2-3 years). The impact of the shocks and their transmission channels are summarized in Table 2 and illustrated in Figure 1.

61. The three credit crunch shocks affect the real and financial sectors of the model economy through different channels of transmission:

- The intertemporal channel is present in all three simulations. Because the lending rates increase, it is optimal for households to cut back their consumption today, and hence reduce aggregate demand. This is the most traditional channel of monetary policy transmission. The intertemporal channel has also other attributes of a demand-side shock: a drop in output leads to a drop in prices and inflation.

- The cost channel is quantitatively important only in type 1 simulation (the "domestic lending shock"), since it works through the lending-deposit spread. The higher the spread, the costlier it is for households and firms to hold liquid assets (low-interest deposits or money) for their transactions. An increase in the spread therefore adds to the effective price of consumption facing households, and to the nominal marginal cost of production facing firms. As a result, this channel resembles a supply-side shock: prices and inflation rise, whereas economic activity falls. The domestic lending shock is the only one that pushes inflation above its long run level in a period of an output downturn.

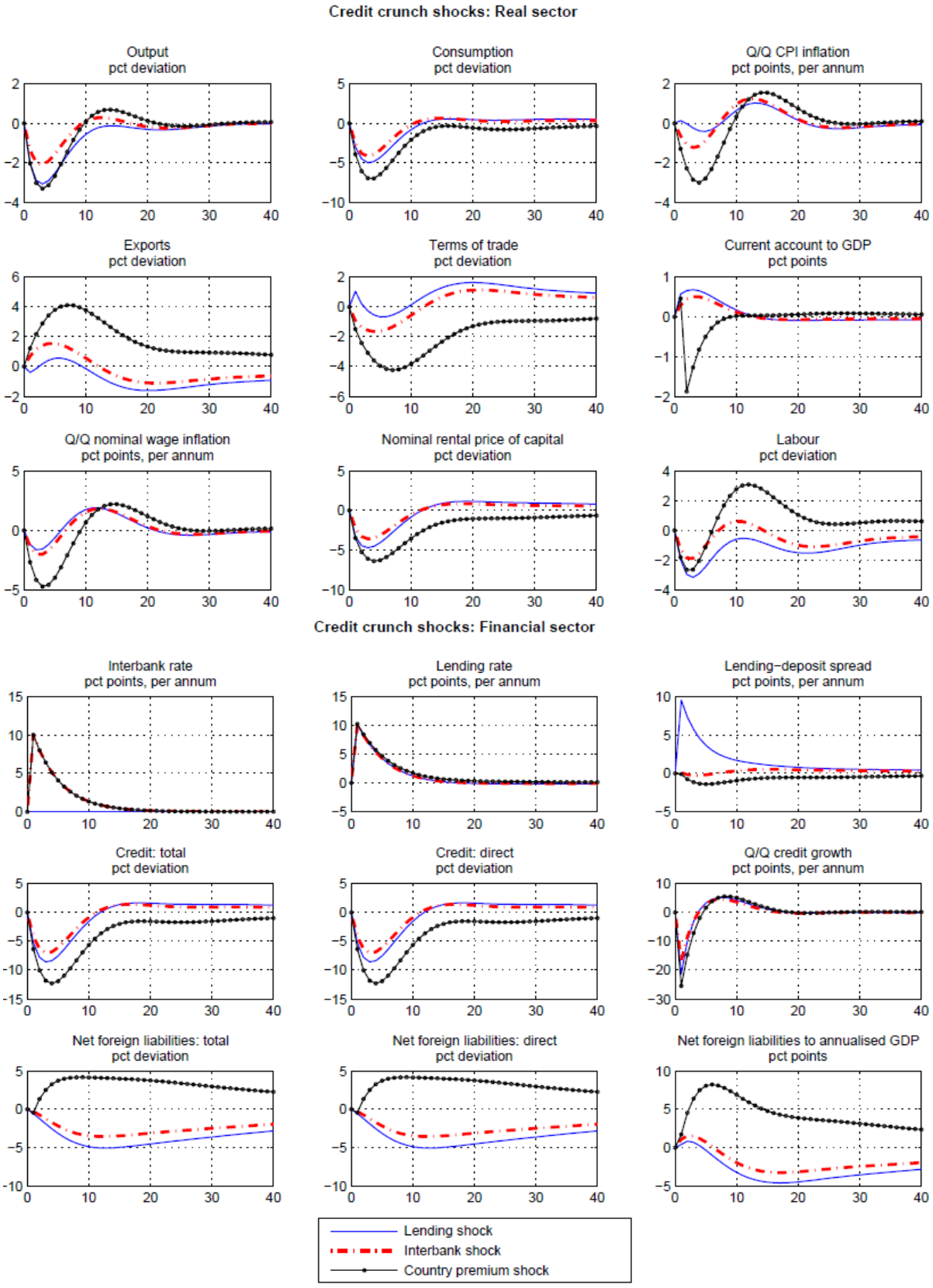
- The income channel is linked to the rate the country must repay its debt, and is only present in type 2 simulation (the "country risk premium shock"). A higher rate produces a large deterioration in real consumption demand and in the net investment position (relative to type 1 and type 3 simulations).

62. The impact of the three shocks on real activity depends also on the response of exports. Because the rest of the world's demand for domestic exports is assumed to be price-elastic, whether the domestic cost of production increases or decreases after the financial shock matters for the response of exports (i.e., whether the demand or supply-side channel prevails). This is best seen comparing type 1 (the "domestic lending shock") and type 2 (the "country foreign risk premium") simulations: the supply-side shock nature of the domestic lending shock makes production more expensive, pushing export prices up and leading to a reduction in the world demand for domestic goods. This drop in exports deteriorates domestic economic conditions further. On the other hand, the country risk premium and interbank shocks reduce domestic prices, stimulating exports.

Table 2.The Simulated Effects of the Exogenously Induced Credit Supply Shocks

	Domestic Lending Shock	**Country Risk Premium Shock**	**Interbank Shock**
The shock	10 pp rise in banks' lending rate	10 pp rise in the rate at which banks and corporates borrow from abroad	10 pp rise in the rate banks refinance from the interbank market
Transmission channel	The shock affects the economy primarily through the intertemporal channel and the cost channel.	The shock affects the economy primarily through the intertemporal channel and income channel.	The shock affects the economy primarily through the intertemporal channel.
On impact	• **Lending rate** goes up • **Lending-deposit spread** goes up, because the deposit rate is unchanged (marginal rate of funding not affected)	• **Lending rate** goes up • No change in the **lending-deposit spread**, because marginal rate of funding also goes up	• **Lending rate** goes up • No change in the **lending-deposit spread**, because marginal rate of funding also goes up
Step 1	• **Consumption** falls because of intertemporal smoothing (higher lending rate). • **Cost of bank funding** goes up, given the higher spread, shifting up the output supply curve, and pushing **domestic prices**. Though firms partially substitute bank lending for direct foreign borrowing, the cost of borrowing increases. • **Terms of trade** and competitiveness deteriorates as domestic prices rise; **exports** fall.	**Consumption falls** because of intertemporal smoothing (higher lending rate), but also because of the need to roll-over foreign debt at higher cost (income channel).	**Consumption** falls , because of intertemporal smoothing (higher lending rate).
Step 2	• **Output** falls, because of lower exports and consumption. • Demand for **domestic credit** falls, given lower output. • Demand for **direct foreign borrowing** also falls, but less than domestic credit demand • **Net foreign liabilities** fall, as credit demand falls. • **Inflation** goes up, given the higher cost of production	• **Output** falls because of lower consumption. • Demand for **domestic credit** falls given lower output. • Demand for **direct foreign borrowing** falls. • **Net foreign liabilities** increase, because of the higher refinancing costs, and despite falling credit demand. • **Inflation** falls, given the fall in output. • **Terms of trade** and competitiveness improves. • **Exports** rise, partially mitigating the fall in output.	• **Output f**alls because of lower consumption • Demand for **domestic credit** falls, given lower output. • Demand for **direct foreign borrowing** falls. • **Net foreign liabilities** fall, as credit demand falls. • **Inflation** falls, given the fall in output. • **Terms of trade** and competitiveness improves. • **Exports** rise, partially mitigating the fall in output.
Step 3	• Demand for factor inputs falls. • Real/nominal **rental rate of capital** falls given fixed supply • **Price of capital** falls, given the lower nominal rental rate and higher lending rate (which is used in discounting future rental streams), despite higher domestic price level. • Nominal and real **wages** fall. • **Employment** falls, given the fall in output. The fall in real wages (relative to the cost in other inputs) is not enough to compensate the impact of falling output, given the drop in labor supply (the higher lending-deposit spread reduces the supply of labor since it changes the willingness to work against consumption. Both interest rates affect the household decision making directly – as the cost of borrowing and receipts from holding deposits against consumption rise).	• Demand for factor inputs falls. • Real/nominal **rental rate of capital** falls, given fixed supply. • **Price of capital** falls, given the lower nominal rental rate and higher lending rate (discount rate). • Nominal and real **wages** fall. • **Employment** fluctuates around the original level, as the fall in output is compensated by lower wages (which makes labor cheaper relative to imports as another production factor whose price – the exchange rate – does not change.	• Demand for factor inputs falls. • Real/nominal **rental rate of capital** falls given fixed supply • **Price of capital** falls, given the lower nominal rental rate and higher lending rate (discount rate). • Nominal and real **wages** fall. • **Employment** fluctuates around the original level, as the fall in output is being compensated by lower wages (which makes labor cheaper relative to imports as another production factor whose price – the exchange rate – does not change).

Figure 1. Simulated Effects of the Exogenously Induced Credit Crunch Shock



63. On the financial sector side, the volume of credit falls in all three simulations (ranging from approximately 5 to 10 percent). The credit supply curve, which is calibrated to be relatively flat, shifts upward in all three simulations, making bank loans more expensive. While financial intermediaries partially substitute bank loans with direct borrowing (except in type 2 shock where there is no room for substitution, because the costs of both funding sources increase by the same amount), the overall cost of credit increases. The demand for credit also falls through other channels: first, the response of real consumption (through the intertemporal and income channels in the first round) determines the volume of real consumer credit demand; second, real consumption together with real exports (mainly through the cost channel) determine the overall change in output, and hence firms' real credit demand for working capital; and third, the movement in domestic prices translates the changes in real credit into nominal credit.

64. The credit crunch simulations clearly highlight the linkages between the real and financial sectors of the economy. All three financial shocks have significant real sector implications, generating much lower consumption, output, employment, and prices of factor inputs. The size of the impact is larger in the foreign risk premium and lending shock scenarios, compared with the interbank shock. The large decline in output under the risk premium shock reflects the sharp fall in consumption (given the intertemporal smoothing by consumers and the need to roll over foreign debt at a higher cost), and despite the rise in exports that partially mitigates the fall in output. Under the domestic lending shock, the output fall reflects both the significant drop in consumption and the initial fall in exports as the rise in domestic prices leads to a deterioration in the terms of trade. In the interbank shock scenario, the decline in output is smaller given the more moderate drop in consumption and the rise in exports that partly mitigates the output fall. Inflation also falls, reflecting the lower economic activity. The impact on inflation of the domestic lending shock is small, given the rise in the cost of production (as in a supply shock).

65. Activity in the domestic financial sector is also reduced following the shocks. Under all three scenarios, the negative shock to credit supply initially generates (i) higher bank lending rates; (ii) lower demand for bank credit as loans become more expensive and output and consumption fall; (iii) lower foreign borrowing by banks (due to lower demand for bank loans—under all three shocks, and/or to more expensive external funds—under the foreign risk premium shock); and (iv) lower direct borrowing by corporations (either due to lower production—under all three scenarios, and/or higher cost of borrowing from abroad—under the foreign risk premium shock). The fall in bank credit is bigger under the foreign risk premium shock (followed by the domestic lending shock), given the larger drop in output and consumption, compared with the interbank shock. NFLs of firms and banks rise (and the current account deteriorates) under the risk premium shock (while the opposite happens under the other two scenarios) because of the higher refinancing costs, and despite lower foreign borrowing by the financial intermediation sector and the lower credit demand.

66. As the credit crunch fades away following the first year, economic activity (and prices) overshoots before stabilizing at pre-shock levels, with corresponding movements in other nominal and real variables. This overshooting generates additional economic oscillations lasting two to three years before the economy stabilizes. The oscillations are most pronounced in the case of the foreign risk premium shock, because the limited scope of

the corporates to substitute loans from the banking sector with direct foreign borrowing results in a sharper contraction in production. When the shock disappears, bank lending and interest rates return to their pre-shock levels. It takes longer for net foreign liabilities to return to their pre-shock levels partly because it takes time for domestic prices relative to foreign prices (terms of trade) to reach their steady state level; the risk premium that changes interest rates in response to the deviation of NFL from its steady state level also adjusts very slowly.

B. Policy Induced Credit Crunch

Price-based Controls on Bank Credit

67. In this experiment, we examine the effects of two policy measures aimed at reducing the growth of bank loans to the private sector by making costly, and hence reducing, the funding sources of credit: (i) an increase in reserve requirement (RR) on domestic deposits; and (ii) an increase in RR on banks' foreign borrowing. We also look at the implications of potential circumvention of the second measure, by allowing for the possibility of direct foreign borrowing by firms; the latter is normally outside the control of the monetary authority, and is, therefore, not normally subject to reserve requirements, thereby creating scope for firms to get around the measures affecting banks.[15] To compare it with the case of no circumvention, we remove the direct foreign borrowing channel by assuming that the RR can also be enforced on firm's direct borrowing, hence letting the cost of the two types of foreign funds be affected identically.

68. The objective of these experiments is to analyze the real and financial sector implications of these price based measures aimed at affecting bank credit. In all three simulations, the RRs are raised by 10 percentage points in the first period, and are gradually brought back at an autoregressive rate of 0.95 (the autoregressive rate is set so that the effect of the shock dies out in 4-5 years, reflecting the fact that when such measures are imposed, agents treat them more or less as permanent, and set expectations accordingly. The impact of these shocks and their transmission channels are provided in Table 3 and Figure 2.

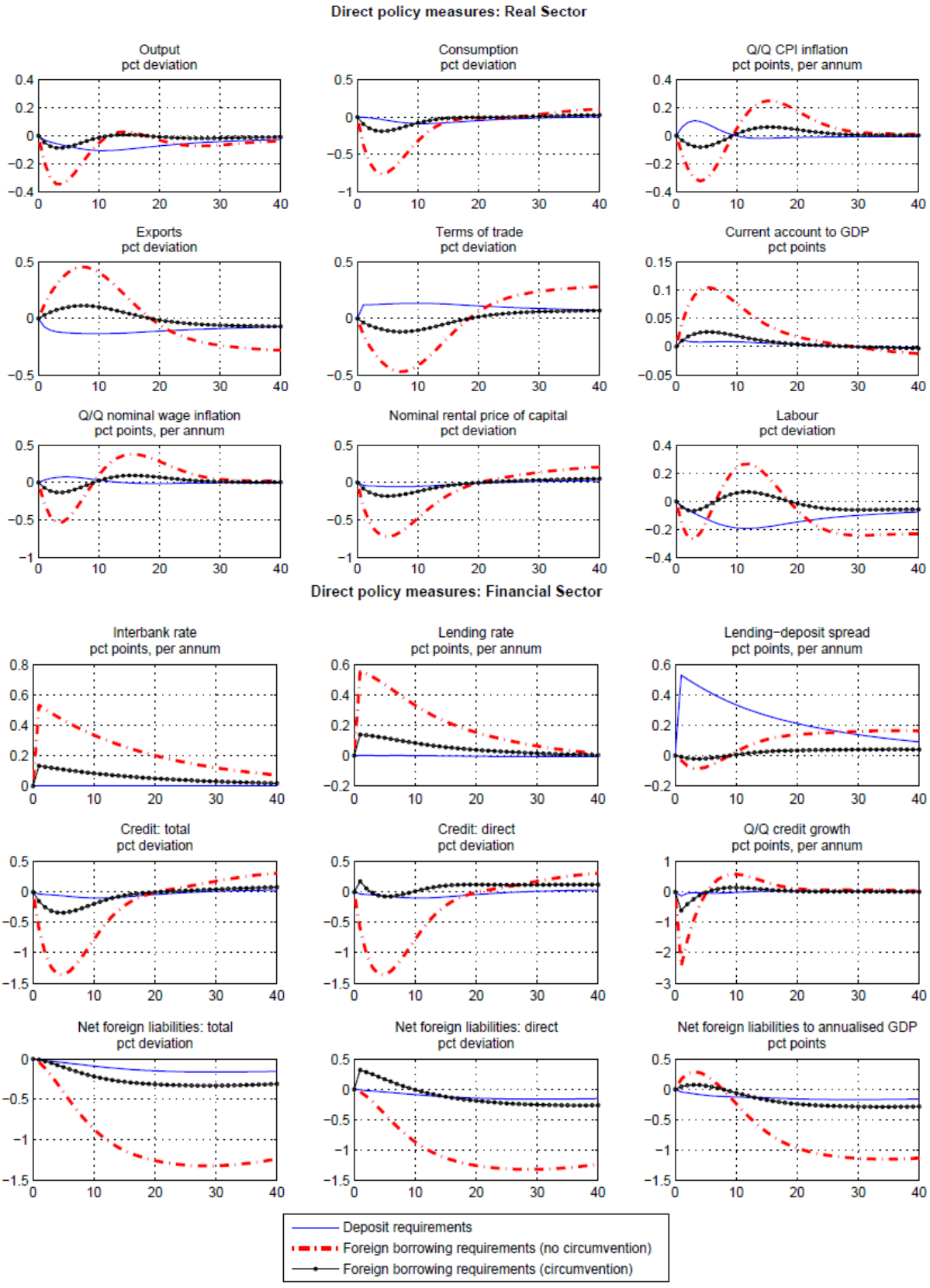
69. The simulations illustrate that the way the RRs on deposits and foreign borrowing influence real economic activity depends on the implications of the two policy measures for the behavior of lending and deposit rates. The two instruments have similar qualitative effects on output, consumption, and employment, but differing consequences for domestic prices, exports, and the current account balance, reflecting how the changes in the two instruments are transmitted to the economy. The shock to the RR on deposits affects the economy primarily through the cost channel, resembling a supply side shock. The shock to the RR on foreign borrowing affects the economy mainly through the intertemporal substitution channel:

[15] Recall, however, that the two types of foreign borrowing (i.e., foreign borrowing through the "official" domestic banking sector, and foreign borrowing intermediated outside the domestic banking sector) are assumed to be imperfect substitutes—a reasonable assumption since not all firms may have easy direct access to external funds.

Table 3. The Simulated Effects of the Policy Shocks to Credit Supply: Price-based Credit Measures

	Higher reserve requirement on deposits	Higher reserve requirement on foreign borrowing (no circumvention)
Shock	The shock raises the RR by [10] percentage points in the first period, gradually bringing it back at an autoregressive rate of 0.95.	The shock raises the RR by [10] percentage points in the first period, gradually bringing it back at an autoregressive rate of 0.95.
Transmission channel	The shock affects the economy primarily through the cost channel, resembling a supply side shock. It causes a decrease in the deposit rate, and hence a higher lending-deposit spread.	The shock affects the economy mainly through the intertemporal substitution channel. It leads to an increase in the bank lending rate, as well as in the deposit rate (since marginal costs of all bank activities rise), hence with little change in lending-deposit spread.
On impact	**The deposit rates** fall, while lending rates remain unchanged. This is because the marginal rate of funding from abroad remains unchanged, and hence the rates banks pay to depositors need to fall to compensate for the higher RR.	The marginal cost of borrowing from abroad for banks increase, making loans to the private sector more expensive (higher **lending rate**). It also drives up **deposit rates** by approximately the same amount, leaving the lending-deposit spread little changed.
Step 1	The higher **lending-deposit spread** makes debt financing of firms more expensive, pushing up their supply curve, and raising **prices**.	Higher lending rates bring **consumption** down (intertemporal substitution of consumption today for consumption tomorrow). Demand for **consumer loans** also falls.
Step 2	• Higher prices of domestic goods then lead to substitution away from domestic goods, leading to a fall in **net exports,** hence lower **output**, and lower **consumption** given falling export revenues. • **Bank credit and direct borrowing** decline given lower output and consumption. • **Wages** increase, matching inflation, while the real wage remains about unchanged.	• **Output** falls, with falling consumption. • Falling output brings down **inflation**.
Step 3	• **The real rate of capital rental** (as the price of capital flow) falls with falling output: with the supply of capital fixed, falling production and demand for capital translates into a lower real rental rate. Nominal rental rates fall too, although most of the fall in the real rental rate comes through higher inflation of domestic goods. • **The nominal price of capital** (as an asset) increases: Although the nominal rental rate is lower throughout the simulation, the higher general price level in the economy also drives up the price of capital in the future (so that ultimately, the relative price of production and capital are unchanged). The higher expected price of capital in the future also translates to higher price today, offsetting the effect of lower rental rates. • **Employment** declines proportionately more than the fall in production, because: (i) lower output lowers labor demand, and (ii) the price of labor (whose real wages are unchanged) increases relative to that of imports (nominal exchange rate constant in contrast to falling nominal wages) and capital (real price of capital falls), so the demand for labor declines more than the demand for imports and capital.	• **Net exports** increase on account of improved terms of trade (lower domestic prices). • Higher exports partially mitigate the effect of falling consumption on **output**, so output declines less than consumption. • Falling output and consumption bring down demand for **bank credit**. • With lower credit, **net foreign borrowing** also declines. • Subsequently, **nominal and real wages** fall in line with falling demand for labor • **Employment** falls, but proportionately less then output, because real wages fall relative to the price of imports (nominal exchange rate constant), thus mitigating the effect of falling output on employment. • **Nominal rental rate of capital** falls more than the rate of inflation, so that the real rental rate falls. Falling output shifts down the demand for capital curve, which (with a fixed capital supply) translates to a falling real rental rate. **Price of capital** (as an asset) declines owing both the fall in the nominal rental price as well as the decline in the general price level that pushes down the final price of assets.
Step 4 (long run)	Falling output over time brings inflation down, offsetting the effect of higher lending-deposit spread that gradually vanish. This triggers substitution back to domestic goods, leading to a gradual recovery of output, consumption and credit. Higher price of capital translates into a lower country risk premium that contributes to a faster decline in lending-deposit spread.	• Falling domestic prices over-time bring more demand to domestic production. Output and credit recover, and labor even temporarily increases above the initial level thanks to the relatively low real wages (compared to real exchange rate). • • Through the cost channel, prices go up, eroding the competitive advantage.

Figure 2. Simulated Effects of the Price-Based Credit Measures



- RRs on deposits push the deposit rate down, without first-round effects on the lending rate, since the marginal rate at which extra funds are available is still given by the unchanged foreign interest rate. As a result, the lending-deposit spread rises, making it costly to hold liquidity for private agents (households for consumption purchases and firms for payment of the input factor bill). This direct policy instrument hence works primarily through the cost channel, similar to a supply-side shock.

- RRs on foreign borrowing, on the other hand, increase the marginal refinancing cost of the banking sector. Both the lending and deposit rates go up in response, with very little effect on the spread, implying that real activity goes down mainly through the intertemporal substitution channel.

70. All simulations see a drop in output and employment. In the case of RRs on deposits, the output fall is driven mainly by exports, whereas in the case of RRs on foreign borrowing, domestic demand matters more. Higher deposit RRs work as a supply-side shock, thereby resulting in lower output and higher prices. Domestic aggregate demand, on the other hand, initially does not change much (with little change in lending rates); lower output is therefore due mainly to lower exports, with domestic goods now more expensive. In contrast, the higher RR on foreign borrowing reduces aggregate demand (and output) through higher lending rates. The demand for domestic exports increases given the lower domestic prices, thus mitigating the extent of the overall output decline. Lower output results in a fall in bank credit as a result in all scenarios, as well as a decline in net total foreign borrowing. The size of the responses of model variables is much larger for the shock to RR on foreign borrowing.

71. Overall, the shock to RRs on foreign borrowing affect the real economy through a similar propagation mechanism, and has similar effects on the real and financial sector variables, whether or not the measure can be circumvented through the possibility of direct borrowing by the corporate sector. One important exception is the behavior of direct foreign borrowing by corporations; the latter increases under the circumvention scenario, despite the fall in total demand for credit, because the effect of the cheaper relative cost of borrowing directly from abroad, compared to borrowing from the domestic banking system, dominates. Moreover:

- The quantitative impact of the shock on model variables is smaller when the private sector can bypass the RR on banks by directly borrowing from abroad at an unchanged cost, thereby substituting partially the banking sector credit that becomes more expensive with the higher RR. The circumvention is not full, because the two types of loans are not perfect substitutes. Despite the substitution, the overall cost of credit for domestic firms increase (higher effective lending/borrowing rate in Figure 2), resulting in a contraction in output of the domestic sector, and a fall in consumption, employment, and total credit to the private sector. The effective lending rate facing the real sector is even higher when we shut down the alternative borrowing channel. The fall in employment, consumption and output is hence much larger when corporates cannot substitute the more expensive bank loans with loans from abroad.

- When firms can circumvent through direct foreign borrowing, the effect on total net liabilities is also smaller, as the decline in banks' foreign borrowing from abroad is largely offset by the increase in firms' foreign direct borrowing at an unchanged interest rate. If the two types of funds were perfect substitutes, firms would simply stop borrowing from the banking sector, and replace these funds with direct loans from abroad. The effective lending rate would hence not be affected by the policy measure, with no implications for real economic activity.

72. The policy simulations analyzed here illustrate that measures to affect bank credit can have significant effects on the real sector of our stylized economy. The overall effect of the measures would depend, however, on the type of controls imposed, as well as the private sector's ability to get around the measures by substituting the targeted credit with alternative sources of funding. The impact of the measures on the targeted macro aggregates (such as, total credit to the private sector—provided both by domestic banks and from abroad—and total foreign liabilities of the economy) could therefore be much weaker than desired.

Credit growth controls

73. In this experiment, we examine the impact of imposing limits on the growth rates of credit extended by banks. The limits are for a period of one year, and are abandoned subsequently. The set-up of the credit controls is known to, and anticipated by, all private agents. Banks are required to extend credit at a rate 4 percentage points lower than in "normal" times (i.e. in the long-run or, strictly speaking, in the steady-state) for four consecutive quarters.

74. The credit controls are introduced as a quantitative restriction to an individual bank's optimization problem, and give rise to a shadow value affecting the lending rate. Because the controls are imposed on the growth rate, and not on the level, of credit, today's lending rate setting is determined not only by today's, but also tomorrow's expected shadow value of the restriction. The information set-up of the exercise (i.e. how long the controls are *announced* to last, how long they are *expected*, and how long they actually last) is therefore important for the outcomes. The main transmission channels of the policy shock and its impact on the real and financial sectors of the economy are summarized in Table 4 and illustrated in Figure 3.

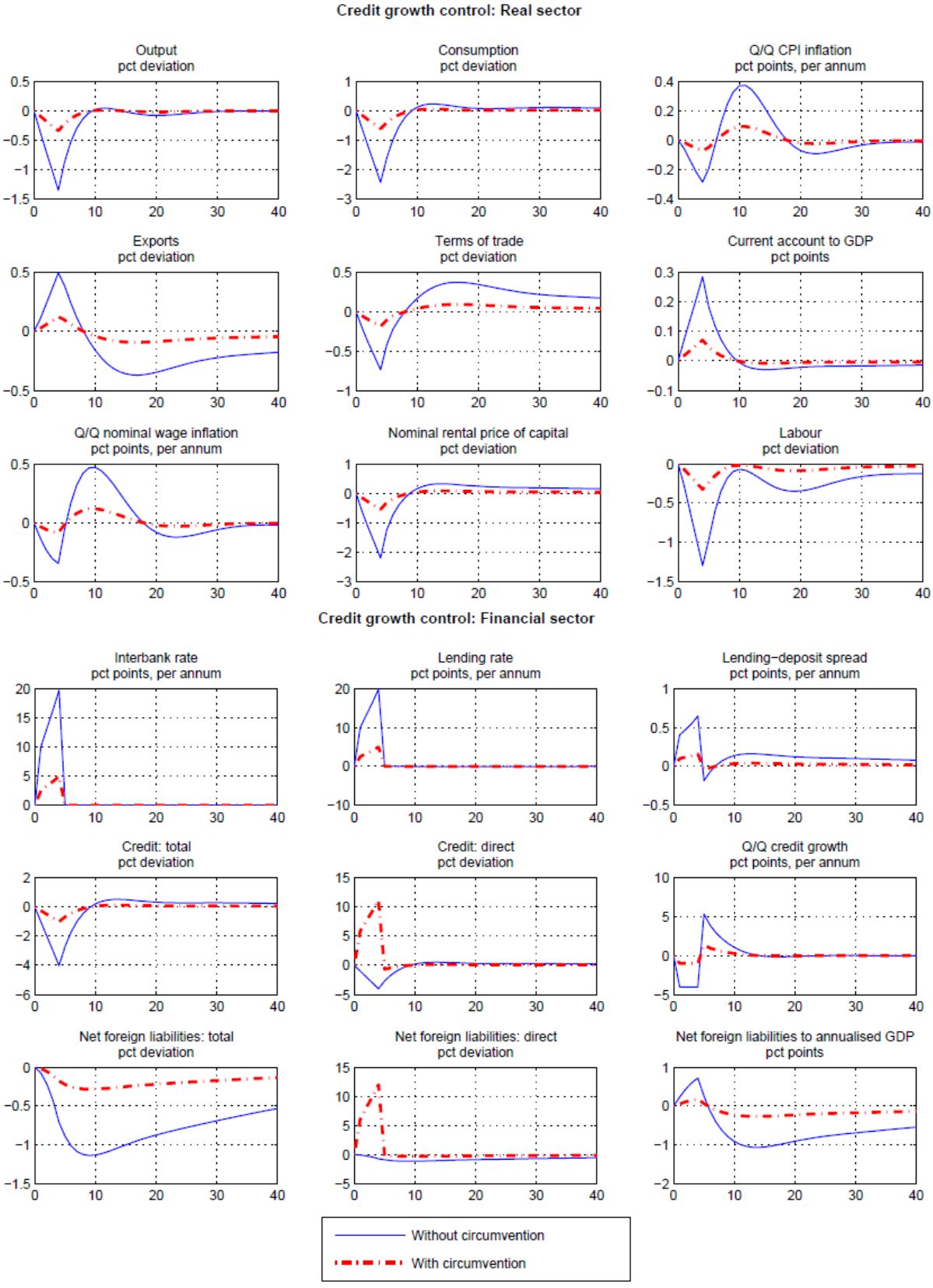
75. The impact of the credit limit on the real economy is similar qualitatively to those of the increase in reserve requirements on foreign borrowing. Real economic activity, consumption, and employment fall as bank credit to the private sector is constrained by the monetary authority, with the shock transmitted to the economy through an increase in banks' lending rate that leads to a higher lending-deposit rate spread (hence making output and consumption more costly). The fall in inflation leads to an increase in exports and an improvement in the current account. Total borrowing from abroad goes down as bank credit and economic activity falls.

76. Similar to the earlier experiment, the magnitude of the shock impact on the financial and real variables of the model is more subdued when the corporate sector can partially substitute bank credit with direct borrowing from abroad (i.e., with circumvention of the

Table 4. The Simulated Effects of the Individual Policy Shocks to Credit Supply: Credit Growth Controls

The shock	A limit is imposed on the growth rate of credit extended by the banks. The limits are maintained for the period of one year, and abandoned afterwards. The shock is equivalent to imposing an extra constraint on banks' optimization: $L_t \leq \overline{L}$.
Transmission channel	The credit control affects the economy through two main channels: drop in consumption (intertemporal channel) and exports (more expensive production worsening the competitiveness).
On impact	• **Credit to households and firms** decline in line with the imposed credit growth controls. • The **lending rate** increases, reflecting the rise in the shadow value of the credit constraint, since credit controls are costly for banks. • The **bank lending-deposit spread** goes up, since deposit rates are not affected on impact, because the marginal rate of foreign borrowing is unchanged. • **Bank foreign liabilities** fall, as the need for external borrowing to support credit growth declines.
Step 1	• **Consumption** falls, following the rise in the lending rate. • Firms replace partially the more expensive bank credit for cheaper **direct foreign borrowing** as the cost of bank credit goes up, but the overall cost of credit to firms rises (and overall credit, both from domestic banks and from abroad, decline – see step 2). • **Inflation** falls, as the fall in demand (consumption) offsets the higher production costs (supply curve shifts up with higher lending-deposit spread). • **Terms of trade** improve, as the domestic prices falls.
Step 2	• **Exports** increase, as competitiveness (terms of trade) improve. • **Output** falls because of falling consumption. • **Direct foreign borrowing** also falls, as the output falls, although less than bank credit Overall, total foreign borrowing (by banks and firms) is lower because less credit extension by banks and lower output by firms require less borrowing from abroad.
Step 3	• **Real and nominal returns to capital** decline. With output down, the demand for capital declines, which (given the fixed supply of capital) translates into falling real rental rate. Nominal rates of return fall too, as the rise in inflation does not bring real rates down sufficiently. • **Price of capital (as an asset)** declines, following the decline in nominal rental rates and higher lending rates . • After a temporary drop, **nominal wages** rise to match higher inflation so that real wages are about unchanged. • **Employment** drops, as labor demand falls and the real wage rate does not adjust. The decline in labor is more pronounced given the higher price of labor relative to foreign inputs (nominal exchange rate unchanged),
Step 4 (Long-run effects)	• There is a sharp reversal, after the growth controls are removed, with some oscillations before the economy reverts to its steady state. The falling output brings inflation down. Lower inflation subsequently improves terms of trade, exports, and output. The interest rates adjust immediately after the controls are removed, and credit recovers, going back to its steady state after three years.

Figure 3. Simulated Effects of the Direct Credit Controls



bank credit limits imposed on domestic banks). After the credit growth controls are removed, the economy reverts to its steady state following some oscillations in the model variables. With the falling output bringing inflation down, terms of trade, and consequently exports, improve, finally pushing output up as well. The interest rates adjust immediately after the controls are removed, and credit to the private sector recovers back to its steady state.

V. Conclusions and Policy Implications

77. This paper developed a stylized, small, open economy macro model that incorporates an explicit financial sector in a stylized DSGE model of monetary policy transmission. In an environment characterized by a high degree of openness, financial dollarization, and a managed exchange rate, the model features a dominant role for banks that intermediate foreign or domestic financial flows in the form of loans to households and corporates through a costly production process, maintain required reserves with the monetary authority, and clear the net surplus or deficit of funds with the world financial market. The model also incorporates non-bank intermediaries, which combine bank loans and funds obtained directly from abroad and extend this bundle of funds to nontradables firms.

78. Calibrating the model to a stylized emerging European economy, the paper simulated real and financial sector implications of various external and policy-related shocks. In particular, it illustrated the model's use for policy analysis in an emerging market economy where policy-makers are concerned about risks associated with rapid credit growth (e.g., current account imbalances and fast accumulation of private and banking sector external debt, and exposure to risks of a sudden decline in the availability of funds to the economy) in the absence of traditional tools of monetary policy transmission (e.g. short-term interest rates). In such an environment the policymakers often resort to more direct instruments, such as foreign exchange market intervention, and regulatory and direct controls on domestic banks.

79. To illustrate how various policy measures and shocks affect the key economic and financial aggregates, the paper analyzed the implications of an externally-induced and a policy-induced credit crunch. In particular, it considered three sources of an externally induced credit crunch: (i) tighter lending conditions by banks, as a result of increased risk aversion in lending to the private sector (due, e.g., to heightened economic and funding uncertainties); (ii) costlier access to external funding by banks; and (iii) costlier external borrowing for the entire economy. It also analyzed the implications of direct monetary policy measures aimed at reducing the rapid growth of bank loans: (i) reserve requirements on excessive bank lending; (ii) reserve requirements on banks' borrowing from abroad; and (iii) credit limits for banks.

80. The three simulations analyzing externally-induced credit crunch illustrate that all three financial shocks have significant real sector implications, generating much lower consumption, output, employment, and prices of factor inputs. The impact on the current account depends on how imports (net exports) react to the shocks. Activity in the domestic financial sector is also reduced, with higher bank lending rates, lower demand for bank credit, lower foreign borrowing by banks, and lower direct borrowing by corporations. The fall in credit to households and corporations, and the impact on the real variables, are the

largest under the foreign risk premium shock, which causes an increase in the cost of borrowing by both banks and corporations, thereby reducing the scope for firms to substitute bank borrowing with funds directly from abroad.

81. The policy-induced negative supply shocks can also have significant real and financial sector implications. Both price-based measures that reduce bank credit by reducing its funding sources (i.e., the reserve requirements on bank deposits and bank foreign borrowing) result in a drop in output, consumption, and employment. The effects of changes in deposit reserve requirements are quantitatively much smaller than those of foreign borrowing reserve requirements. This is because reserve requirements on deposits affect only deposit rates on impact (lending rates are unaffected given perfect competition among banks). On the other hand, reserve requirements on foreign borrowing affect both lending and deposit rates, because they change the marginal cost of funds for the banks. However, because households are net borrowers, lending rates matter more than deposit rates.

82. The impact of the credit limit on the real economy is similar qualitatively to those of the increase in reserve requirements on foreign borrowing, because both affect the marginal cost of financing in a similar way. Real economic activity, consumption, and employment fall as bank credit to the private sector is constrained by the monetary authority. The shock is transmitted to the economy through an increase in bank lending rates that make output and consumption more costly.

83. The policy simulations also illustrate that the overall effect of the direct measures would depend on how the controls are transmitted to the rest of the economy, as well as on the private sector's ability to get around the measures by substituting the targeted credit with alternative sources of funding. The quantitative impact of the shock on model variables is smaller when the private sector can bypass the reserve requirements and bank credit limits by directly borrowing from abroad, thereby substituting partially the banking sector credit that becomes more expensive. The impact of the measures on the targeted macro aggregates (e.g., total credit to the private sector—provided both by domestic banks and from abroad—and total foreign liabilities of the economy) could therefore be much weaker than desired.

84. The model has been developed to serve as a practical tool, assisting monetary policy making in emerging small open economies characterized by a high degree of dollarization and exchange rate management. The policy experiments presented here illustrate that the model is a useful tool in studying policy responses to various real and financial sector shocks. Based on the model responses to a given policy shock, policymakers could judge the net benefit of alternative measures to deal with financial sector challenges faced. Moreover, the model's malleable format and its relatively easy mapping to data would also make it a useful and practical forecasting tool.

85. With its capacity to model the interactions between the real and financial sector of an emerging market economy, the model could also be used for financial stability analysis. In particular, it could be used to test the sensitivity of various financial and macroeconomic variables to alternative shocks (e.g., to the exchange rate, interest rates, output, capital inflows in the form of bank borrowing, and policy instruments). The results of such experiments could provide input to determining internally consistent macro scenarios that

feed into stress testing the resilience of the banking sector against various extreme but plausible domestic and external shocks.

86. One should bear in mind, however, some important model simplifications that may reduce the model's usefulness in analyzing some significant financial or real sector phenomena. First, in its current version, the model is not a full general equilibrium model in that it does not provide micro foundations for the link between the borrower's ability to service its debt and the cost of the debt. This in turn limits the analysis of the potential impact of changes in asset quality on bank balance sheets and hence the feedback loop between real and financial sectors. The model also excludes financial accelerator mechanisms and motivation for a precautionary capital build-up. Moreover, the channel capturing the effects of a deteriorating corporate sector balance sheet (e.g. through an exchange rate depreciation) on the cost of borrowing is only approximate. Finally, the simplification of bank balance sheets to exclude the need to hold capital limits the model's capacity to analyze other important regulations, such as changes in capital requirements. Some extensions of the model that incorporate these features are currently being developed.[16]

[16] The recent extensions of the model include (i) a housing sector, with housing wealth and house prices generating a financial accelerator effect through the households' balance sheets, (ii) endogenous bank capital with costly deviations from the optimum loan to capital ratio, and (iii) endogenous default rates of the households vis-à-vis large unexpected depreciations and/or income drops. These models have been used to study the choices the policy makers face in emerging market economies hit by the world financial crisis.

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