Aggregate risk and bank capital: Incentive-based analysis of capital regulation in an open economy*

Jaromír Beneš[†]

Michael Kumhof[‡]

David Vávra[§]

February 11, 2011

Work in progress

Abstract

We develop a simple model that integrates the basic channels of both monetary and macroprudential policy transmission, with special reference to emerging-market economies. The model is meant to be an example of an operational tool used for practical policy making and advice. We illustrate the use of the model developing a number of hypothetical scenarios that simulate various sources of risk to both monetary policy and financial stability in a typical emerging-market economy: shocks to the country spread, terms of trade shocks, and asset price bubbles.

[0]The views expressed herein are those of the authors and do not reflect the views of any of the affiliate institutions.

[†]Research Department, International Monetary Fund. jbenes@imf.org. Corresponding author.

[‡]Research Department, International Monetary Fund. mkumhof@imf.org.

[§]O.G.Research, Prague. dvavraatog@gmail.com.

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1 Introduction

We aim to develop a simple model that would incorporate the basic interactions between real business cycles (i.e. fluctuations in prices and quantities related to real economic activity) and (macro)financial cycles (i.e. fluctuations in risk on the balance sheets of financial instutions), and could be used to quantify the basic channels of both monetary and macroprudential policy transmission, with special reference to emerging-market economies. Models of this kind are needed for regulators and policymakers to lay foundations of an operational framework upon which the practical macroprudential policy making could be based. We do not mean to take the model we build at face value: We rather see its role as a platform upon which a broader amount of information, including not only the model's assumptions but also other off-model evidence and expert judgment, can be combined to produce and co-ordinate sensible policy advice.[1]

We built in several features we find crucial for building such a framework and modelling the interplay between the real and financial sectors, some of them rather novel in monetary macro models. They can be summarised as follows. Bank lending is associated with credit risk, and banks are exposed to some of the aggregate, non-diversifiable, risk. Exposed to such non-diversifiable risk, the banks need to have their own net worth (equity, bank capital), and the net worth plays a non-trivial role in determining the banks' lending policy. This observation is in contrast to a large amount of macroeconomic models with financial frictions and state-contingent debt contracts, originated by Carlstrom and Fuerst (1997) and Bernanke et al. (1999).

Furthermore, bank capital is subject to regulation, but this regulation is not "hard-wired" as a binding constraint into the banks' decision-making, as has been the working assumption of some of the models with regulated banks, e.g. Angeloni and Faia (2009). The regulation is rather a system of penalties that creates certain incentives for their behaviour, as put by Milne (2002). This way, we give rise to endogenous regulatory capital buffers, which are an important empirical regularity in all banking systems, see e.g. Jokipii and Milne (2008), and are able to interpret the responses of such capital buffers to various shocks using value-at-risk (or capital-at-risk) types of conditions, such those derived by Estrella (2004) or Peura and Jokivuolle (2004). A necessary condition, though, for the existence of the capital buffers is that acquiring fresh capital is subject to some sort of frictions, rigidities, costs, or delays, as emphasised by many

[1] Exactly this is the best practice of the world's leading central banks in practical monetary policy making and forecasting.

authors, including Van den Heuvel (2002), Estrella (2004), or Peura and Keppo (2006). Finally, there exists an endogenous link between the characteristics of aggregate uncertainty facing the banks, and the banks' own behaviour.

We illustrate the use of the model in a series of policy experiments and simulations. We explain the potential macroprudential consequencies of some of the major shocks that may pose systemic risk in a typical emerging-market economy: a country spread shock, a terms of trade shock, or an asset price bubble. Although we show the implications of various combinations of macroprudential and monetary policy responses, we do not provide a formal welfare-based metric to evaluate the optimality of these. The main two reasons are as follows. First, while it is relatively easy to evaluate the *costs* of capital requirements, such as lower output because of a higher cost of borrowing as in Estrella (2004), redirection of credit away from riskier but more productive projects as in Tchana (2009), or reductions in liquidity services provided by bank liabilities as in Van den Heuvel (2008), it is relatively difficult to model the *benefits* thereof (i.e. curbing excessive risk taking and excessive leverage) without resorting to very specific assumptions whose quantification would be rather unrobust. We believe that proper evalutation of such benefits will, to a large degree, involve policymakers' judgment, Tucker (2009), Saporta (2009). Second, the outcomes of policies aimed at financial stability are heavily affected by non-linearities arising during less likely but more damaging episodes of systemic tail-risk shocks. Evaluating such policies cannot be therefore based on the traditional linear-quadratic control framework, as is the most of the optimal monetary policy literature; it must adopt more global numerical methods.

The paper is organised as follows. In section 2, we set forth the financial sector, i.e. the interactions and frictions arising between households and banks. In section B, we detail the rest of the model. We then design and conduct our policy experiments and simulations in section 5. Section 6 concludes. Some more technical details are provided in Appendices A to **??**.

2 Financial Structure of the Model

In this section, we describe financial interactions and frictions between households and banks. These are then incorporated in a simple general equilibrium macroeconomic model of a small open economy in the next section.

Our aim is to create a feedback loop between the real economy and the financial sector, and make financial institutions subject to capital regulation. To that end, we find the following three elements critical: (i) There exist endogenous stochastic defaults on some of the financial liabilities in equilibrium; (ii) At least some of the credit risk cannot be diversified by financial institutions, in other words, banks bear some of the aggregate risk, and their net worth can be hit by unexpected shocks; (iii) The (Modigliani-Miller type of) equivalence between debt financing and capital breaks down so that bank lending is affected by the level of bank capitalisation.

In our model, we introduce those three key elements through the following assumptions. Households borrow from banks to finance their current and capital expenditures. The contract between the two parties is affected by financial frictions arising because of limited enforcement:[2] A borrower may choose to default on his or her obligations without further consequences, in which case the lender can only seize the borrower's assets that collateralise the loan (here: productive capital), and recover the market value less a liquidation cost. Note that in our model with limited enforcement and collateralised borrowing, the risk premium emerging as a result of the financial frictions affects not only capital purchases (and hence aggregate investment), but also consumption. This is, indeed, a very appealing feature in models of small open economies for it has the power to "close" the model (i.e. induce a stable long-run distribution of the consumption-to-wealth ratio) in a more theory-consistent way than other, more ad-hoc, mechanisms used; see Schmitt-Grohé and Uribe (2003) for an overview of such mechanisms.

Furthermore, the debt contracts in our model are non-contingent upon future outcomes; that this, lending rates are fixed at the beginning of the contract and cannot be adjusted later on, just like in the real world. This is an important difference from a large amount of monetary literature with the so-called financial accelerator that builds upon state-contigency of lending rates, such as Bernanke et al. (1999). The main implication is that lenders are now to exposed non-diversifiable aggregate risk (on top of the usual diversifiable idiosyncratic risk).[3]

Finally, the banks are subject to *ex-post* capital requirements, introduced in the form of a penalty charged whenever a bank's net worth calculated *after* the returns on assets and the costs of liabilities are realised falls below a regulatory minimum. We adopt this type of incentive-based model of capital regulation from the bank portfolio choice literature, for instance Milne (2002). As emphasised by many authors, e.g. Peura and Keppo (2006), Van den Heuvel

[2]See e.g. Alburquerque and Hopenhayn (2004), Lorenzoni and Walentin (2007), or Gerlter and Karadi (2010) for examples of other macro models with limited or costly enforcement.

[3]The idea of non-contingent contracts in a macro-prudential model is also found in Zhang (2009). However, the author makes the cut-off idiosyncratic productivity fixed ex ante, not the lending rate, an assumption that bears in our view less realism.

(2002), capital adequcy requirements will only play a non-trivial role in the bank portfolio choice if recapitalisation is costly or associated with some kinds of imperfections: Our assumption of ex-post regulation is exactly one of such. On top if it, we also introduce another kind of capital market rigidity, namely shareholders' cost of injecting or withdrawing capital to or from the banks after the return on equity is realised. In the extreme case (with the cost made infinitely large) the bank capital can be only cumulated from retained earnings – an assumption made, in fact, relatively frequently in models with financial frictions. This other type of bank capital imperfection will be introduced in section B.

To keep the exposition of the basic problems simple, we derive our results under the following two simplifying assumptions. First, all financial assets and liabilities, including foreign borrowing (introduced in the next subsection) are denominated in local currency. It is, though, relatively straightforward to adapt the equations for any currency structure. In Appendix **??**, we show a version with full financial dollarisation, which is also extensively used in our policy experiments.

Second, note the bank makes two basic types of choices in our model. It needs to specify the terms of the debt (loan) contract with the household, and to find an optimal structure of its liabilities, i.e. capital (equity) and foreign borrowing to finance the loans, given capital requirements in place. We separate these two decisions from each other: We can think of the bank as consisting of two branches: a wholesale branch, acquiring finance, and a retail lending branch, screening customers and signing contracts with them. Each branch then takes the other's decisions as given.

2.1 Contract between the Bank and the Household

There a single representative household that consists of a large number of members indexed by $j \in (0,\, 1)$. While consumption decisions are made by the household as a whole (and will be described in the next section), capital purchases and bank loans are chosen by each member individually taking the household's shadow value of wealth as given. This assumption provides full risk sharing to the household members, and makes them all identical at the time they make their decisions despite the fact that they face idiosyncratic uncertainty afterwards.

At time t, member j purchases $P_{K,t}K_t^j$ worth of capital, and takes a loan L_t^j signing a debt contract collateralised by the capital and the future returns thereon. The contract specifies a non-contingent gross interest rate $R_{L,t+1}^j$. At the beginning of time $t+1$, the capital becomes worth $R^j_{K,t+1} P_{K,t} K^j_t$, where $R^j_{K,t+1}$ is the individual return on capital (including both a rental price received from producers, capital gains, and depreciation). The return has two components, an aggregate one, $R_{K,t+1}$, and an idiosyncratic one, ω^j_{t+1},

$$R^j_{K,t+1} = R_{K,t+1} \omega^j_{t+1},$$

and $\omega^j_{t+1} \in (0, \infty)$ is a random variable with a known c.d.f. identical across all household members and denoted by $\Phi(\cdot)$, and normalised relative to $R_{K,t+1}$ so that $\mathbb{E}_t[\omega^j_{t+1}] = 1$.

At the same time, she is also supposed to repay $R^j_{L,t} L^j_t$. If the value of capital (including the rentals) falls, however, below the amount due, she defaults on the loan, and runs away letting the bank seize the capital. Given the aggregate return on capital, $R_{K,t+1}$, the cut-off idiosyncratic productivity for a default is given by

$$\bar{\omega}^j_{t+1} := \frac{R^j_{L,t} L^j_t}{R_{K,t+1} P_{K,t} K^j_t} = \frac{R_{L,t}}{R_{K,t+1}} \ell_t. \tag{1}$$

where $\ell_t := L_t/(P_{K,t} K_t)$ is a loan-to-value ratio. The bank seizes and sells the capital of the defaulted in the market, receiving the market value, $R_{K,t+1} \omega^j_{t+1} P_{K,t} K^j_t$, less a liquidation cost, which is a fraction $\nu \in (0, 1)$ of the market value.

We write the effective loan repayment expected to be made by household member j as $\mathbb{E}_t[R^j_{L,t} L_t \, g(\omega^j_{t+1})]$, and the loan repayment expected to be received by the bank as $\mathbb{E}_t[R^j_{L,t} L^j_t \, h(\omega^j_{t+1})]$. It follows that

$$g(\omega) = 1 - \Phi(\omega) + \frac{1}{\omega} \int_0^{\omega} \omega \, \mathrm{d}\, \Phi(\omega) = \frac{1}{\omega} G(\omega), \tag{2}$$

$$h(\omega) = 1 - \Phi(\omega) + (1-\nu) \frac{1}{\omega} \int_0^{\omega} \omega \, \mathrm{d}\, \Phi(\omega) = \frac{1}{\omega} H(\omega). \tag{3}$$

We are now ready to work out the terms of the optimal debt contract between the bank and household member j. To that end, we need to find L^j_t, K^j_t, and $R^j_{L,t}$ to maximise the household's expected value

$$\max_{L^j_t, K^j_t, R^j_{L,t}} \Lambda_t \left[L^j_t - P_{K,t} K^j_t \right] + \\ + \beta \, \mathbb{E}_t \, \Lambda_{t+1} \left[-R^j_{L,t} L^j_t \, g(\omega^j_{t+1}) + R_{K,t+1} P_{K,t} K^j_t \right] \tag{4}$$

where Λ_t is the household's shadow value of nominal wealth[4], subject to a rationality constraint requiring that the bank receive (at least) the opportunity

[4]That is, a current-dated Langrange multiplier associated with the household's budget constraint

cost. As the contract is non-contingent, the rationality constraint can only hold in expectations,

$$\mathbb{E}_t\left[\frac{R^j_{L,t} L^j_t\, h(\omega^j_{t+1})}{R_{E,t+1}}\right] = r_t L^j_t, \tag{5}$$

where $R_{E,t+1}$ is the future aggregate return on equity. The opportunity cost, r_t, is determined by the wholesale branch, and is derived in the next subsection.

Substituting the Lagrange multiplier on (5) away from the three first-order conditions to the optimal contract problem, we obtain the following two equations:

$$\mathbb{E}_t\left[\frac{\beta\Lambda_{t+1}}{\Lambda_t} R_{K,t+1}\, G'(\bar{\omega}^j_{t+1})\right] = \frac{1}{r_t}\,\mathbb{E}_t\left[\frac{R_{K,t+1}}{R_{E,t+1}} H'(\bar{\omega}^j_{t+1})\right], \tag{6}$$

$$\mathbb{E}_t\left[\frac{\beta\Lambda_{t+1}}{\Lambda_t} R_{K,t+1}\left(1 - G(\bar{\omega}^j_{t+1})\right)\right] = \ell^j_t - 1, \tag{7}$$

and the rationality constraint, (5), proper. Eq. (6) can be interpreted as a modified Euler equation linking the marginal utility of consumption (entering the equation through the shadow value Λ_t) to the cost of intertemporal substitution. Eq (7) is a capital price equation.

Because the ex-ante distributions of the idiosyncratic components of the returns on capital, ω^j_{t+1}, are identical across all members of the household, the contractual terms will be the same, and all members will choose the same loan-to-capital ratio under the same lending rate. However, neither the individual nor the aggregate levels of L^j_t, $L_t := \int_0^1 L^j_t \,\mathrm{d}\, j$, K_t, and $K_t := \int_0^1 K^j_t \,\mathrm{d}\, j$ themselves are determined by these conditions, and will follow from the rest of the model.

Finally, the expressions for $G(\omega)$, $G'(\omega)$, $H(\omega)$, and $H'(\omega)$ when the idiosyncratic component is distributed log-normally can be found in Bernanke et al. (1999). We list the first-order conditions with these expressions in Appendix A.

2.2 Bank Capital Choice

We now turn to determining how much capital the bank will hold and how much foreign funding it will obtain to finance its lending, and how the required return in the rationality constraint is determined. We first exposit the basic trade-off facing the bank. Foreign borrowing is a cheaper source of funds than capital (that the interest rate on the foreign funds, $R_{F,t}$, is lower than the expected, or requested, return on equity, $R_{E,t+1}$, is explained later), therefore absent capital regulation the bank would always choose to avoid capital funding. However, it is subject to *ex-post* capital requirements obligating the bank to have sufficient value after the returns on its assets and the costs of its liabilities are realised, or face a penalty proportional to the assets:

$$R_{t+1}L_t - R_{F,t}F_t < \gamma R_{t+1}L_t \Rightarrow \text{penalty } \upsilon L_t. \tag{8}$$

The condition, similar to Milne (2002), formalises the fact that we think of capital regulation as an incentive-based mechanism affecting the bank's optimal portfolio choice, rather than a inequality binding at all times. The distinction between the incentive-based model and a hard-wired restriction only arises though when the world is uncertain. Were the return on loans, R_{t+1}, known in advance and free of risk, a bank faced with (8) would simply maintain capital and loans in fixed proportion provided the two regulation parameters, γ and υ, are restrictive enough.

The bank behaves competitively taking as given the distribution of the total return on its assets, R_{t+1}, received from the retail branch,

$$R_{t+1} := \frac{\int_0^1 R^j_{L,t} L^j_t \, h(\bar{\omega}^j_{t+1}) \, \mathrm{d}\, j}{L_t}, \quad L_t := \int_0^1 L^j_t \, \mathrm{d}\, j, \tag{9}$$

as well as the costs of its liabilities, $R_{F,t}$ and $R_{E,t+1}$. It chooses the volume of loans, L_t, foreign funding, F_t, and capital (equity), E_t, to maximise the shareholders' value,

$$\max_{L_t,F_t,E_t} \; \mathbb{E}_t \left[\frac{R_{t+1}L_t - R_{F,t}F_t - \upsilon L_t \Psi(\widetilde{R}_{t+1})}{R_{E,t+1}} \right] - E_t \tag{10}$$

subject to a balance sheet identity, $L_t = F_t + E_t$. As explained earlier, we abstract from limited liability and allow for possible $t+1$ states with the bank's value negative (making the shareholders liable);[5] we investigate the quantitative effects of limited liability on the bank's optimal choice numerically in Appendix **??**, and find them rather negligible. The $t+1$ cash flows are discounted by the shareholders' opportunity cost, i.e. the aggregate return on equity. The last term in the numerator is the expected cost of the regulatory penalty weighted by the probability of the bank's falling below the regulatory minimum; $\Psi(\cdot)$ denotes the c.d.f. of the return on loans. The cut-off return on loans, $\widetilde{R}_{t+1}$, which will push the bank right to the edge of capital adequacy at the beginning of time $t+1$, is given by (8),

$$\widetilde{R}_{t+1} := \frac{R_{F,t}F_t}{(1-\gamma)L_t} = \frac{R_{F,t}}{1-\gamma}(1-e_t),$$

[5] We could alternatively assume that the shareholders' liability is limited but they loose the bank's franchise, or charter, value upon its liquidation as e.g. in Estrella (2004). Making the franchise value equal the regulatory penalty would reproduce the results.

where $e_t := E_t/L_t$ is the equity-to-loans ratio. Note that $\widetilde{R}_{t+1}$ is known at time t and an fixed (non-stochastic).

Substituting for F_t from the balance sheet, we solve for the optimal L_t and E_t. The first-order conditions for L_t and E_t are, respectively, as follows:

$$\mathbb{E}_t\left[\frac{R_{t+1}}{R_{E,t+1}}\right] = \mathbb{E}_t\left[\frac{1}{R_{E,t+1}}\right]\left[R_{F,t} + \upsilon\Psi(\widetilde{R}_{t+1}) + \upsilon\,\psi(\widetilde{R}_{t+1})\frac{R_{F,t}}{1-\gamma}e_t\right], \quad (11)$$

$$R_{F,t}\left[1 + \frac{\upsilon\,\psi(\widetilde{R}_{t+1})}{1-\gamma}\right] = \frac{1}{\mathbb{E}_t[1/R_{E,t+1}]}. \quad (12)$$

where $\psi(\cdot)$ is a p.d.f. (assumed to exist) corresponding to $\Psi(\cdot)$.

Interpreted in plain terms, eq. (11) says that the lending spread will, *ceteris paribus*, increase in response to reductions in the capital-to-loans ratio (or, equivalently, increases in leverage). This is a very intuitive result since low capital is associated with a higher probability of the bank's falling below the regulatory minimum and incurring a penalty. We illustrate the shape of such a "wholesale" lending function in Figure 1; the two curves are computed around the model's steady state for two different std deviations of the idiosyncratic component of the return on capital: 0.35 (actual calibration) and 0.25. In fact, some other authors, including Furfine (2001), Gerali et al. (2010), or Angelini et al. (2010), take a more direct shortcut subjecting the banks to a reduced-form convex cost determined by the distance from a regulatory minimum. Furthermore, eq. (12) equates the cost of debt liabilities (foreign borrowing) and the cost of bank capital adjusted for the effect the capital has on the expected cost of the regulatory penalty. Also note that the two conditions do not pin down the scale of the bank's business, i.e. the levels of L_t or E_t, only its leverage.

When plugged back in eq. (10), the two conditions give rise to zero *expected* economic profits, owing to the fact that the expected cost of the regulatory penalty is linearly homogenous in L_t and E_t. This is consistent with our competitive market assumption made initially.

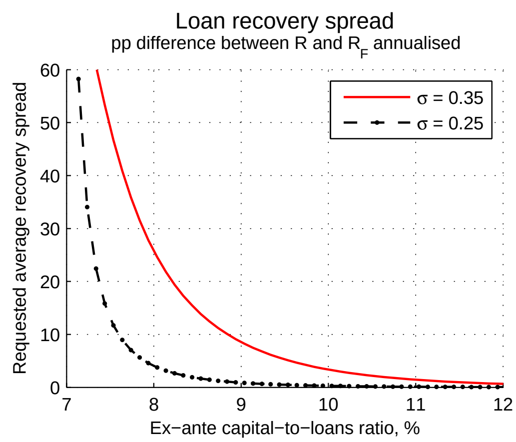
Finally, we use eq. (11) to define the required expected return on loans used in the rationality constraint, eq. (5), to the contractual problem above. Because we cannot express the expected return on the assets directly we must derive the required return on loans relative to the aggregate return on bank capital, i.e.

$$\mathbb{E}_t\left[\frac{R_{t+1}L_t}{R_{E,t+1}}\right] = r_t L_t, \quad (13)$$

where r_t follows from eq. (11),

$$r_t := \mathbb{E}_t\left[\frac{1}{R_{E,t+1}}\right]\left[R_{F,t} + \upsilon\Psi(\widetilde{R}_{t+1}) + \upsilon\psi(\widetilde{R}_{t+1})\frac{R_{F,t}}{1-\gamma}e_t\right]. \quad (14)$$

Figure 1: "Wholesale" lending supply curve: Requested average recovery spread as a function of bank-capital-to-loans ratio.



The fact that eq. (13) refers to the total volume (integral) of loans whereas (5) is a constraint associated with a loan to an individual is irrelevant because differentiating either expression w.r.t. L_t^j or $R_{L,t}^j$ yields the same results.

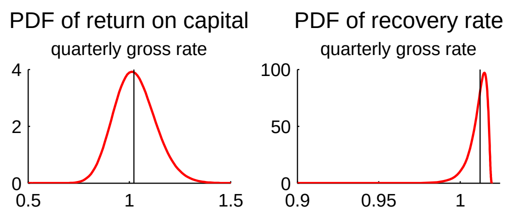
2.3 Return on Loans

To complete the specification of the financial interactions, we need to relate the conditional distribution of the return on loans, $R_{t+1|t}$, taken as given in the previous subsection, to the relevant source of aggregate uncertainty, i.e. the conditional distribution of the household's return on productive capital, $R_{K,t+1|t}$ and. Recall that the c.d.f. and p.d.f. of the return on loans is necessary for us to evaluate expressions (11), (12), and (14).

We first derive a functional mapping between R_{t+1} and aggregate $R_{K,t+1}$. Then, we use this mapping to express the distribution of $R_{t+1|t}$ as a function of $R_{K,t+1|t}$, and re-write the bank's first-order conditions in these terms. Last, we deal with the endogeneity problem arising between the return on capital, $R_{K,t+1}$, and the optimal behaviour of the bank. The distribution of $R_{K,t+1|t}$ must be known at the time of quantifying the bank's behaviour; however, the distribution of $R_{K,t+1|t}$ depends, in general, on the model as a whole, and hence also on the banks. We explain possible ways to approach this kind of problem.

For given $R_{L,t}$ and ℓ_t, we get the following mapping from a particular value

Figure 2: Distribution of return on loans.



$R_{K,t+1}$ to the bank's return on loans, $R_{t+1} = \rho(R_{K,t+1})$:

$$\rho(R_{K,t+1}) := R_{L,t+1} h(\widetilde{\omega}_{t+1}) = \frac{1}{\ell_t} R_{K,t+1} H(\widetilde{\omega}_{t+1}),$$

where $\widetilde{\omega}_{t+1} := R_{L,t}\ell_t / R_{K,t+1}$, and the functions $h(\cdot)$ and $H(\cdot)$ are defined by (3). Note that the function $\rho(\cdot)$ maps $(0, \infty)$ onto $(0, R_{L,t}]$ by design. In other words, the actual return on loans can only reach $R_{L,t}$ at maximum, which case would obviously occur only if no-one defaulted. With $\rho(\cdot)$ at hand, we can now calculate the c.d.f. and p.d.f. for R_{t+1} (denoted earlier by $\Psi(\cdot)$ and $\psi(\cdot)$, respectively) based on the c.d.f. and p.d.f. for $R_{K,t+1}$, which we denote by $F(\cdot)$ and $f(\cdot)$, respectively:

$$\Psi = F\left(\rho^{-1}\right),$$
$$\psi = f\left(\rho^{-1}\right) \cdot (\rho^{-1})' = f\left(\rho^{-1}\right) \cdot (\rho')^{-1},$$

where the first derivative is given by

$$\rho'(R_{K,t+1}) = \frac{1}{\ell_t} \left[H(\widetilde{\omega}_{t+1}) - H'(\widetilde{\omega}_{t+1})\, \widetilde{\omega}_{t+1} \right].$$

More specifically, to evaluate these functions at the cut-off return $\widetilde{R}_{t+1}$, we proceed as follows. We first find $\widetilde{R}_{K,t+1} := \rho^{-1}(R_{t+1})$, and set $\Phi(\widetilde{R}_{t+1}) = F(\widetilde{R}_{K,t+1})$. Then, we find $\widetilde{\omega}_{t+1} := R_{L,t}L_t/(\widetilde{R}_{K,t+1}P_{K,t}K_t)$, and set

$$\psi(\widetilde{R}_{t+1}) = \frac{f(\widetilde{R}_{K,t+1})\, \ell_t}{\left[H(\widetilde{\omega}_{t+1}) - H'(\widetilde{\omega}_{t+1})\, \widetilde{\omega}_{t+1} \right]}.$$

We illustrate the relationship between the distribution of the return on capital and the distribution of the return on loans (or the recovery rate) in Figure 2. Plotted in the graphs are the p.d.f. of R_K and the implied p.d.f. of R based on the model's calibration and taken around the steady state. Note that R is restricted to an interval $(0, R_L]$ by construction.

We can now discuss how to jointly determine the distribution $F(\cdot)$ and the bank's optimal choice of capital. If we wish to interpret the model at its face value, i.e. treat it as the truth, we can find a fixed point of the problem by iterating the following way:

1. Start with an initial guess of the distribution $F(\cdot)$.
2. Derive the the bank's first-order conditions taking $F(\cdot)$ as given.
3. Calculate the model's approximate dynamic solution.
4. Use a log-normal distribution to approximate the distribution of the one-step-ahead forecast $R_{K,t+1|t}$.
5. Step 4 gives you another guess of $F(\cdot)$. Go back to step 2, and continue until convergence.

The procedure is clearly based on an assumption that we believe the model is reasonably good at producing density forecasts for $R_{K,t+1}$. This may be a too strong claim since models are often crude simplifications, and cannot explain all dimensions of observed data (not to speak of the fact that they are *not meant* to explain all dimensions), especially variables like asset prices. In more practical applications, we may therefore resort to describing the uncertainty around $R_{K,t+1|t}$ using other (perhaps more empirical) sources of evidence, and allow for a discrepancy between the distribution used to derive the bank's behaviour, and the one implied by the model as whole. This is also consistent with the fact that the credit risk is, in the real world, affected by many more factors beyond a single asset price, and our model's return on capital is just an imperfect, yet useful, proxy.

2.4 Heterogenous banks

[Explain why we need heterogenous banks – smooth penalty at an aggregate level ...] We therefore introduce a continuum of banks indexed by $b \in (0, 1)$. Each bank will specialise in a particular sector of the economy (regional or industrial), indexed by the same b, and each of these sectors will have its own stochastic component affecting the sectorwide return on capital, ε^b_{t+1},

$$R^b_{K,t+1} = R_{K,t+1}\varepsilon^b_{t+1}.$$

Each ε^b_{t+1} is is distributed log-normally with $\mathbb{E}_t\left[\varepsilon^b_{t+1}\right] = 1$ and $\text{var}_t\left[\varepsilon^b_{t+1}\right] = \sigma^2_\varepsilon$, and is independent of the economywide return, $R_{K,t+1}$.

The results derived so far for a representative bank will change only in that we need to factor in the new source of uncertainty. In other words, we can introduce a sector-specific c.d.f and p.d.f. of $R^b_{K,t+1}$ denoted by $F_b(\cdot)$ and $f_b(\cdot)$, respectively. These new distribution functions replace $F_b(\cdot)$ and $f_b(\cdot)$ in all equations in the previous subsection 2.3.

The heterogenous banks will have, though, less trivial effects on the aggregation of the model. We describe the aggregate dynamics of the financial sector in subsection B.4.

3 Overview of the Complete Model

In this section, we briefly describe the rest of the model and its calibration. The full detail of the optimising behaviour of all model agents, along with a list of parameter values, is provided in appendix B.

The model's financial sector intermediates the flow of funds between the economy and the rest of the world. The banks' only source of non-capital finance is cross-border borrowing; in other words, we assume away the existence of local deposits. Oversimplified though at first sight, the assumption is still a useful shortcut that describes the essence of financial intermediation in many of the emerging-market economies: their transition has been marked with current account imbalances and rapid credit inflow from abroad, with the banking sector playing a prominent role.

We keep the real sector of the model economy relatively uncomplicated in the sense that it is based on a single production function. At the same time, we add a number of features that help to produce realistic dynamics, and make the model's structure flexible to encompass a variety of different types of emerging-market economies. In particular, we design the model so that it provides a high level of flexibility in calibrating the real exchange rate elasticities of final demand components (consumption, investment, exports), and the responses in trade balance, current account, and the economy's net position to cycles in these components. These are, in turn, characteristics most critical to our analysis of the linkages between the real and financial sectors.

The structure of the real sector is as follows. In addition to the financial sector described above, the economy consists of a representative household (with a continuum of members), a producer, a retailer, and an exporter. Because the household is the only agent in the real sector that has its own net worth, the distinction between the household and the individual types of firms is therefore immaterial, and we can in fact think of all of them as a single entity.

The household as a whole (as opposed to individual household members) makes purchases of consumption goods and investment goods. While the consumption goods are produced by the local producer and sold by the local retailer, the investment goods consist of a local component, identical to the consumption goods, and a directly imported component. The two components are perfect complements, and must be combined in fixed proportions. Furthermore, the household supplies labour with some degree of monopoly power (necessary for sticky wages, see below), rents out physical capital, and invest in bank capital.

The representative local producer, who behaves competitively in all input and output markets, combines two local input factors, labour and physical capital, and intermediate imports to produce local goods. These are then demanded by the local retailer and the exporter. The local retailer resells the goods to the household (as consumption and investment) exerting some degree of monopoly power in her output market (necessary for sticky prices). The exporter is a world price taker, in other words, the economy's terms of trade are exogenous. Moreover, like investment goods, exports consist of a local component and a direcly imported component (re-exports) and the two must be combined in fixed proportions.

The four agents are constrained by a number of real and nominal rigidities, of which all except the last three ones now considered standard in monetary small open economy models:

- external habit in the household's consumption;
- wage adjustment costs with full backward indexation;
- investment adjustment costs;
- price adjustment costs with full backward indexation;
- adjustment costs of changing the proportion of the two variable input factors (local labour and intermediate imports);
- export adjustment costs.
- bank capital market rigidities;

In our experiments, we expose the household to financial dollarisation and currency mismatches. In other words, a fixed proportion of bank loans is denominated in foreign currency (while all final and input factor prices are set in local currency). The currency structure is imposed and not optimised by any of the agents. Dollarisation of liabilities of households and non-financial firms is one of the major limitations monetary policymakers face when operating under floating exchange rate regimes, and a major source of systemic financial risk.

Finally, the local household owns only a certain proportion of the banks operating in the country; the remainder is in the hands of foreigners. This latter assumption not only reflects the reality of most of the emerging-market economies (whose banking sectors are often dominated by subsidiaries of foreign mother banks) but is also necessary to produce sensible dynamics of the economy's net position and its current account.

4 Macroprudential Policy

Unlike monetary policy tools, capital requirements do have permanent effect on the allocation of real resource in equilibrium. Put simply, this is because higher requirements raise the marginal cost of lending and increase the wedge between the refinance rate and the retail lending rates. The consequences thereof are similar to imposing a tax on the households' borrowing. In this sense, macroprudential policy can be viewed more like fiscal policy, a point made also by other authors, e.g. Bianchi and Mendoza (2010).

We document the above facts by running a simple non-stochastic steady-state comparative static exercise, and plotting the implied long-run levels of various macroeconomic and financial indicators under different levels of the capital requirements, γ, between 5 and 12 %, see Figure 3.

We can – very loosely – infer from the graphs that there are both costs and benefits associated with tighter macroprudential policies. In other words, as explained in more detail by e.g. Estrella (2004), macroprudential regulators face a trade-off: on the one hand, higher capital requirements reduce output and consumption (in our model, this is mainly because of a higher cost of physical capital – see the increasing lending spread), on the other hand, they also help limit the leverage of both the financial institutions and non-financial agents. This, in turn, gives rise to a more stable financial environment, removing–to some extent–some of the externalities or market failures.

Furthermore, there has been an ongoing debate among national regulators and international prudential regulation bodies about adopting time-varying capital requirements, or other macroprudential tools. The idea is that the macroprudential policy stance should pro-actively react to the cyclical position of the economy and the financial sector. A number of authors have attempted to translate this idea into pro-cyclical macroprudential rules by linking the capital requirements to real economic activity, or into macroprudential policies aimed at stabilising indicators based on real economic activity, such as credit-to-GDP ratios.

We find this approach rather unappealing because it relies on a very reduced-form way of thinking of macroprudential policy. Consistent with its scope and objectives would be a pro-active macroprudential policy rule prescribing tight capital requirements in times when risk builds up on the balance sheets of financial institutions (forcing the banks create capital cushions), and letting the banks draw the capital cushions down in times when the risk materialises. The fact that times of large risk build-ups are often observed in times of output expansion is a reduced-form empirical observation that cannot be taken as granted (think of an analogy in monetary policy where absent any supply-side shocks, inflation and demand correlate positively.) Instead, methodologies need to be developed to measure the amount of systemic risk across the financial sector, and relate the macroprudential policy to such measures. As noted by many, e.g. Tucker (2009) or Milne (2009), the risk measures can be hardly based on a single framework or single model, and will involve a large amount of judgment, considerably more than in the business of monetary policy making.

We use a simple pro-active macroprudential rule in our asset price bubble simulation in subsection 5.3. In that rule, we measure the credit risk by the observed lending spread,

$$\gamma_t = \bar{\gamma} + \phi_\gamma \left(R_{L,t} - R_{F,t} - \Delta \right)$$

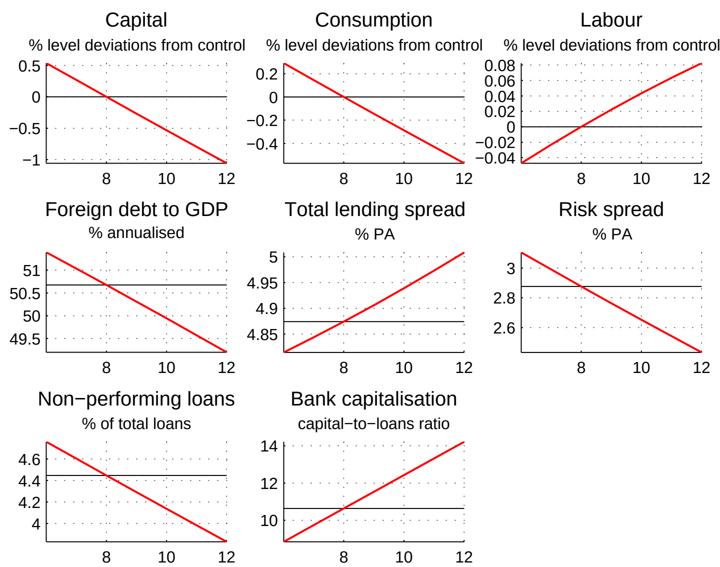
where $\Delta_t := \bar{R}_L - \bar{R}_F$ is the steady-state spread. The rule is, obviously, model specific and is not meant to be adapted mechanically in practical macroprudential policy making.

5 Simulation Experiments

In this section, we show a number of shock simulations that trigger an episode of financial distress. We use these simulations to explain the basic interactions between the real and financial cycle, the role of bank capital in the transmission of the shocks, and the tools macroprudential policy can use to contain some of the financial risk arising as a consequence of the shocks.

We first simulate an exogenous shock to the level of bank capital. We do not specify the exact underlying cause of such a capital drop; the experiment is only meant to explain the mechanics of the banks' reaction to such shock, the way the banks re-capitalise themselves again, and the impact on the real economy. Second, we expose the economy to a sudden increase in the country

Figure 3: Comparative static with changing capital requirements.

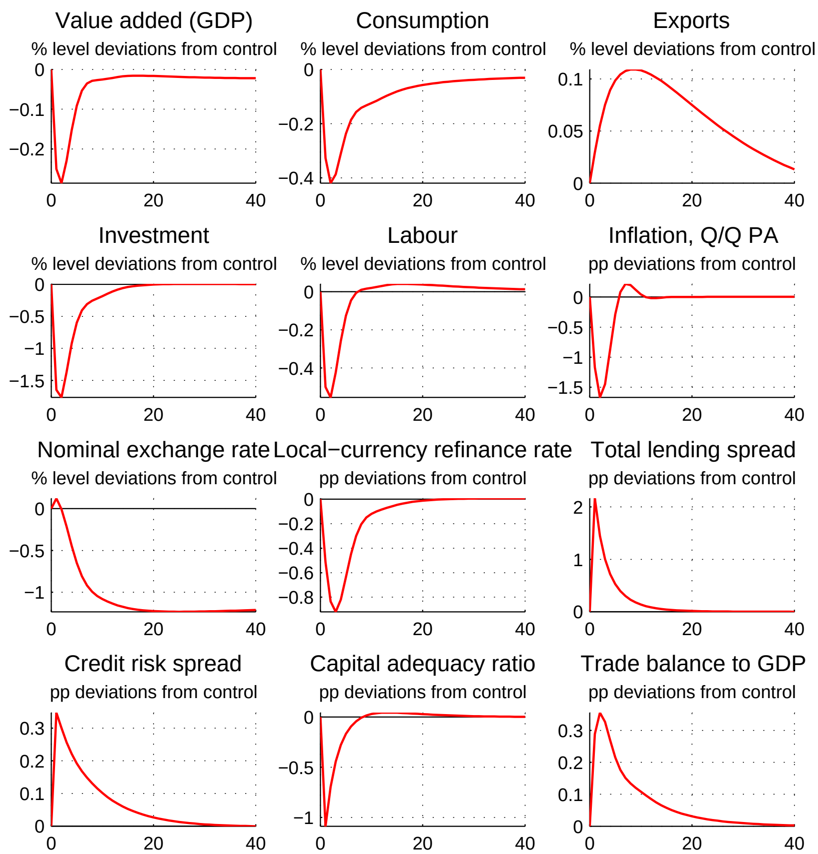


risk premium, i.e. in the rate at which the banks are able refinance the loans to households. In this experiment, we compare the outcomes (i) generated with and without the banking sector, and (ii) under two different levels of the premium, "small" and "large" (defined by whether they trigger a systemic risk event) to show the non-linearities of macrofinancial models. Last, we simulate an asset price bubble (a persistent deviation of the observed market price of physical capital from its fundemantals) and its burst to illustrate the very notion of financial cycles, i.e. times when a considerable amount of risk builds up on the balance sheets of banks, followed by times when the risk can actually materialise. In this experiment, we compare the outcomes under a fixed level of capital requirements and those under a pro-active macroprudential rule.

5.1 Bank Capital Shock

In this experiment, we exogenously reduce the level of initial bank capital, i.e. E_{t-1}, by 10 %. As we see in Figure 4, the shock brings the capital adequacy ratios down by about 1 pp on impact and eliminates about a half of the regulatory capital cushion. The banks react by cutting back its lending. In the model, the only way to do so is by increasing the lending spreads. We see a 200 bp hike initially that dissipates gradually over two to three years. In the real

Figure 4: Bank capital shock 10 %

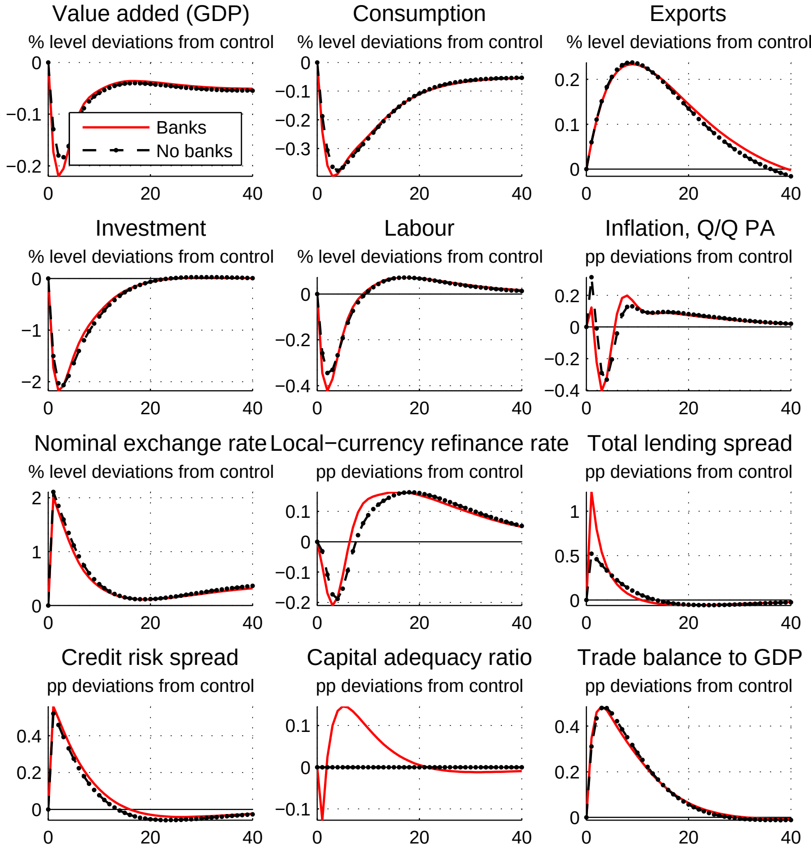


world, though, the banks would probably combine price increases with tighter non-price credit conditions, and the observed interest rates would not be driven so high. Furthermore, the elevated lending spread also leads to gradual re-capitalisation of the banks, as the return on bank capital remains higher than normal for a prolonged period of time.

The effect of the shock on the real economy is offset to some extent by monetary policy. The refinance rate is cut by about 90 bp during the first year, which is accompanied by a small depreciation followed by steady appreciation. Domestic demand reduction amounts to a drop in GDP by less than 0.3 % in the first year.

Figure 5: Country spread shock, 100 b.p.

— Baseline model − · − No banking sector

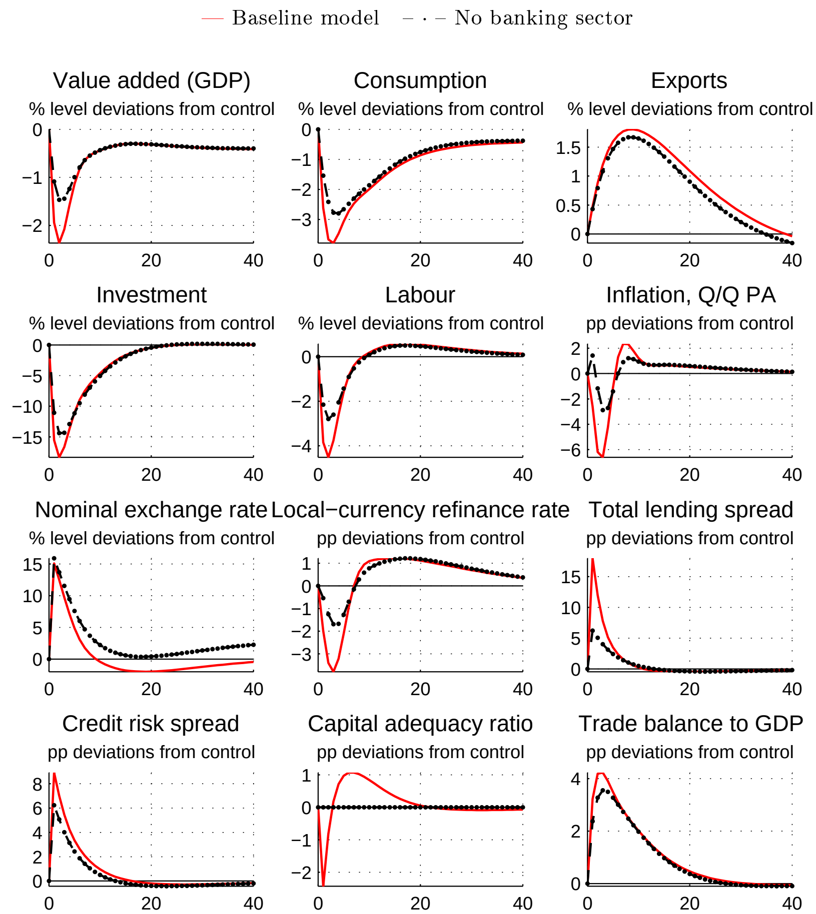


5.2 Increases in Country Spread

In the following two simulations, we increase the foreign-currency refinance rate, R_F^*, by 100 bp and 800 bp annualised, respectively, see Figures 5–6. The shock is persistent with autocorrelation of 0.90. We report results for two versions of the model: one with the banking sector as described earlier in the paper, and the other without the banking sector. In the latter version, we simply keep the wholesale lending spread as well as the bank-capital-to-loans ratio constant (fixed at their respectivel steady states).

The shock, which bears resemblance with sudden-stop scenarios, triggers a potentially very harmful combination of an exchange rate depreciation and

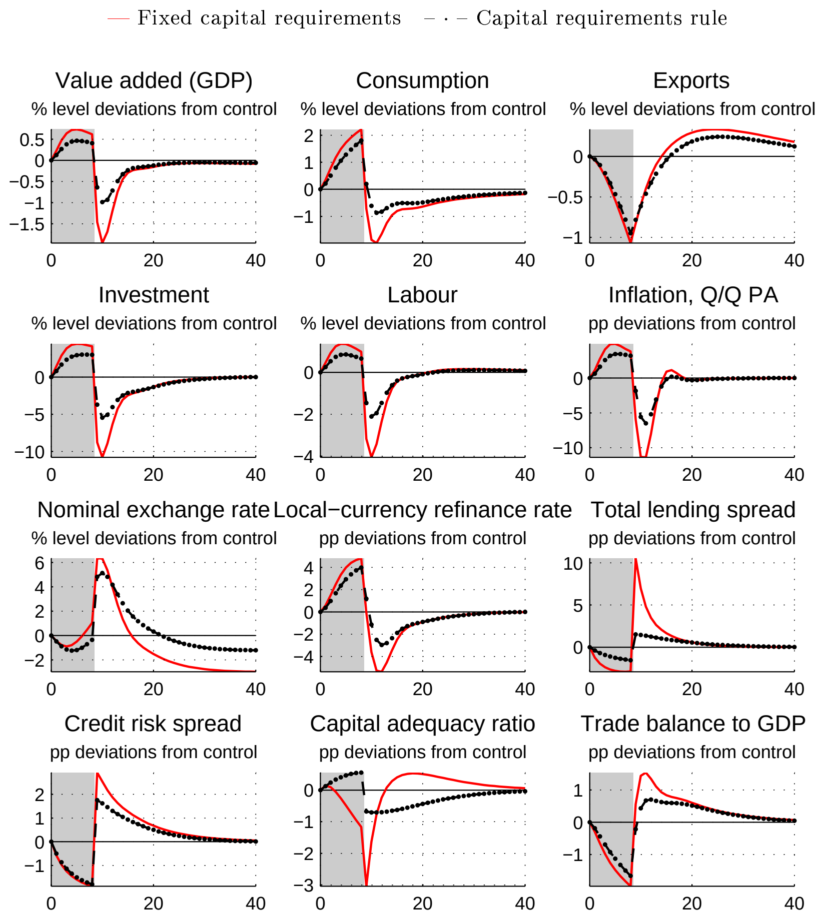
Figure 6: Country spread shock, 800 b.p.



an asset price fall. In economies with substantial financial dollarisation, such a combination may push the leverage of the non-financial sector unusually high above the levels prevailing in normal times, and result in increases in non-performing loans. If the losses on the bank assets exceed the bank capital cushions, the shock can create serious systemic risk.

The uncertainty about the eventual effects of such a shock in the real world is large. This is because the mechanisms that determine whether a systemic crisis occurs or not are intrinsically non-linear and exhibit a kind of threshold behaviour; such mechanisms are therefore very difficult to parameterise. We document the non-linearities by simulating two different sizes of the shock, a small one of about 100 bp annualised, and a large one of about 800 bp annualised,

Figure 7: Asset price bubble



with the latter sufficient to significantly hit the bank capital. Note that the 800 bp corresponds well to increases in the spreads facing some of the emerging-market economies when the global financial crisis spread across the world.

5.3 Asset Price Bubble

We simulate an *irrational* bubble in the price of physical capital and its subsequent burst. The term irrational, introduced by Bernanke and Gertler (1999), refers to the fact that there exists a persistent exogenous wedge between the observed (or market) asset price and its fundamental path which breaks the model's rational-expectations asset price equation.

We calibrate the bubble as follows. Once arisen, the bubble is expected to persist into the next period growing at a quarterly rate of 2.5 % with a probability about 96 %, or burst (with the asset prices abruptly falling straight to their fundamental value) with a probability about 4 %. Whether the bubble continues or bursts is determined exogenously (by the design of the experiment), and is out of control of any of the model's agents, including the monetary authority or macroprudential regulator. We let the bubble grow over eight consecutive quarters (the probability of which is about 76 %) with the capital prices exceeding the fundamentals by about 20 %. At the beginning of the third year, we prick the bubble. The simulation results are shown in Figure 7. The highlighted area depicts the initial eight quarters during the bubble exists.

From a macroprudential point of view, the initial period is a time when considerable risk builds up on the bank balance sheets. The burst of the bubble is then a moment when the risk materialises. Putting aside the problem of how to accurately measure the risk in the real world (or, equivalently, how to measure the extent of an asset price bubble in this particular case), we show that a pro-active capital requirements rule could reduce the effects the bursting bubble has on the position of the financial institutions, and help prevent a systemic crisis in a larger region of shocks.

6 Conclusions

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A Details of Financial Structure

B The Real Sector

B.1 Households

The representative household chooses (as a whole) consumption, C_t, investment in physical capital, I_t, labour, N_t, the wage rate, W_t, and bank capital (equity), E_t, supplied to the market, to maximise its expected lifetime utility,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log\left(C_t - \chi\,\bar{C}_{t-1}\right) - \tfrac{1}{\eta} {N_t}^{\eta} \right]$$

where $\bar{C}_{t-1}$ is the last period's consumption externalised from the household's consideration (external habit – think of habit based on past aggregate, not one's own individual, consumption), and N_t is labour (hours worked) supplied to the manufacturer, subject to

- a budget constraint

$$\begin{aligned} P_{K,t}K_t - L_t + \kappa E_t(1-\tau_{E,t}) = \\ R_{K,t}P_{K,t-1}K_{t-1} - R_{L,t-1}L_{t-1}\,g_t + \kappa R_{E,t}E_{t-1} + W_tN_t(1-\tau_W) \\ - P_tC_t - \left[\psi P_t + (1-\psi)P_{M,t}\right] I_t(1+\tau_{I,t}) + v_t, \end{aligned}$$

  where κ is the proportion of bank capital owned by the local households (the remainder is owned by foreign agents), and v_t is the sum of profits received all agents owned by the household, and private costs incurred by the various agents in the model economy and transferred back to the household's budget. The profits and costs entering the budget through v_t are enumerated in subsection B.4 when we aggregate the model's stocks and flows;

- the law of motion for physical capital,

$$K_t = (1-\delta_K)K_{t-1} + I_t.$$

  and

- a CES demand curve for labour,

$$N_t = (W_t/\bar{W}_t)^{-\frac{\mu}{\mu-1}}\bar{N}_t,$$

  where $\bar{W}_t$ and $\bar{N}_t$ are taken as given, and μ describes the monopoly power of the household in the labour market.

The term $\tau_{E,t}$ in the budget constraint above captures a cost associated with bank capital market imperfections (rigidities),

$$\tau_{E,t} := \tfrac{\xi_E}{2} \left[\log E_t - \log(\delta_E R_{E,t} E_{t-1})\right]^2 ,$$

The return on capital, $R_{K,t}$, includes the rentals, Q_t, received from producers, capital gains, and depreciation, measured by δ_K,

$$R_{K,t} := \frac{Q_t + (1-\delta_K)P_{K,t}}{P_{K,t-1}}.$$

The role of the bank capital cost, $\tau_{E,t}$, is to limit banks' ability to raise fresh capital in response to adverse shocks or changes in capital regulation. The mechanis can be seen from the first-order condition w.r.t. E_t. Here, we reproduce only an approximate condition (with some of the second-order terms dropped from it) for the reader's convenience; the accurate condition is found in Appendix **??**, eq. (**??**):

$$\mathbb{E}_t \left[\frac{\beta \Lambda_{t+1}}{\Lambda_t} R_{E,t+1} \right] \overset{\text{f.o.}}{\approx} 1 + \xi_E \left[\log E_t - \log(\delta_E R_{E,t} E_{t-1})\right] \\ - \beta \xi_E \left[\log E_{t+1} - \log(\delta_E R_{E,t+1} E_t)\right]. \quad (15)$$

In the extreme case with $\xi_E \to \infty$, bank capital would be supplied only at the level of past retained earnings (corrected by a constant δ_E whose only purpose is to make sure that E_t behaves well along a balanced-growth path; the constant is set to the inverse of the long-run return on equity, ${R_{E,t}}^{-1}$). When $\xi_E > 0$ but finite, the household's willingness to increase bank capital supply above the retained earnings will be a function increasing in the expected returns. In time so financial distress or banks' undercapitalisation, which are associated with higher-than-normal expected returns on bank capital in our model, the household will provide capital injections helping thus re-capitalise the banks. Note that we allow for negative flows of bank capital, meaning dividends paid to the household.

Finally, the quantities L_t, K_t, $R_{L,t-1} L_{t-1}\, g_t$, and $R_{K,t} P_{K,t-1} K_{t-1}$ refer to the respective integrals over all individual members of the household, and are deteremined by the individual decisions detailed in the previous section. The household as a whole takes these as given.

B.2 Production, Retail, and Export

Manufacturing The representative manufacturer, who behaves competitively in both input and output markets, uses capital, K_t, labour, N_t, and imports,

M_t, to produce local goods,

$$Y_t = k_t^{1-\alpha_N-\alpha_M}(A_tN_t)^{\alpha_N}M_t{}^{\alpha_M},$$

where A_t is an exogenous productivity process. The manufacturer faces adjustment costs of changing the quantity of labour, N_t and imports, M_t, employed. By choosing the input factors, k_t, N_t, and M_t, and the level of output, Yt, she maximises the firm's value,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1} \left[P_{Y,t}Y_t - Q_tk_t - P_tN_t(1+\tau_{N,t}) - P_{M,t}M_t(1+\tau_{M,t}) \right],$$

with the two adjustment costs given by $\tau_{N,t} := \frac{\xi_N}{2}\left(\log N_t - \log N_{t-1}\right)^2$ and $\tau_{M,t} := \frac{xi_M}{2}\left(\log M_t - \log M_{t-1}\right)^2$, respectively. The adjustment costs are adopted from Shapiro (1986) and Hall (2004). The imports, M_t, are purchased from abroad, at a world price converted by the nominal exchange rate, $P_{M,t} = S_tP_t^*$, where P_t^* is an exogenous process.

Local retail The representative local retailer resells goods purchased from the manufacturer; she operates with monopoly power μ subject to price adjustment costs, and chooses the final price, P_t, and output, D_t to maximise the firm's value,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1} \left[P_tD_t(1-\tau_{P,t}) - P_{Y,t}D_t \right],$$

subject to a CES demand curve

$$D_t = (P_t/\bar{P}_t)^{-\frac{\mu}{\mu-1}}\bar{D}_t$$

where $\bar{P}_t$ and $\bar{D}_t$ are taken as given. The price adjustment cost is not very different from Rotemberg (1982), but augmented with full backward indexation,

$$\tau_{D,t} := \frac{\xi_Y}{2}\left[\log\left(P_t/\bar{P}_{t-1}\right) - \log\left(P_{t-1}/\bar{P}_{t-2}\right)\right]^2.$$

Export The representative exporter resells goods purchased form the manufacturer in an international market, taking the output price, $P_{X,t}$ as given, subject to adjustment costs of changing the level of exports. She chooses X_t to maximise the firm's value,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1} \left\{ P_{X,t}X_t(1-\tau_X) - \left[\psi P_{Y,t} + (1-\psi)P_{M,t}\right]X_t \right\},$$

where

$$\tau_{X,t} := \frac{\xi_Y}{2} \left[\log X_t - \log X_{t-1} \right]^2 .$$

The country's terms of trade, $T_t = P_{X,t}/P_{M,t}$ follow an exogenous process.

All the adjustment costs above, including the bank capital adjustment cost incurred by the household, are private costs, not social costs, and are paid back to the household's budget, see also the definition of the term v_t in (16).

B.3 Monetary and Macroprudential Policy

Monetary policy In our simulation exercises, we experiment with different two basic types of monetary policy conduct: an exchange rate peg, and inflation targeting. The peg is introduced simply by exogenising the path for the nominal exchange rate,

$$\log S_t = \log S_{t-1} + \epsilon_{S,t},$$

where $\epsilon_{S,t}$ can be thought of as changes in the central parity. Because our model does not have a portfolio balance channel built in we implicitly assume that the exchange rate is managed through unsterilised foreign exchange operations, and the central bank looses control of the local money market. We refer the readers to e.g. Sarno and Taylor (2001) for a detailed discussion of this matter.

Under inflation targeting, on the other hand, the central bank's systematic behaviour is summarised in an interest rate rule,

$$R_{F,t} = \varrho R_{F,t-1} + (1-\varrho) \left[\bar{R}_F + \phi_p \left(\mathbb{E}_t \log[\Pi^4_{t+h}] - \log \bar{\pi}^4 \right) \right] + \epsilon_{R,t},$$

where $\epsilon_{M,t}$ is a monetary policy surprise, i.e. a deviation from the systematic rule, $\Pi^4_t := P_t/P_{t-4}$ is a year-on-year gross rate of final price changes, π^4 is the central bank's inflation target, and the policy control horizon, h, is treated parameterically.

Macroprudential policy Macroprudential policy consists in setting two parameters, the minimum capital requirements, γ, and the penalty, υ. In our simulations, we fix the value of υ (reported in Appendix **??**, Table **??**), and experiment with time-varying reaction functions for γ.

B.4 Symmetric Equilibrium and Aggregation

In symmetric equilibrium, we set $\bar{C}_t = C_t$, $\bar{P}_t = P_t$, $\bar{D}_t = D_t$. Furthermore, the following three market clearing conditions hold: $Y_t = D_t + \psi X_t$, $D_t = C_t + \psi I_t$, and $k_t = K_{t-1}$.

The term v_t in the household's budget consists of the following:

$$\begin{aligned} v_t := {} & P_{Y,t}Y_t - Q_t k_t - P_t N_t(1+\tau_{N,t}) - P_{M,t}M_t(1+\tau_{M,t}) \\ & + P_t D_t(1-\tau_{P,t}) - P_{Y,t}D_t \\ & + P_{X,t}X_t(1-\tau_X) - P_{Y,t}X_t \\ & + \kappa\, E_t\, \tau_{E,t} + W_t N_t\, \tau_{N,t} + P_{M,t}M_t\, \tau_{M,t} + P_t D_t\, \tau_{P,t} + P_{X,t}X_t\, \tau_X . \end{aligned} \tag{16}$$

We can now use the household's budget constraints to express a balance of payments equation, which effectively describes the law of motion for the net financial position of the country as whole. Denoting net foreign liabilities by NFL_t,

$$NFL_t := L_t - \kappa E_t,$$

we can write

$$\begin{aligned} NFL_t = {} & R_{W,t-1} NFL_{t-1} \\ & + (R_{L,t-1} g_t - R_{W,t-1}) L_{t-1} - \kappa (R_{E,t} - R_{W,t-1}) E_{t-1} \\ & - \left[\psi P_{X,t} X_t - P_{M,t} M_t - (1-\psi) P_{M,t} I_t\right]. \end{aligned}$$

B.5 Parameter Calibration

Table 1: Steady-state parameters

α_M	Import share of gross production	0.20
α_N	Labour share of gross production	0.40
β	Household discount factor	0.976
γ	Capital requirements	0.08
δ	Physical capital depreciation	0.01
ϵ	Proportion of bank equity held by local households	0
η	Inverse of labour supply elasticity	0
κ	Proportion of capital collateralising bank loans	0.25
μ	Monopoly power in goods and labour markets	1.10
ν	Liquidation costs	0.04
σ	Std. dev. of idiosyncratic shocks to return on capital	0.35
ς	Std. dev. of aggregate return on capital	0.15
υ	Regulatory penalty	0.02
ψ	Share of directly imported investment and exports	0.60

Table 2: Transitory dynamics and policy parameters

θ	Degree of financial dollarisation	1.00
ξ_E	Bank capital market rigidities	∞
ξ_I	Investment adjustment cost	0.50
ξ_K	Capital adjustment cost	0.50
ξ_P	Price adjustment cost	18.00
ξ_W	Wage adjustment cost	18.00
ξ_X	Export adjustment cost	100.00
ξ_Y	Adjustment cost of changing labour-import ratio	3.00
χ	Consumer habit	0.80
ϕ_R	Monetary policy response to inflation	2.00
h	Monetary policy horizon	3
ϕ_γ	Macroprudential response to lending spread	$\{0, 5\}$