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Cyclically Adjusted Provisions and Financial Stability

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IDB WORKING PAPER SERIES N° IDB-WP-656

Cyclically Adjusted Provisions and Financial Stability

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Cyclically Adjusted Provisions and Financial Stability

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Abstract*

This paper studies the extent to which alternative loan loss provisioning regimes affect the procyclicality of the financial system and financial stability. It uses a DSGE model with financial frictions (namely, balance sheet and collateral effects, as well as economies of scope in banking) and a generic formulation of provisioning regimes. Numerical experiments with a parameterized version of the model show that cyclically adjusted (or, more commonly called, dynamic) provisioning can be highly effective in terms of mitigating procyclicality and financial instability, measured in terms of the volatility of the credit-output ratio and real house prices, in response to financial shocks. The optimal combination of simple cyclically adjusted provisioning and countercyclical reserve requirements rules is also studied. The simultaneous use of these instruments does not improve the ability of either one of them to mitigate financial instability, making them partial substitutes rather than complements.

JEL classifications: E32, E44, E52

Keywords: Provisioning regimes, Reserve requirements, DSGE models

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1 Introduction

The role of accounting standards in promoting banking procyclicality and financial volatility has come under renewed scrutiny since the global financial crisis. Under International Accounting Standard (IAS) 39, the rules for impairment of loans currently follow the so-called incurred loss model, which assumes that loans will be repaid in their entirety and that objective evidence to the contrary—events that would have an impact on the estimated future cash flows of the loan—must be identified before any impairment losses are recognized. Critics of IAS 39 have argued that recognition after identification of evidence, such as a counterparty failing to meet its contractual obligations, is too late in the credit cycle because the expenses in the income statement for impairments then accumulate in downturns, when losses materialize. This provisioning regime therefore tends to exacerbate procyclicality: in good times, when lending is already at a high level, banks are not required to set aside buffers for expected losses and thus overstate the economic value of their loan portfolios while they understate losses in their income statements. As a result, lending can be expanded beyond the amount that would be desirable. By contrast, in downturns high credit losses occur, but the lack of available provisions increases the losses reported in banks’ income statements, which reduce capital and may force banks to recapitalize or reduce lending and sell assets.² Thus, from the perspective of procyclicality, the main potential drawbacks of current accounting rules are i) increased volatility in banks’ financial statements, ii) the rules concerning incurred and expected losses in loan portfolios, and iii) the impact of accounting standards on banks’ lending practices.

In contrast to the incurred loss model, the so-called expected loss model implements a forward-looking methodology. Under this model, credit losses that are expected to occur are recognized early in the credit cycle; impairments are therefore made in a more timely manner, potentially dampening procyclicality in loan provisioning. Thus, provisions set aside in good times serve as a buffer against risk and reduce the likelihood of banks becoming insolvent.

Spain was one of the first countries to implement so-called “dynamic” provisioning

²See Cavallo and Majnoni (2002), Bikker and Metzmakers (2005), Beatty and Liao (2011), and Pool et al. (2015) for empirical evidence on the relationships between bank lending, loan loss provisioning, and business cycles.

rules.³ In more recent years a number of countries in Latin America have implemented similar schemes. These countries include Bolivia, Colombia, Peru, and Uruguay. Although the details of these schemes differ in several ways from the Spanish system (see Wezel, 2010; Chan-Lau, 2012; and Wezel et al., 2012), they all share a common goal—ensuring that banks are not required to increase the reserves that they must hold against loan losses at exactly the same time that their capacity to lend is needed to help promote an economic recovery.

However, so far there has been relatively little analytical and empirical work focusing on the countercyclical performance of these systems, and their benefits in terms of financial stability. Studies based on Spain’s experience by Saurina (2009), Jiménez et al. (2012), and Fernández de Lis and García Herrero (2013) found that the Spanish provisioning model reduced procyclicality but did not eliminate it. López et al. (2014), in a study of Colombia over the period 2003-2011, found that countercyclical loan loss provisions are negatively related with the amplitude of credit cycles. Lim et al. (2011), and a more comprehensive econometric study by Cerutti et al. (2015) over the period 2000-13, found that dynamic provisioning was highly effective in mitigating the procyclicality of credit. More theoretical general equilibrium models include Goodhart et al. (2013) and Agénor and Zilberman (2015). In Goodhart et al. (2013) dynamic provisioning is formalized as a requirement for the bank to keep cash on its balance sheet in good states of the world, when the growth of real estate-related credit exceeds a certain threshold. Provisioning involves banks setting aside a portion of today’s profits to cover future (expected) losses. However, the form of “provisions” defined in that model is more akin to a reserve ratio, that is, a form of liquidity regulation: when loan growth is high, banks are required to hold an increasing proportion of their assets in cash. The effects of requiring banks to build up provisions ahead of a downturn cannot be analyzed in that setting. Agénor and Zilberman (2015), drawing in part on the partial equilibrium framework of Bouvatier and Lepetit (2012), do capture this feature in a dynamic stochastic general equilibrium (DSGE) model with credit market imperfections. They define two alternative loan loss provisioning regimes: a specific

³Dynamic (also referred to as “statistical”) provisioning is an extension of through-the-cycle provisioning; the latter refers to provisions made on the basis of the expected loss-given default of a loan throughout its duration, whereas the former is calculated using time series on default probabilities. See Burroni et al. (2009) for a more detailed discussion.

provisioning system, in which provisions are triggered by past due payments, and a dynamic provisioning system, in which both past due payments and expected losses over the whole business cycle are accounted for, and provisions are smoothed over the cycle. Their numerical experiments showed that a dynamic provisioning regime can be highly effective in mitigating the procyclicality of the financial system. However, in studying optimal simple rules they focus mainly on the case of an integrated mandate for the central bank and a dynamic provisioning regime with full smoothing—in the sense that any deviation in the fraction of nonperforming loans from its steady-state value is fully reflected in the calculation of total provisions. The possibility of “overprovisioning” (a more than proportional response to deviations in the fraction of nonperforming loans, or any other measure of cyclical fluctuations), as well as independent mandates for monetary policy and macroprudential regulation, are not discussed. Moreover, they do not consider the extent to which dynamic provisioning should be (optimally) combined with other macroprudential instruments to promote financial stability.

The purpose of this paper is to fill this gap, using a more general DSGE model with financial frictions and a housing market, as well as a generic formulation that captures some key features of the provisioning regimes currently in use in various countries around the world, especially Latin America. The analysis focuses on the extent to which these regimes affect the procyclicality of the financial system as well as real and financial volatility. In addition, we examine the optimal combination of simple dynamic (or, more appropriately in our view, cyclically adjusted) provisioning and countercyclical reserve requirements rules. This is important because in recent years reserve requirements have been actively used, in Latin America and elsewhere. At the analytical level, much recent discussion has focused on the use of these requirements as a countercyclical macroprudential tool, rather than as an instrument of liquidity management or a substitute to monetary policy.⁴ We also consider two types of financial shocks, one associated with borrowers’ default risk and the other with asset prices and collateral values.

Our numerical experiments, based on a parameterized version of the model for a “typical” middle-income economy, allow us to establish three key results. First, we show that cyclically adjusted provisioning can be highly effective in mitigating procycli-

⁴See, for instance, Agénor et al. (2015) for a detailed discussion, albeit in an open economy context.

cality and financial volatility; this is consistent with the results obtained by Agénor and Zilberman (2015) in a simpler framework. However, the relationship between the parameter that characterizes the response of provisions to cyclical movements in default risk and financial volatility follows a U-shaped pattern. At first, a more aggressive policy mitigates financial volatility—measured in terms of a weighted average of the volatility of the credit-to-GDP ratio and the volatility of real house prices—because the policy stabilizes credit, investment and activity. But beyond a certain point, market interest rates become more volatile, and so do lending and aggregate demand; financial volatility therefore begins to increase again. The optimal policy is obtained at the point where the volatility index is minimized. Second, we also show that the optimal policy involves “excess smoothing,” in the sense that it entails a more than proportional reaction to cyclical movements in the share of nonperforming loans (or, equivalently here, the probability of default). Third, our analysis shows that cyclically adjusted provisioning and countercyclical reserve requirements are not complements; the use of either one of these instruments does not improve the ability of the other to mitigate financial volatility. At the same time, the optimal countercyclical provisioning rule performs significantly better than the optimal reserve requirement rule. In that sense, the two instruments are partial substitutes. Fourth, we show that although an optimal cyclically adjusted provisioning regime can also be defined in terms of reaction to cyclical output, responding to that variable does not perform as well as responding to changes in nonperforming loans.

The remainder of the paper is divided into six parts. Section 2 presents the model, which is based in part on Agénor et al. (2013) and Agénor and Zilberman (2015). It captures two types of financial frictions: balance sheet and collateral effects, as well as costly production of loans and deposits, which creates economies of scope in banking and the possibility of reserve requirements acting in a countercyclical manner through their impact on deposit and loan rates. In addition, banks operate in an environment of monopolistic competition. The equilibrium solution of the model and some key features of its steady state and log linearization are discussed in Section 3, whereas a parameterization for a “typical” middle-income economy is presented in Section 4. The results of two transitory financial shocks (an increase in the risk of default and a negative shock to asset prices) are discussed in Section 5. The optimal

cyclically adjusted provisioning rule, and the optimal combination of that rule with a reserve requirement rule, are discussed and analyzed in Section 6. Sensitivity analysis is performed in Section 7. The last section offers some concluding remarks and discusses some possible extensions of the analysis.

2 The Model

Consider a closed economy consisting of seven types of agents: a representative household, a representative final good (FG) firm, a continuum of intermediate good (IG) firms, a capital good (CG) producer, a continuum of commercial banks, a government, and a central bank, which also acts as the bank regulator. The IG firms rent capital from the CG producer and combine it with labor to produce a unique intermediate good. Intermediate goods are then combined by the FG firm, who produces a homogeneous final good, which, in turn, can be used for either consumption, investment or government spending.

Commercial banks receive deposits from households and supply credit to the CG producer for investment purposes. There is monopolistic competition in the markets for deposits and loans; banks therefore set both the deposit and the loan rates. They also borrow from the central bank to cover any shortfall in funding. The supply of loans is perfectly elastic at the prevailing lending rate. Banks receive gross interest payments on investment loans and pay back principal plus interest on households' deposits and loans from the central bank. In addition, banks hold loan loss reserves, which are invested in riskless, one-period government bonds. Loan loss provisioning rules are set by the central bank.

2.1 Household

The representative household consumes, holds deposits and cash, invests in one-period government bonds, and supplies labor to IG firms.

The objective of the household is to maximize the utility function

$$U_t = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left\{ \frac{C_{t+s}^{1-\varsigma}}{1-\varsigma} + \eta_N \ln(1 - N_{t+s}) + \ln(x_{t+s}^{\eta_x} H_{t+s}^{\eta_H} \epsilon_t^H) \right\}, \quad (1)$$

where C_t denotes consumption of the final good, N_t the share of total time endowment (normalized to unity) spent working, x_t a composite index of real monetary assets, and

H_t the stock of housing. \mathbb{E}_t is the expectations operator conditional on information available up to period t and $\beta \in (0, 1)$ denotes the discount factor. Parameter ς is the inverse of the intertemporal elasticity of substitution in consumption, whereas $\eta_N, \eta_x, \eta_H > 0$ are preference parameters. In standard fashion, housing services are proportional to their stock. The random variable ϵ_t^H is a housing demand shock, which follows an $AR(1)$ process of the form $\epsilon_t^H = (\tilde{\epsilon}^H)^{1-\rho^H} \epsilon_{t-1}^{\rho^H} \exp(\xi_t^H)$, where $\rho^H \in (0, 1)$ and $\xi_t^H \sim \mathbf{N}(0, \sigma_{\xi^H})$.

The composite monetary asset is generated by combining real cash balances, m_t^P , and real bank deposits, d_t :

$$x_t = (m_t^P)^\nu d_t^{1-\nu}, \quad (2)$$

where $\nu \in (0, 1)$.

The representative household's budget constraint is given by

$$C_t + d_t + b_t^P + p_t^H \Delta H_t + m_t^P = \left(\frac{1 + i_{t-1}^D}{1 + \pi_t}\right) d_{t-1} + \left(\frac{1 + i_{t-1}^B}{1 + \pi_t}\right) b_{t-1}^P \quad (3)$$

$$+ \frac{m_{t-1}^P}{1 + \pi_t} + w_t N_t + \int_0^1 \Pi_{j,t}^G dj + \Pi_t^K - T_t,$$

where i_t^D is the interest rate on deposits, i_t^B the return on holdings, b_t^P holdings of one-period government bonds, w_t the real wage, $\int_0^1 \Pi_{j,t}^G dj$ and Π_t^K profits made by the IG producers and the CG producer, respectively, π_t the inflation rate, p_t^H the real price of housing, and T_t real lump-sum taxes.

Maximizing (1) subject to (2) and (3) with respect to C_t , N_t , d_t , m_t^P , b_t^P , and H_t , and taking interest rates and prices as given, yields

$$C_t^{-\varsigma} = \beta \mathbb{E}_t[C_{t+1}^{-\varsigma} \left(\frac{1 + i_t^B}{1 + \pi_{t+1}}\right)], \quad (4)$$

$$d_t = \frac{\eta_x(1 - v)C_t^\varsigma(1 + i_t^B)}{i_t^B - i_t^D}, \quad (5)$$

$$m_t^P = \frac{\eta_x v C_t^\varsigma(1 + i_t^B)}{i_t^B}, \quad (6)$$

$$N_t = 1 - \frac{\eta_N(C_t)^{1/\varsigma}}{w_t}, \quad (7)$$

$$p_t^H H_t^d = \left\{1 - \mathbb{E}_t\left(\frac{1 + \pi_{t+1}^H}{1 + i_t^B}\right)\right\}^{-1} \eta_H \epsilon_t^H C_t^{1/\varsigma}, \quad (8)$$

where π_t^H is the rate of increase in nominal house prices. All these equations take a familiar form, except for (8), which shows that an increase in the expected future rate of increase in housing prices, or a fall in the bond rate, lead (all else equal) to a rise in today's demand for housing.

2.2 Final Good Producer

The final good, Y_t , is produced by assembling a continuum of imperfectly substitutable intermediate goods Y_{jt} , with $j \in (0, 1)$:

$$Y_t = \left\{ \int_0^1 [Y_{jt}]^{(\theta-1)/\theta} dj \right\}^{\theta/(\theta-1)},$$

where $\theta > 1$ denotes the constant elasticity of substitution between the differentiated intermediate goods.

The FG producer chooses the optimal quantities of intermediate goods, Y_{jt} , that maximize its profits, taking as given both the prices of the intermediate goods, P_{jt} , and the final good price, P_t . This yields

$$Y_{jt} = Y_t \left(\frac{P_{jt}}{P_t} \right)^{-\theta}. \quad (9)$$

The zero-profit condition yields the final good price:

$$P_t = \left\{ \int_0^1 (P_{jt})^{1-\theta} dj \right\}^{1/(1-\theta)}. \quad (10)$$

2.3 Intermediate Good Firms

There is a continuum of IG producers, indexed by $j \in (0, 1)$. Using capital and labor each firm produces a perishable good, which is sold on a monopolistically competitive market. The IG firm rents capital from the CG producer at the rate r_t^K , and labor, at the rate w_t . Each IG firm j faces the production function

$$Y_{jt} = N_{jt}^{1-\alpha} K_{jt}^\alpha, \quad (11)$$

where N_{jt} is labor supplied by the representative household to firm j , K_{jt} capital rented by firm j , and $\alpha \in (0, 1)$.

The IG firm solves a two-stage pricing decision problem. In the first stage, each IG producer minimizes the cost of renting capital and employing labor, taking wages and

the rental price of capital as given. Specifically, the IG firm solves $\min_{N_{jt}, K_{jt}} w_t N_{jt} + r_t^K K_{jt}$, subject to (11). The optimal capital-labor ratio takes the familiar form $K_{jt}/N_{jt} = \alpha(1 - \alpha)^{-1} (w_t/r_t^K)$, with the unit real marginal cost equal to

$$mc_{j,t} = \frac{w_t^{1-\alpha} (r_t^K)^\alpha}{\alpha^\alpha (1 - \alpha)^{1-\alpha}}. \quad (12)$$

In the second stage, each IG producer chooses a sequence of prices P_{jt} so as to maximize discounted real profits. In Rotemberg fashion, they all incur a cost in adjusting prices, of the form

$$PAC_t^j = \frac{\phi_F}{2} \left(\frac{P_{jt}}{\tilde{\pi}^G P_{jt-1}} - 1 \right)^2 Y_t, \quad (13)$$

where $\phi_F \geq 0$ is the adjustment cost parameter and $\tilde{\pi}^G = 1 + \tilde{\pi}$ is the gross steady-state inflation rate. The second-stage optimization problem is thus⁵

$$\{P_{jt+s}\}_{s=0}^\infty = \arg \max \mathbb{E}_t \sum_{s=0}^\infty \beta^s \lambda_{t+s} J_{jt+s}^I,$$

where real profits at t , J_{jt}^I , are defined as $J_{jt}^I = [(P_{jt}/P_t) - mc_t]Y_{jt} - PAC_t^j$. Taking $\{mc_{t+s}, P_{t+s}, Y_{t+s}\}_{s=0}^\infty$ as given, the first-order condition for this maximization problem takes the standard form

$$\begin{aligned} (1 - \theta) \left(\frac{P_{jt}}{P_t} \right)^{-\theta} \frac{1}{P_t} + \theta \left(\frac{P_{jt}}{P_t} \right)^{-\theta-1} \frac{mc_{jt}}{P_t} - \phi_F \left\{ \left(\frac{P_{jt}}{\tilde{\pi}^G P_{jt-1}} - 1 \right) \frac{1}{\tilde{\pi}^G P_{jt-1}} \right\} \\ + \beta \phi_F \mathbb{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{P_{jt+1}}{\tilde{\pi}^G P_{jt}} - 1 \right) \left(\frac{P_{jt+1}}{\tilde{\pi}^G P_{jt}^2} \right) \frac{Y_{t+1}}{Y_t} \right\} = 0. \end{aligned} \quad (14)$$

2.4 Capital Good Producer

The CG producer owns all physical capital in the economy and uses a linear technology to produce capital goods. In order to produce these goods, the CG firm spends I_t on the final good. It must pay for these goods in advance and borrows from commercial banks at the beginning of the period. Thus, the real amount borrowed from banks, l_t , is

$$l_t = I_t. \quad (15)$$

⁵Because IG firms are owned by unconstrained households (to whom they transfer their profits), the firm's discount factor for period- $t + s$ profits is $\beta^s \lambda_{t+s}$, where λ_{t+s} is the marginal utility value (in terms of consumption) of an additional currency unit of profits at $t + s$. The same discount factor is used by the CG producer and banks.

The household makes its exogenous housing stock, \bar{H} , available without any direct charge to the CG producer, who uses it as collateral against which it borrows from banks. However, repayment is uncertain. If loans are repaid in full, an event that occurs with probability $q_t \in (0, 1)$, the total cost faced by the CG producer at the end of period t is $(1 + i_t^L)l_t$, where $1 + i_t^L$ is the aggregate gross interest rate charged by banks. If there is default, which occurs with probability $1 - q_t$, the CG producer loses the collateral that it pledged to secure the loan; collateral is given by $\kappa \mathbb{E}_t p_{t+1}^H \bar{H}$, where $\kappa = \int_0^1 \kappa^i di$ and $\kappa^i \in (0, 1)$ is the fraction of the housing stock pledged as collateral to each bank i , and $K_t = \int_0^1 K_{jt} dj$. Thus, expected repayment is $q_t(1 + i_t^L)l_t + (1 - q_t)\kappa \mathbb{E}_t p_{t+1}^H \bar{H}$.⁶

To produce new capital the CG firm combines gross investment with the existing stock of capital, adjusted for depreciation and adjustment costs:

$$K_{t+1} = I_t + (1 - \delta_K)K_t - \frac{\Theta_K}{2} \left(\frac{K_{t+1}}{K_t} - 1 \right)^2 K_t, \quad (16)$$

where $\delta_K \in (0, 1)$ denotes the constant rate of depreciation, and $\Theta_K > 0$ the adjustment cost parameter. The new capital stock is then rented to the IG producers at the rate r_t^K .

The CG producer chooses the level of capital stock so as to maximize the value of discounted stream of dividend payments to households subject to equation (16). Specifically, defining $\mathbb{E}_t \Pi_{t+1}^K = r_t^K K_t - q_t(1 + i_t^L)l_t - (1 - q_t)\kappa \mathbb{E}_t p_{t+1}^H \bar{H}$ as the CG producer's expected real profits at the end of period t , the first-order condition yields (see Appendix A of Agénor, Alper and Pereira da Silva, 2015):

$$\begin{aligned} \mathbb{E}_t r_{t+1}^K &= q_t(1 + i_t^L) \mathbb{E}_t \left\{ \left[1 + \Theta_K \left(\frac{K_{t+1}}{K_t} - 1 \right) \right] \left(\frac{1 + i_t^B}{1 + \pi_{t+1}} \right) \right\} \\ &\quad - \mathbb{E}_t \left\{ q_{t+1}(1 + i_{t+1}^L) \left[1 - \delta_K + \frac{\Theta_K}{2} \left[\left(\frac{K_{t+2}}{K_{t+1}} \right)^2 - 1 \right] \right] \right\}, \end{aligned} \quad (17)$$

which shows that the repayment probability affects the expected rate of return to capital through its effect on expected repayment in both period t and period $t + 1$.

The amount borrowed by the CG producer is a Dixit-Stiglitz basket of differentiated

⁶To avoid a corner solution with no lending we assume that the condition $\mathbb{E}_t p_{t+1}^H \bar{H} \leq (1 + i_t^L) l_t$ always holds.

loans, each supplied by a bank i , with a constant elasticity of substitution $\zeta^L > 1$:⁷

$$l_t = \left[\int_0^1 (l_t^i)^{(\zeta^L-1)/\zeta} di \right]^{\zeta^L/(\zeta^L-1)}.$$

The demand for type- i loan, l_t^i , is thus given by the downward-sloping curve

$$l_t^i = \left(\frac{1 + i_t^{L,i}}{1 + i_t^L} \right)^{-\zeta^L} l_t, \quad (18)$$

where $1 + i_t^{L,i}$ is the rate on the loan extended by bank i and $1 + i_t^L = \left[\int_0^1 (1 + i_t^{L,i})^{1-\zeta^L} di \right]^{1/(1-\zeta^L)}$ the aggregate loan rate.

2.5 Commercial Banks

Banks are risk neutral and of comparable size; they are indexed by $i \in (0, 1)$. They collect differentiated deposits from households and extend (as discussed earlier) differentiated loans to the CG producer in an environment of monopolistic competition. The supply of credit is perfectly elastic at the prevailing loan rate and therefore the total amount of lending provided by banks is given by equation (15). To fund any shortfall in funding, each bank borrows a real amount $l_t^{B,i}$ from the central bank at a cost i_t^R , which is also referred to as the refinance rate. Moreover, bank i holds one-period government bonds (a safe asset) in quantity $b_t^{B,i}$, with interest of i_t^B .

2.5.1 Balance Sheet

As the loan portfolio takes into account expected loan losses, consistent with standard practice loan loss reserves, LR_t^i , are subtracted from total loans.⁸ Bank i 's balance sheet is thus

$$l_t^i - LR_t^i + b_t^{B,i} + RR_t^i = d_t^i + l_t^{B,i}, \quad (19)$$

⁷The assumption that loans are differentiated across banks could be justified by the assumption that, due to proximity for instance, each bank has an advantage over the others in terms of inspecting a borrower's cash flows and balance sheet, observing his activities, and ensuring that he conforms to the terms agreed upon in the loan contract. This advantage is, however, only temporary, given that in a symmetric equilibrium they behave identically.

⁸Loan loss provisions are defined, in standard accounting rules, as an estimation of probable loan losses for a current year and are charged as an expense, deducted from current profits (see (28) below). Loan loss reserves, by contrast, are a balance sheet item that depends on loan-loss provisions, accumulated charged off loans—that is, loans that are in actual default and removed from the bank's balance sheet—and loan recoveries. The latter two components would not add much additional insight to the analysis and are ignored here for simplicity.

where RR_t^i denotes required reserves held at the central bank, which do not pay interest and are determined by:

$$RR_t^i = \mu_t^R d_t^i, \quad (20)$$

where $\mu_t^R \in (0, 1)$ is the reserve requirement ratio. Equation (19) shows that loan loss reserves, just like bank capital, are fundamentally an alternative way of funding bank lending operations.

In each period banks invest their loan loss reserves in the safe asset ($LR_t^i = b_t^{B,i}$) and earn a return of i_t^B on them. Given this assumption, the balance sheet constraint (19) can be used to determine residually the level of borrowing from (or deposits at) the central bank:

$$l_t^{B,i} = l_t^i - (1 - \mu_t^R) d_t^i. \quad (21)$$

The aggregate supply of deposits by households is a basket of differentiated deposits, each supplied to a bank i , with a constant elasticity of substitution $\zeta^D > 1$ between different types of deposits:

$$d_t = \left[\int_0^1 (d_t^i)^{(1+\zeta^D)/\zeta^D} di \right]^{\zeta^D/(1+\zeta^D)}.$$

The supply of type- i deposit, d_t^i , is thus given by the upward-sloping curve

$$d_t^i = \left(\frac{1 + i_t^{D,i}}{1 + i_t^D} \right)^{\zeta^D} d_t, \quad (22)$$

where $1 + i_t^{D,i}$ is the deposit rate offered by bank i and $1 + i_t^D = \left[\int_0^1 (i_t^{D,i})^{1+\zeta^D} di \right]^{1/(1+\zeta^D)}$ the aggregate deposit rate.

2.5.2 Provisioning Regimes

Banks must satisfy regulation in the form of setting loan loss provisions, LP_t , which are deducted from current earnings. As in Agénor and Zilberman (2015), they build provisions up gradually during the period; this leads to a partial adjustment formulation, which takes the form

$$LR_t^i = (LR_{t-1}^i)^{\rho_{LR}} (LP_t^i)^{1-\rho_{LR}}, \quad (23)$$

where $\rho_{LR} \in (0, 1)$ is a persistence parameter.

Provisioning rules can take two forms. With *specific* provisioning, provisions are triggered by the fraction of nonperforming loans (or, equivalently here, the probability

of default); with *cyclically adjusted* provisioning, provisions take into account both past due payments, as before, but also expected or latent losses over the whole business cycle. Thus, provisions are smoothed over the cycle and are less affected by the current state of the economy.

To capture these different regimes, the general specification proposed in this paper is as follows:

$$LP_t^i = \Lambda_0(1 - q_t^i)l_t^i + \max \left\{ 0, \Lambda_1 \left(\frac{q_t^i}{\tilde{q}^i} - 1 \right) l_t^i + \Lambda_2 \left(\frac{Y_t}{\tilde{Y}} - 1 \right)^{\theta_L} l_t^i \right\}, \quad (24)$$

where $\Lambda_0 > 0$, $\Lambda_1, \Lambda_2 \geq 0$, and $\theta_L \geq 0$. The case of specific provisions is obtained by setting $\Lambda_1 = \Lambda_2 = 0$, so that

$$LP_t^i = \Lambda_0(1 - q_t^i)l_t^i, \quad (25)$$

where Λ_0 can be interpreted as the steady-state fraction (or coverage ratio) of expected losses, whose level is defined as $(1 - q_t^i)l_t^i$, with $1 - q_t^i$ the default probability. Thus, given the max operator in (24), specific provisions are the minimum level that banks must comply with.

If $\Lambda_1 > 0$ and $\Lambda_2 = 0$, and assuming that the max operator is not binding, expression (24) gives

$$LP_t^i = \Lambda_0(1 - q_t^i)l_t^i + \Lambda_1 \left(\frac{q_t^i}{\tilde{q}^i} - 1 \right) l_t^i, \quad (26)$$

which generalizes the case considered in Agénor and Zilberman (2015).⁹ The difference between (25) and (26) is that with cyclically adjusted provisioning, during an expansion, when the default probability $1 - q_t$ is lower than the estimation of default risk over the whole cycle $1 - \tilde{q}$ (or, equivalently, when $q_t > \tilde{q}$), banks will build up more provisions.

Specification (24) is more general than the cases considered in the literature in the sense that, in addition to the special cases outlined earlier, it brings in an additional element when $\Lambda_2 > 0$: the possibility that cyclical movements in a macroeconomic variable, aggregate output Y_t , may also affect the calculation of cyclically adjusted provisions when $\Lambda_1 \geq 0$. This case is consistent with the Peruvian formula, which uses the growth rate of output (see Wezel et al., 2012).

⁹Agénor and Zilberman write the right-hand side of (26) in the form $\Lambda_0(1 - q_t^i)l_t^i + \Lambda_1\Lambda_0(q_t^i - \tilde{q}^i)l_t^i$, which can also be written as the weighted average $\Lambda_1\Lambda_0(1 - \tilde{q}^i)l_t^i + (1 - \Lambda_1)\Lambda_0(1 - q_t^i)l_t^i$; their focus is on the case where $\Lambda_1 \in (0, 1)$.

The general specification (24) is consistent with the view that, if provisions can take into account more credit information and better anticipate and quantify the expected losses associated with a loan portfolio (using either only bank-specific or macroeconomic information), they would provide additional buffers to mitigate procyclicality and promote financial stability. This would occur both by discouraging (although not necessarily eliminating) excessive lending in booms and by strengthening banks prior to downturns.

2.5.3 Interest Rate Determination

As noted earlier, banks are monopolistically competitive in the markets for deposits and loans. They therefore set interest rates to maximize the present value of expected profits. In addition, banks also optimize their monitoring effort. Specifically, each bank can affect the repayment probability on its loan to the CG producer, q_t^i , by expending effort; the higher the monitoring effort, the safer the loan. Thus, greater monitoring is also desirable from the borrower's perspective.¹⁰ For simplicity, the probability of repayment itself, rather than monitoring effort *per se*, is taken to be the choice variable.

Formally, each bank sets its (gross) deposit and loan rates and the repayment probability in order to maximize the present value of its end-of-period expected real profits:

$$\max_{1+i_t^{D,i}, 1+i_t^{L,i}, q_t^i} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \lambda_{t+s} \Pi_{t+s+1}^{B,i}, \quad (27)$$

where $\mathbb{E}_t \Pi_{t+s+1}^{B,i}$ is defined as, $\forall s$,¹¹

$$\begin{aligned} \mathbb{E}_t \Pi_{t+s+1}^{B,i} = & \mathbb{E}_t \left\{ q_{t+s}^i (1 + i_{t+s}^{L,i}) l_{t+s}^i \right. \\ & + (1 - q_{t+s}^i) (\kappa^i p_{t+s+1}^H \bar{H}) + (1 + i_{t+s}^B) LR_{t+s}^i - (1 + i_{t+s}^D) d_{t+s}^i \\ & \left. - (1 + i_{t+s}^R) [l_{t+s}^i - (1 - \mu_t^R) d_{t+s}^i] - LP_{t+s}^i - x_{t+s}^{M,i} - \Gamma(l_t^i, d_t^i) \right\}, \end{aligned} \quad (28)$$

¹⁰As noted by Allen et al. (2011: 988-89), one way of interpreting this assumption is that banks observe information on borrowers and then use it to help improve their performance. Another is that banks and borrowers have complementary skills: producers have expertise in running the firm, whereas banks provide financial expertise that helps to improve the borrower's expected value. Note also that, because there is only a single CG producer in this setting, banks do not expend effort to select (*ex ante*) potential borrowers.

¹¹Note that loan loss provisions, LP_t^i , are deducted from the bank's profits but also enter partly as gross income because loan loss reserves are invested in government bonds ($LR_t^i = b_t^{B,i}$).

where $x_t^{M,i}$ is the pecuniary cost of monitoring (in real terms) faced by bank i , defined as

$$x_t^{M,i} = \Phi\left(\frac{\kappa^i \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t^i}, \frac{Y_t}{\tilde{Y}}\right) \frac{(q_t^i)^2}{2} l_t^i, \quad (29)$$

where the unit cost function $\Phi()$ is taken to depend on bank i 's collateral-loan ratio and cyclical output, Y_t/\tilde{Y} , with a ' \sim ' denoting a steady-state value. Both variables are assumed to have a negative effect on (unit) monitoring costs. First, a higher collateral-loan ratio mitigates moral hazard problems and induces borrowers to take less risk and exert more effort in ensuring that their investments are successful; in addition, it may induce them to be more compliant with bank monitoring requirements. Second, in boom times, when profits and cash flows are high, (unit) monitoring costs tend to fall because borrowers are more diligent and the risk of default also falls.

The function $\Gamma(l_t^i, d_t^i)$ is assumed to be strictly increasing and convex, so that $\Gamma_l, \Gamma_d > 0$, $\Gamma_{ll}, \Gamma_{dd} > 0$; in addition, it is also assumed to be linearly homogeneous. By implication of linear homogeneity, $\Gamma_{ld} < 0$, that is, a higher volume of deposits lowers the cost of lending by providing more information on (potential) borrowers. There is therefore cost complementarity or economies of scope—that is, lower costs of producing a combined set of products than the sum of costs producing them individually—a well-documented feature of banking (see, for instance, Dijkstra 2013). In what follows, we will focus on the case where $\Gamma(l_t^i, d_t^i)$ can be represented by the Diewert cost function

$$\Gamma(l_t^i, d_t^i) = \gamma_D d_t^i + \gamma_L l_t^i - 2\gamma \sqrt{d_t^i l_t^i}, \quad (30)$$

where $\gamma_D, \gamma_L, \gamma > 0$.¹²

Bank i maximizes profits subject to the downward-sloping loan demand equation by the CG producer (18), the balance sheet constraint (21), the upward-sloping supply curve of deposits (22), endogenous monitoring costs (29), the cost function (30), and given the provisioning regime, the value of collateral, the (unit) cost of monitoring and the refinance rate. As shown in Appendix A, in a symmetric equilibrium, the solution to this optimization problem leads to the following first-order conditions:

$$q_t = \min \left\{ \Phi^{-1}\left(\frac{\mathbb{E}_t p_{t+1}^H \bar{H}}{l_t}, \frac{Y_t}{\tilde{Y}}\right) [1 + i_t^L - (\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t})], 1 \right\}, \quad (31)$$

¹²An alternative specification, which has the same properties and generalizes the functional form suggested by Edwards and Végh (1997, footnote 14), is $\Gamma(l_t^i, d_t^i) = \sqrt{\gamma_L (l_t^i)^2 + \gamma_D (d_t^i)^2}$, where $\gamma_L, \gamma_D > 0$.

$$1 + i_t^D = \frac{\zeta^D}{1 + \zeta^D} \left\{ (1 - \mu_t^R)(1 + i_t^R) + \gamma_D - \gamma\left(\frac{l_t}{d_t}\right)^{0.5} \right\}, \quad (32)$$

$$1 + i_t^L = \frac{\zeta^L}{q_t(\zeta^L - 1)} \left\{ 1 + i_t^R + \gamma_D - \gamma\left(\frac{d_t}{l_t}\right)^{0.5} + \frac{\partial LP_t}{\partial l_t} - (1 + i_t^B) \frac{\partial LR_t}{\partial l_t} \right\}. \quad (33)$$

Condition (31) shows that, all else equal, a higher loan rate, or a higher level of cyclical output, tends to increase incentives to monitor borrowers. Thus, the optimal level of monitoring is increasing in the loan rate, as in Allen et al. (2011), for instance. Intuitively, a higher loan rate increases incentives to monitor because it raises the bank's pay-off if there is no default and the loan is repaid.

Condition (31) also shows that the collateral-loan ratio exerts conflicting effects on the level of effort and the repayment probability. On the one hand, there is a moral hazard effect (reduced incentives for borrowers to take risks), which raises q_t . On the other, there is a loss-limiting effect, due to the fact that collateral limits the loss that the bank incurs in case of default; all else equal, it thus reduces incentives to monitor borrowers and tends to lower q_t . In what follows we assume, consistent with the preponderance of the evidence for middle-income countries (see Agénor and Pereira da Silva, 2014), that the former effect dominates, so that the net effect of an increase in the collateral-loan ratio is to raise the probability of repayment. For tractability, and assuming an interior solution, we therefore write (31) in the form

$$q_t = \left(\frac{Y_t}{\tilde{Y}}\right)^{\varphi_1} \left(\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t}\right)^{\varphi_2} \left(\frac{1 + i_t^L}{1 + \tilde{i}^L}\right)^{\varphi_3} \epsilon_t^Q, \quad (34)$$

where $\varphi_1, \varphi_2, \varphi_3 > 0$. The random variable ϵ_t^Q , which captures nonsystematic shocks to the repayment probability, follows an $AR(1)$ process, $\epsilon_t^Q = (\tilde{\epsilon}^Q)^{1-\rho^Q} (\epsilon_{t-1}^Q)^{\rho^Q} \exp(\xi_t^Q)$, where $\rho^Q \in (0, 1)$, $\xi_t^Q \sim \mathbf{N}(0, \sigma_{\xi^Q})$, and $\tilde{\epsilon}^Q$ normalized to unity.

Condition (32) indicates that the deposit rate is a markdown over the marginal cost of borrowing from the central bank, adjusted for the marginal cost of managing deposits. Condition (33) shows that the loan rate depends not only on the repayment probability, the marginal cost of borrowing, and the marginal cost of producing loans, but also on the loan loss provisioning regime. As discussed in Agénor and Zilberman (2015), what may be called the *provisioning cost channel* is related to the composite term $\partial LP_t / \partial l_t - (1 + i_t^B) (\partial LR_t / \partial l_t)$ in (33). This term results from the relationship between loan loss reserves invested in a safe asset and the direct cost effect of raising

provisions. Intuitively, a one-unit increase in lending raises the flow of provisions by $\partial LP_t / \partial l_t$; this is costly for banks (provisions reduce profits) and accordingly they adjust the loan rate upward. However, the fact that the induced change in loan loss reserves, $\partial LR_t / \partial l_t$, yields a gross return of $1 + i_t^B$, tends at the same time to lower the loan rate. From (23),

$$\frac{\partial LR_t}{\partial l_t} = (LR_{t-1})^{\rho_{LR}} (1 - \rho_{LR}) (LP_t)^{-\rho_{LR}} \frac{\partial LP_t}{\partial l_t},$$

which implies that the composite term in (33) can be written as

$$\frac{\partial LP_t}{\partial l_t} - (1 + i_t^B) \frac{\partial LR_t}{\partial l_t} = [1 - (1 + i_t^B) (LR_{t-1})^{\rho_{LR}} (1 - \rho_{LR}) (LP_t)^{-\rho_{LR}}] \frac{\partial LP_t}{\partial l_t},$$

where, from (24), and assuming that the max operator is not binding,

$$\frac{\partial LP_t}{\partial l_t} = \Lambda_0(1 - q_t) + \Lambda_1\left(\frac{q_t}{\tilde{q}} - 1\right) + \Lambda_2\left(\frac{Y_t}{\tilde{Y}} - 1\right)^{\theta_L}.$$

In turn, this equation implies that, in the case of specific provisions,

$$\frac{\partial LP_t}{\partial l_t} = \Lambda_0(1 - q_t), \quad (35)$$

whereas in the case of cyclically adjusted provisions, with $\Lambda_2 = 0$,

$$\frac{\partial LP_t}{\partial l_t} = \Lambda_0(1 - q_t) + \Lambda_1\left(\frac{q_t}{\tilde{q}} - 1\right). \quad (36)$$

In line with the evidence on the high degree of loan rate stickiness in middle-income countries, and following Agénor and Alper (2012), a simple partial adjustment to the equilibrium solution (33) is imposed.¹³

2.6 Central Bank

The central bank's assets consist of loans to commercial banks $l_t^B = \int_0^1 l_t^{B,i} di$ and holdings of government bonds, b_t^C , whereas its liabilities are given by currency in circulation, m_t^S , and reserve requirements:

$$l_t^B + b_t^C = m_t^S + RR_t. \quad (37)$$

¹³A more rigorous analysis of loan rate stickiness could involve introducing Rotemberg-type quadratic adjustment costs in the profit function (28), as, for instance, in Hulsewig et al. (2009), Gerali et al. (2010), and Güntner (2011), or Calvo-type pricing, as in Henzel et al. (2009). However, this would complicate the analysis without providing much additional insight.

Changes in the central bank's holdings of government bonds are specified as

$$b_t^C - \frac{b_{t-1}^C}{1 + \pi_t} = -\kappa^C(l_t^B - \frac{l_{t-1}^B}{1 + \pi_t}), \quad (38)$$

where $\kappa^C \in (0, 1)$. Combining (37) and (38) yields

$$m_t^S = \frac{m_{t-1}^S}{1 + \pi_t} + (1 - \kappa^C)(l_t^B - \frac{l_{t-1}^B}{1 + \pi_t}) - (RR_t - \frac{RR_{t-1}}{1 + \pi_t}). \quad (39)$$

This equation allows us to distinguish between two monetary policy regimes: open-market operations ($\kappa^C = 1$) and a standing facility ($\kappa^C = 0$), where changes in central bank lending have a full impact on the supply of cash.

The central bank's refinance rate, i_t^R , is set on the basis of a standard Taylor-type rule:

$$\frac{1 + i_t^R}{1 + \tilde{i}^R} = (\frac{1 + i_{t-1}^R}{1 + \tilde{i}^R})^\chi \left\{ (\frac{1 + \pi_t}{1 + \pi^T})^{\varepsilon_1} (\frac{Y_t}{\tilde{Y}})^{\varepsilon_2} \right\}^{1-\chi}, \quad (40)$$

where π^T is the target inflation rate, Y_t/\tilde{Y} is again the cyclical component of output, $\chi \in (0, 1)$ the degree of interest rate smoothing and $\varepsilon_1, \varepsilon_2 > 0$.

2.7 Government

The government spends G_t on the final good and issues one-period risk-free bonds, held by households, commercial banks, and the central bank. The government collects lump-sum taxes on households, pays interest to them on their holding of government bonds, and receives all interest income generated by the central bank by supplying loans to the commercial bank and by holding government bonds. Thus, its budget constraint in real terms is

$$T_t + (\frac{1 + i_{t-1}^R}{1 + \pi_t})l_{t-1}^B + (\frac{1 + i_{t-1}^B}{1 + \pi_t})b_{t-1}^C + b_t = (\frac{1 + i_{t-1}^B}{1 + \pi_t})b_{t-1} + G_t, \quad (41)$$

where $b_t = b_t^P + b_t^B + b_t^C$ and $b_t^B = \int_0^1 b_t^{B,i} di$. Government spending is a constant fraction of output of the final good:

$$G_t = \psi Y_t, \quad (42)$$

where $\psi \in (0, 1)$.

Figure 1 summarizes the main real and financial flows among agents captured by the model.

2.8 Market-Clearing Conditions

In what follows we assume that the government maintains a balanced budget by adjusting lump-sum taxes, while keeping its overall stock of bonds constant at b . Moreover, the stock of bonds held by the central bank is also assumed to be constant at b^C .

In a symmetric equilibrium, households are identical and IG firms produce the same output and set equal prices. Therefore, $K_{j,t} = K_t$, $N_{j,t} = N_t$, $Y_{j,t} = Y_t$ and $P_{j,t} = P_t$ for all $j \in (0, 1)$.

The supply of loans by the commercial bank and the supply of deposits by households are assumed to be perfectly elastic at the prevailing interest rates and therefore markets for loans and deposits always clear.¹⁴ The goods market-clearing condition is

$$Y_t = C_t + I_t + G_t + \frac{\phi_F}{2} \left(\frac{1 + \pi_t}{1 + \tilde{\pi}} - 1 \right)^2 Y_t. \quad (43)$$

Loans are made in the form of cash. Therefore, the equilibrium condition in the currency market is obtained by equating the supply of cash with total holdings of cash, by households and firms:

$$m_t^S = m_t^P + l_t. \quad (44)$$

3 Steady State and Log-Linearization

The steady-state properties of the model are presented in Appendix B. Several of these properties (regarding, for instance, the relationship between prices and marginal costs) are familiar, so we focus here only on those characterizing the key financial variables. Under the assumption of zero inflation in the steady state ($\pi^T = 0$), the long-run value of the bond rate is equal to the policy rate, that is, $\tilde{i}^B = \tilde{i}^R = \beta^{-1} - 1$. This equality ensures that the commercial bank has no incentive to borrow from the central bank in order to invest in government bonds. From (32), the deposit rate is

$$1 + \tilde{i}^D = \frac{\zeta^D}{1 + \zeta^D} \left\{ (1 - \tilde{\mu}^R)(1 + \tilde{i}^R) + \gamma_D - \gamma \left(\frac{\tilde{l}}{\tilde{d}} \right)^{0.5} \right\}, \quad (45)$$

which requires appropriate restrictions on the cost parameters γ and γ_D to ensure that $\tilde{i}^R > \tilde{i}^D$ (otherwise banks would have no incentives to take on deposits).

¹⁴Walras's Law ensures that the market for bonds always clears and therefore this market is ignored.

In the steady state, loan loss reserves and loan loss provisions under all regimes are equal to

$$\widetilde{LR} = \widetilde{LP} = \Lambda_0(1 - \tilde{q})\tilde{l}, \quad (46)$$

where, from (34), $\tilde{q} = (\kappa \tilde{p}^H \bar{H} / \tilde{l})^{\varphi_2}$. Thus, from (33), the loan rate is also the same under both provisioning rules:

$$1 + \tilde{i}^L = \frac{\zeta^L}{\tilde{q}(\zeta^L - 1)} \left\{ 1 + \tilde{i}^R + \gamma_L - \gamma \left(\frac{\tilde{d}}{\tilde{l}} \right)^{0.5} - \tilde{i}^B \Lambda_0(1 - \tilde{q}) \right\},$$

which again requires appropriate restrictions on γ_L and γ to ensure that $\tilde{i}^L > \tilde{i}^R$ (otherwise banks would have no incentives to lend).

The log-linearized equations of the model around a non-stochastic steady state are presented in Appendix C. Many of these equations are familiar and, given the issue at stake, are not repeated here. The equations for loan loss provisions, loan loss reserves in the case where $\Lambda_2 = 0$, the repayment probability, and bank interest rates are given by

$$\widehat{LR}_t = \rho_{LR} \widehat{LR}_{t-1} + (1 - \rho_{LR}) \widehat{LP}_t, \quad (47)$$

$$\widehat{LP}_t = \begin{cases} \hat{l}_t - \tilde{q}/(1 - \tilde{q})\hat{q}_t & \Lambda_1 = 0 \\ \hat{l}_t + [\tilde{q}(\Lambda_1 - \Lambda_0)/\Lambda_0(1 - \tilde{q})]\hat{q}_t & \Lambda_1 > 0 \end{cases}, \quad (48)$$

$$\hat{q}_t = \varphi_1 \hat{Y}_t + \varphi_2 (\mathbb{E}_t \hat{p}_{t+1}^H - \hat{l}_t) + \varphi_3 \hat{i}_t^L + \epsilon_t^Q, \quad (49)$$

$$\hat{i}_t^D = (1 - \tilde{\mu}^R) \hat{i}_t^R - 0.5\gamma \sqrt{\tilde{l}/\tilde{d}} (\hat{l}_t - \hat{d}_t), \quad (50)$$

$$\hat{i}_t^L = \hat{i}_t^R + 0.5\gamma \sqrt{\tilde{d}/\tilde{l}} (\hat{l}_t - \hat{d}_t) - (1 + \tilde{i}^L) \hat{q}_t - (1 - \tilde{q})(1 + \tilde{i}^B) \hat{i}_t^B \quad (51)$$

$$+ \Lambda_0(1 - \Lambda_1)(1 - \tilde{q})\rho_{LR}(1 - \rho_{LR})(\widehat{LP}_t - \widehat{LR}_{t-1}).$$

These equations illustrate fairly well the partial equilibrium effects of temporary shocks. For instance, an unanticipated increase in default risk (that is, a reduction in ϵ_t^Q) lowers the repayment probability and raises the loan rate. In turn, the increase in the loan rate raises incentives to monitor, thereby mitigating the initial drop in the repayment probability. However, movements in the loan rate also affect the demand for credit as well as the deposit and the bond rates, which in turn affect investment, output, and loan loss provisions and reserves—with feedback effects on interest rates and the repayment probability. To study these general equilibrium effects requires a numerical analysis of the complete model.

4 Parameterization

As noted in the introduction, most of the countries that introduced cyclically adjusted provisioning regimes in recent years are upper-income Latin American countries. Accordingly, the model is parameterized for a “typical” middle-income country. To do so we focus as much as possible on Agénor et al. (2013); we therefore refer to that study for a detailed discussion of some of our choices. In addition, for some of the parameters that are “new” or specific to this study, we consider alternative values.

Parameter values are summarized in Table 1. The discount factor β is set at 0.99, a fairly standard value. The intertemporal elasticity of substitution, ς , is 0.5, in line with estimates for middle-income countries (see Agénor and Montiel, 2015). The preference parameter for leisure, η_N , is set at 1.5, in order to obtain a proportion of time allocated to market work equal to about 60 percent. The preference parameter for composite monetary assets, η_x , is set at a low value of 0.01 to capture the fact that money brings little utility, whereas the share parameter in the index of money holdings, ν , which corresponds to the relative share of cash in narrow money, is set at 0.4 to capture the relatively higher use of cash in developing countries. The steady-state weight of housing in the utility function, η_H , is set to 0.02 in order for the ratio of housing wealth to GDP to be approximately 1.4 in the steady state. The degree of persistence of the housing demand shock is assumed to be relatively low, $\rho_H = 0.7$.

The share of capital in output of intermediate goods, $1 - \alpha$, is set at 0.3 (a fairly standard value) whereas the elasticity of demand for intermediate goods, θ , is set at 6—implying a steady-state value of the markup rate, $\theta/(\theta - 1)$, equal to 20 percent. The adjustment cost parameter for prices, ϕ_F , is set at 74.5. The rate of depreciation of private capital, δ_K , is set equal to 0.03, corresponding to an annual rate of 12.6 percent. The adjustment cost for transforming investment into capital goods, Θ_K , is set at 30, to capture significant frictions in that process.

For the parameters characterizing bank behavior, we take the effective collateral-loan ratio, κ , to be 0.2. The elasticity of the repayment probability with respect to cyclical output is set at $\varphi_1 = 0.03$, whereas the elasticities with respect to the collateral-loan ratio and the loan rate are set at $\varphi_2 = 0.05$ and $\varphi_3 = 0.2$, respectively. Based on these values the initial repayment probability is calibrated at 0.92, to reflect a relatively

high default rate. As in Agénor and Zilberman (2015), the persistence parameter ρ_{LR} is set at 0.8, to approximate the standard stock-flow relationship between loan loss reserves and past reserves.³ The elasticities of substitution ζ^D and ζ^L , which measure the degree of monopoly power in banking, are set at 2.0 and 4.5, in line with the values used, for instance, by Dib (2010). The parameter characterizing the partial adjustment imposed on the loan rate in (33) is set to 0.9, to capture a high degree of stickiness. The costs parameters γ , γ_D and γ_L are calibrated at 0.01, 0.1, and 0.1, respectively. These values help to generate reasonable values for steady-state deposit and loan rates.⁴ The degree of persistence of the repayment probability shock is set at $\rho^Q = 0.8$.

For the parameters characterizing central bank behavior and the government, the persistence parameter in the central bank's policy response is set at $\chi = 0.8$. We also set $\varepsilon_1 = 1.5$ and $\varepsilon_2 = 0.2$. All three values are consistent with estimates of Taylor-type rules for Latin America (see, for instance, Barajas et al., 2014). The reserve requirement rate μ^R is set at 0.1. We focus on the case where monetary policy is operated through a standing facility, so that $\kappa^C = 0$.⁵ Finally, as in Agénor and Alper (2012), the share of government spending in output, ψ , is set at 0.2.

5 Experiments

To illustrate the role of alternative provisioning rules in the transmission of shocks, we consider two transitory disturbances: an increase in the risk of default and a negative shock to asset prices, in the form of a negative disturbance in housing demand.⁶ In what follows we focus on the case where $\Lambda_2 = 0$ and will discuss the alternative case where $\Lambda_2 > 0$ in the sensitivity analysis that we report later on. To highlight the role of provisioning regimes in the transmission of financial shocks, we initially compare the performance of specific and cyclically adjusted provisioning rules, respectively, by

³Recall that our specification captures lags between provisioning requirements and the actual build-up of provisions. Experiments with a higher value of $\rho_{LR} = 0.95$ show little effect on the results.

⁴As can be inferred from (50) and (51), γ_D and γ_L play no role in the dynamics of the model; the values chosen ensure that the steady-state restrictions $\bar{i}^L > \bar{i}^R > \bar{i}^D$, as mentioned earlier, are satisfied.

⁵In preliminary experiments we also considered the case of open-market operations ($\kappa^C = 1$), but differences were relatively minor and are not reported to save space.

⁶We also experimented with a negative shock to productivity by adding a relevant term in (11), but the results are as expected—alternative provisioning regimes do not make much difference in that case. We therefore omit the results to save space.

setting $\Lambda_1 = 0$ and $\Lambda_1 = 1.0$ (the case referred to as “full smoothing” in Agénor and Zilberman, 2015).

5.1 Increased Risk of Default

Consider first a transitory increase in default risk, as captured by a one percentage point drop in the repayment probability. The results are reported in Figure 2, under a specific provisioning regime (continuous blue line) and a cyclically adjusted provisioning regime with $\Lambda_1 = 1$ (dashed red line).

The direct effect of an exogenous reduction in the repayment probability is an immediate increase in the (current and future) loan rate. This, in turn, lowers investment and the rate at which physical capital is accumulated, as well as output and employment. By itself a lower capital stock tends to increase the rental rate of capital. However, the drop in employment lowers real wages, and the net effect on marginal costs is negative. Consequently, inflation also falls on impact.

Because both output and inflation fall, the policy rate falls as well, thereby mitigating the initial increase in the loan rate. The deposit rate, set as a markdown on the policy rate, drops as well, resulting in lower demand for deposits and hence (all else equal) an increase in borrowing from the central bank and an expansion in the monetary base. To raise demand for cash and restore equilibrium in the money market, the bond rate must therefore fall. The drop in the nominal bond rate exceeds the drop in inflation, implying that the real bond rate also falls. Through intertemporal substitution this results in a higher level of current consumption, which mitigates the initial drop in output associated with the drop in investment. At the same time, the cyclical drop in output tends to amplify the response of the repayment probability and the increase in the loan rate.

The key channels through which changes in provisions affect the real economy operate through the relationship between loan loss reserves invested in a risk-free asset and the direct cost effect of holding provisions—the combination of which we earlier referred to as the provisioning cost channel. Following a fall in the repayment probability, the loan loss provisions-loan ratio increases. This leads to a higher loan rate through the direct cost effect of raising provisions—regardless of the provisioning regime. However, as also shown in Figure 2, provisions under the cyclically adjusted regime increase by

less, thereby mitigating the increase in the loan rate and dampening fluctuations on the real side of the economy.

Intuitively, with a cyclically adjusted provisioning regime, loan loss provisions are smoothed over the cycle in such a way that provisions (and, to a lower extent, loan loss reserves) are less affected by the current fraction of nonperforming loans. Thus, although the direct effect of the fall in the repayment probability is to increase the loan rate, its indirect effect (through the provisioning cost channel) is to reduce it when provisions are adjusted to reflect cyclical movements. Because a lower loan rate mitigates the drop in investment and output, a cyclically adjusted provisioning system is more countercyclical than a specific provisioning system.

5.2 Negative Asset Price Shock

Consider next a transitory drop in asset prices induced by a negative housing demand shock, as captured by a 10 percentage point drop in the shock ϵ_t^H in the utility function (1). The results are reported in Figure 3.

A negative shock to the demand for housing services leads to an immediate drop in real house prices, which in turn lowers the collateral-loan ratio. As a result, the repayment probability drops on impact, which translates into a higher loan rate. This in turn leads to a contraction in investment and aggregate demand, which therefore leads to downward pressure on inflation. The movements in output and inflation combine to produce a lower policy rate, which mitigates the initial increase in the loan rate. Because the deposit rate falls, households have incentives to switch to cash; to maintain equilibrium of the currency market the nominal bond rate must fall as well. The real bond rate also falls, thereby inducing households to spend more today. This tends to mitigate the effect of a higher loan rate on aggregate demand. Qualitatively, these features of the transmission mechanism of a housing demand shock are thus similar to those associated with a default risk shock.

The qualitative features of the shock also do not change across provisioning regimes, but there are significant quantitative differences. Loan loss provisions are smoothed to a greater extent under cyclically adjusted provisioning, which means a smaller current and expected increase in the loan rate. As a result, the initial fall in investment is mitigated, and so is the drop in output. Thus, inflation is less volatile and so is the

policy rate.

To summarize the results of these shocks, Tables 2 and 3 provide the asymptotic standard deviations under specific provisioning ($\Lambda_1 = 0$) and a cyclically adjusted provisioning regime with $\Lambda_1 = 1$. The tables confirm that cyclically adjusted provisioning is highly effective in terms of mitigating the volatility of key macroeconomic and financial variables—especially, of course, those variables in terms of which financial stability is subsequently defined, the loan-output ratio and real house prices—even though loan loss provisions and reserves are, naturally enough, more volatile. Fundamentally, the reason why a cyclically adjusted provisioning regime is more effective in terms of macroeconomic and financial stability is because it helps to mitigate changes in the stock of loan loss reserves in the course of the business cycle, as often argued in practice.

6 Optimal Simple Policy Rules

We now focus on optimal, implementable policy rules, in a context where the central bank (which is also the regulator) is concerned with two objectives, macroeconomic stability and financial stability, in a context where the two mandates are *independent*. The first objective, which consists of mitigating inflation volatility and output fluctuations, is achieved through the Taylor rule defined earlier and is set by a Monetary Policy Committee. Thus, the central bank does not optimize with respect to monetary policy. For the second objective, set by a Financial Stability Committee, we first define financial volatility in terms of a weighted geometric average of two indicators: the volatility of the credit-to-GDP ratio and the volatility of real house prices, measured on the basis of the asymptotic standard deviations of these variables. As documented in the literature, both indicators have often been associated with financial crises, in industrial and developing countries alike (see Agénor and Pereira da Silva, 2013; Agénor and Montiel, 2015; and Aikman et al., 2015). However, the evidence is much more robust statistically—particularly for developing countries—for fluctuations in credit. Indeed, empirical studies suggest that once the magnitude of the credit expansion (in terms of growth rate or as a ratio to output) is taken into account, the occurrence or the magnitude of booms in asset prices does not contribute significantly to predicting financial crises. Accordingly, to measure financial volatility we assign weights of 0.8 to

the credit-to-GDP ratio and 0.2 to the volatility of real house prices.⁷

We then assume that the central bank sets its macroprudential instruments to minimize financial volatility and consider two alternative settings: first, the case where it sets the cyclically adjusted provisioning parameter Λ_1 only; second, the case where it sets *jointly* the optimal values of the parameter Λ_1 and the reaction parameter in an alternative macroprudential rule. The premise here is that, by itself, cyclically adjusted provisioning may not be effective enough to dampen procyclicality and that policymakers may need to rely on a range of countercyclical macroprudential tools to achieve that goal.⁸ In what follows we focus on reserve requirements as an additional instrument. As discussed at length in Montoro and Moreno (2011), Cordella et al. (2014), and Agénor et al. (2015), in recent years policymakers in middle-income countries (especially in Latin America) have often used reserve requirements as part of a countercyclical toolkit to mitigate macroeconomic fluctuations. The novelty here is that we take a normative view of the issue and consider the use of a *systematic* reserve requirement rule from the perspective of financial stability only.

6.1 Cyclically Adjusted Provisioning Rule

First, consider the case where the cyclically adjusted provisioning parameter Λ_1 is set so as to minimize financial volatility, while the reserve requirement rate is kept constant and $\Lambda_2 = 0$. The results are shown in Figure 4 for the two shocks considered earlier, using a grid step of 0.3 and measuring volatility relative to the specific provisions case, that is, $\Lambda_1 = 0$.

In both cases the relationship between the parameter Λ_1 and financial volatility follows a U-shaped pattern. Intuitively, as the policy becomes more aggressive, volatility falls at first, because (as can be inferred from Figures 2 and 3) the policy stabilizes credit, investment and output. However, the more aggressive the policy becomes, the more volatile market interest rates become; volatility in domestic interest rates induces more volatility in bank lending, which feeds (through the collateral effect) into the repayment probability and therefore tends to increase financial volatility—so much so

⁷Setting the weight of real house prices to zero or increasing it to as high as 0.5 does not qualitatively affect the results of the paper, especially the “excess smoothing” feature of the optimal provisioning policy.

⁸See, for instance, Chan-Lau (2012). Agénor and Zilberman (2015) consider the combination of provisioning regimes and a credit gap-augmented Taylor rule.

that it eventually dominates the gains in terms of reduced volatility in credit and aggregate demand. Thus, there exists an optimal value for Λ_1 , which in Figure 4 is 4.5 for the default risk shock and 3.0 for the asset price shock.⁹ Put differently, the optimal simple policy rule involves “excess smoothing,” in the sense that it reacts more than proportionally to steady-state deviations in the repayment probability ($\Lambda_1 > 1$). Tables 2 and 3 also show that under the optimal Λ_1 , volatility for most variables (except most notably for loan loss provisions and reserves, as can be expected) is lower than in the “full smoothing” case $\Lambda_1 = 1$, following both shocks.

6.2 Optimal Provisions and Required Reserves

Consider now the case where the Financial Stability Committee of the central bank sets both the cyclically adjusted provisioning parameter Λ_1 and the parameters of a countercyclical reserve requirement rule that relates (as in Agénor et al., 2015) changes in the reserve requirement rate, μ_t^R , to deviations in the ratio of bank loans to total output:

$$\frac{1 + \mu_t^R}{1 + \tilde{\mu}^R} = \left(\frac{1 + \mu_{t-1}^R}{1 + \tilde{\mu}^R} \right)^{\chi_1^R} \left\{ \left(\frac{l_t/Y_t}{\tilde{l}/\tilde{Y}} \right)^{\chi_2^R} \right\}^{1-\chi_1^R}, \quad (52)$$

where $\chi_1^R \in (0, 1)$ and $\chi_2^R > 0$. Equation (50) is now replaced by

$$\hat{i}_t^D = (1 - \tilde{\mu}^R) \hat{i}_t^R - \tilde{i}^R \tilde{\mu}^R \hat{\mu}_t^R - 0.5\gamma \sqrt{\tilde{l}/\tilde{d}} (\hat{l}_t - \hat{d}_t), \quad (53)$$

Equations (51) and (53) help to illustrate clearly the *partial* equilibrium effects of an increase in the reserve requirement rate, μ_t^R . These effects are such that a higher $\hat{\mu}_t^R$ lowers initially the deposit rate \hat{i}_t^D , which reduces the demand for deposits by households \hat{d}_t . At the initial level of loans, $\hat{l}_t - \hat{d}_t$ increases, which raises production costs for the bank. The effect of higher costs is to further reduce the deposit rate and to increase the loan rate; thus, the bank interest rate spread increases unambiguously. The policy is countercyclical, at least with respect to investment.

However, the *general* equilibrium effects weaken this result. The reason is that the higher loan rate tends to reduce the demand for loans, \hat{l}_t . If this effect is small, the partial equilibrium effects described above will continue to hold. But if the fall in \hat{l}_t is large enough to ensure that $\hat{l}_t - \hat{d}_t$ decreases, bank production costs will fall, which

⁹Using a finer grid step than 0.3 yields slightly more precise values for the optimal value of Λ_1 , but doing so is not necessary to illustrate our results.

in turn will mitigate the initial drop in \hat{i}_t^D (with possibly \hat{i}_t^D increasing on net) and the increase in the loan rate (the loan rate must still increase for \hat{l}_t to fall in the first place). Moreover, changes in \hat{i}_t^R and \hat{q}_t may affect the loan rate in such a way that an increase in reserve requirements ends up being procyclical or acyclical.

Figure 5 is drawn in a way similar to Figure 4, for a given value of the persistence parameter $\chi_1^R = 0.8$.¹⁰ It shows that, in the present setting, the net effect is indeed countercyclical under both types of shocks. At the same time, a more aggressive policy has a U-shaped effect on financial volatility. Intuitively, as the policy becomes more aggressive, volatility falls at first, because (as can be inferred from Figures 2 and 3) the policy stabilizes credit, investment and domestic absorption. However, the more aggressive the policy becomes, the more volatile interest rates and deposits become; the volatility in domestic interest rates induces more volatility in lending, and therefore tends to increase financial volatility—so much so that it eventually dominates the gains in terms of reduced volatility in credit and aggregate demand.¹¹ Thus, there exists an optimal value for χ_2^R , which in Figure 5 is 7.5 for the default risk shock and 8.25 for the asset price shock. However, as shown in Tables 2 and 3, the optimal countercyclical reserve requirement rule is not as effective at mitigating volatility of key macroeconomic and financial variables, compared to either a specific provisioning regime ($\Lambda_1 = 0$) or a cyclically adjusted provisioning regime, regardless of whether Λ_1 is set to unity (full smoothing) or optimally. This is especially so with respect to the asset price shock.

Suppose now that the Financial Stability Committee sets *both* the cyclically adjusted provisioning parameter Λ_1 and the reaction parameter χ_2^R in the reserve requirement rule (52) so as to minimize financial volatility, defined as before. The results are shown in Table 4. They indicate that the simultaneous use of a cyclically adjusted provisioning regime and a countercyclical reserve requirements rule does *not* improve the ability of either policy (when set optimally) to mitigate financial volatility. Indeed, as shown in the table, the lowest value of our financial stability measure in either case is achieved when the reaction parameter of the other instrument is zero. Thus, the two instruments are not complementary (in the sense that financial volatility is not lower when a combination of them is used, compared to the case where either one is used

¹⁰Higher or lower values for χ_1^R within a significant range have no qualitative bearing on the results.

¹¹This conjecture is supported by an examination of the individual volatility measures that are used to calculate the composite indices of macroeconomic and financial (in)stability.

separately) but they are substitutes, given that an optimal policy exists in both cases. At the same time, and consistent with the results reported in Tables 2 and 3, the optimal countercyclical provisioning regime performs better than the reserve requirement rule in terms of mitigating financial volatility. In that sense, the two instruments are thus only *partial* substitutes.

7 Sensitivity Analysis

To assess the robustness of the previous results, we focus on three experiments: an alternative formula for calculating loan loss provisions that nets out collateral pledged by borrowers from loans, the possibility that the repayment probability may depend on the ratio of loan loss reserves to total loans, and the case where changes in the cyclically adjusted provisioning rule accounts for a response to cyclical output.

7.1 Provisions and Collateral

Loan loss reserves should in principle reflect not only the probability of default, but also the amount the lender can recover in case of default. An important source of repayment in such an event is the amount of collateral that can be possessed and liquidated. Because collateral has a direct impact on the loss that a bank suffers in the event of default, it should also affect the amount for which it must provision.

However, under the IASB accounting rules, there is no detailed guidance on how collateral should affect provisions. With no international standards, national authorities and bank supervisors have often designed their own regulations on provisions.¹² In some countries, the value of collateral can be subtracted from required provisions to determine actual provisions. In Colombia, for instance, provisions depend on the collateral values associated with different types of loans. Regulations on how banks should value collateral to assess their provisioning requirements also vary across countries, but in many of them fair market value (adjusted for liquidation costs) is the norm.

In the context of the model, this can be captured as follows. Recall that $\kappa \mathbb{E}_t p_{t+1}^H \bar{H}$ denotes the real value of effective collateral pledged by the capital producer; thus, if

¹²See Song (2002) for an early discussion, albeit with a focus on high-income countries.

the *net* value of loans is used to determine provisions, and assuming that disposing of collateral entails no costs, the generic provisioning rule (24) can be written as, with $\Lambda_2 = 0$,

$$LP_t = \left\{ \Lambda_0(1 - q_t) + \Lambda_1\left(\frac{q_t}{\tilde{q}} - 1\right) \right\} (l_t - \kappa \mathbb{E}_t p_{t+1}^H \bar{H}). \quad (54)$$

This specification is consistent with the evidence suggesting that property prices (which affect collateral values) and provisions are inversely correlated, as documented by Davis and Zhu (2009), for instance. Provisioning may thus amplify credit cycles through the collateral channel.

However, given that equations (35) and (36) remain the same, it is immediately clear that this change in the definition of loan loss provisions has no impact on the loan rate, as given in (33). Moreover, given that in each period banks invest all their loan loss reserves in government bonds, this alternative specification does not affect central bank borrowing or the equilibrium condition of the market for cash (39) either, as can be inferred from (21), and (39). Thus, the behavior of the bond rate does not change; given the (linear) structure of the model, defining loan loss provisions net of collateral as in (54) has no tangible macroeconomic effects.

7.2 Loan Loss Reserves and Default Risk

We now consider the case where the repayment probability is also related to the loan loss reserves-loan ratio, so that q_t is now defined as, instead of (34),

$$q_t = \left(\frac{Y_t}{\tilde{Y}}\right)^{\varphi_1} \left(\frac{\kappa \mathbb{E}_t p_{t+1}^H \bar{H}}{l_t}\right)^{\varphi_2} \left(\frac{1 + i_t^L}{1 + \tilde{i}^L}\right)^{\varphi_3} \left(\frac{LR_t/l_t}{\widetilde{LR}/\tilde{l}}\right)^{\varphi_4} \varepsilon_t^Q, \quad (55)$$

where, as discussed in Agénor and Zilberman (2015), φ_4 is in general ambiguous. If the ratio of loan loss reserves to loans raises incentives for banks to monitor borrowers (akin to the “skin in the game” argument often made in the context of bank capital), thereby increasing the repayment probability, then $\varphi_4 > 0$; by contrast, if a higher ratio exacerbates moral hazard and induces more risk-taking by lenders, then $\varphi_4 < 0$.

Simulation results with $\varphi_4 = 0.4$ and $\varphi_4 = -0.4$ are reported in Figures 6 and 7 for the default risk shock and for both the specific and cyclically adjusted provisioning regimes, in the latter case for the benchmark value of $\Lambda_1 = 1$.¹³ These values are on

¹³Similar results are obtained for the asset price shock; we do not report them to save space.

the high side (given the evidence) but are deliberately chosen to illustrate the issues at stake. When the monitoring incentive effect prevails ($\varphi_4 > 0$), the increase in the loan loss reserves-credit ratio mitigates the drop in the repayment probability documented earlier and therefore dampens the initial increase in the lending rate; as a result, investment falls by less than in the specific provisioning regime, mitigating the impact on output, inflation, and the policy rate. At the same time, because the real bond rate drops by less than before, households have weaker incentives to shift consumption to the present and to increase spending today. When $\varphi_4 < 0$ a higher ratio of loan loss provisions to investment loans tends, on the contrary, to magnify the initial fall in the repayment probability, in both regimes. Nevertheless, the direct cost effect of provisions on the loan rate dominates the indirect effect associated with the relative stock of provisions, which operates through the repayment probability. As a result, the net effect is, as in the case where $\varphi_4 > 0$, a smaller drop in the loan rate compared to the specific provisioning regime. Investment and output fall by less as well, and inflation increases by less. Thus, consistent with the results reported in Agénor and Zilberman (2015), regardless of the sign of φ_4 , and even with deliberately high values of that parameter, the cyclically adjusted provisioning regime performs better than the specific provisioning regime in terms of mitigating the procyclicality of the financial system and promoting macroeconomic and financial stability.¹⁴

7.3 Response to Cyclical Output

Based on specification (24), suppose that under cyclically adjusted provisioning the cyclical factor is the deviation in output from steady state, so that, ignoring again the max operator and setting $\Lambda_1 = 0$,

$$LP_t = \Lambda_0(1 - q_t)l_t + \Lambda_2\left(\frac{Y_t}{\tilde{Y}} - 1\right)^{\theta_L}l_t, \quad (56)$$

with the log-linearized equation (48) replaced by

$$\widehat{LP}_t = \hat{l}_t - \left(\frac{\tilde{q}}{1 - \tilde{q}}\right)\hat{q}_t + \frac{\theta_L\Lambda_2}{\Lambda_0(1 - \tilde{q})}\hat{Y}_t. \quad (57)$$

A key issue in this context is whether optimal values of the reaction parameters Λ_2 and θ_L exist. We first consider the case where θ_L is normalized to unity and we solve

¹⁴A more formal analysis based on asymptotic variances (as in Table 2) confirms this conjecture. We do not report these results to save space.

for the optimal Λ_2 . This case is thus symmetric to the one considered early, where the cyclical adjustment is in terms of deviations in the repayment probability.

The results are shown in Figure 7, which is constructed as in Figures 4 and 5 but with a larger grid step of 0.375. The figure shows indeed that an optimal value for Λ_2 (equal to 8.25 for the default risk shock and 10.5 for the asset price shock) also exists in that case.

We next solve jointly for the optimal combination of Λ_2 and θ_L .¹⁵ The results are shown in the three-dimension diagrams of Figure 8. The optimal values are $\Lambda_2 = 2.8$ and $\theta_L = 2.4$ for the default risk shock and $\Lambda_2 = 3.2$ and $\theta_L = 2.8$ for the asset price shock.

Thus, rather than reacting to a financial variable, in principle cyclically adjusted provisions could equally be made to respond to fluctuations in an aggregate macroeconomic variable (output). However, a comparison of the results reported in Tables 3 and 4 shows that, for all the key macroeconomic and financial variables, a response to cyclical output does *not* perform as well as a response to deviations in the repayment probability in terms of mitigating volatility.¹⁶

8 Concluding Remarks

In recent years a growing body of literature has emphasized that accounting standards for incurred and expected losses in the loan portfolio exacerbate procyclicality because incurred losses do not relate to expected losses, to the extent that provisions for future losses are not included. During recession periods, nonperforming loans tend to rise and banks exhibit losses that reduce their capital and their ability to lend. These problems are exacerbated during periods of sharp declines in liquidity. The negative correlation between provisions and loan or output growth documented in a number of empirical studies suggests that banks provision during and not before recessions,

¹⁵Because Λ_2 and θ_L enter symmetrically in the log-linearized equation (57), the optimal value for θ_L , given $\Lambda_2 = 1$, is of course the same as in the reverse case. It is nevertheless useful to solve jointly for Λ_2 and θ_L , given that in practice the rule would be applied in its linear form given in (56). We also tried to solve jointly for Λ_1 and Λ_2 , but we were unable to obtain an optimal combination of these parameters.

¹⁶Moreover, because there are lags in observing GDP, and given that preliminary estimates may be substantially revised, in practice it may be preferable to use a credit variable, for which data are usually available in a timely fashion and hardly subject to revision.

thereby magnifying the effects of downturns.

Using a DSGE model with financial frictions (namely, balance sheet and collateral effects, and costly production of loans and deposits) and a housing market, in this paper we focused on the extent to which alternative provisioning regimes affect the procyclicality of the financial system and financial volatility. Provisions are deducted from reported profits, thereby contributing to smoothing them. Numerical experiments with a parameterized version of the model showed that cyclically adjusted (or, more commonly referred to, dynamic) provisioning can be highly effective in mitigating procyclicality and financial volatility—defined in terms of a weighted average of the credit-output ratio and the volatility of real house prices—in response to financial shocks. In fact, the optimal policy involves “excess smoothing,” in the sense that it entails a more than proportional reaction to cyclical movements in the share of nonperforming loans (or, equivalently here, the probability of default).

In addition, we studied the optimal combination of simple, implementable cyclically adjusted provisioning and countercyclical reserve requirements rules. Our analysis showed that the simultaneous use of these instruments does not improve the ability of either one of them to mitigate procyclicality and financial stability. Thus, they are not complementary (in the sense that a combination of them does not help to achieve lower financial volatility than using either one individually) but substitutes, given that an optimal policy exists in both cases. Moreover, our results showed that the optimal provisioning rule performs significantly better (in terms of mitigating both macroeconomic volatility and financial volatility) than the optimal reserve requirement rule. With respect to an asset price shock, the optimal countercyclical reserve rule does not improve outcomes significantly, compared to either a specific provisioning regime or a cyclically adjusted provisioning regime. While we cannot rule out the possibility that these results are a feature of our calibration, they suggest that the two instruments are only partial substitutes. We also found that even though an optimal cyclically adjusted provisioning regime may be defined in terms of reaction to an aggregate macroeconomic variable, cyclical output, responding to that variable does not perform as well as responding to changes in nonperforming loans in terms of mitigating macroeconomic and financial volatility.

Our analysis could be extended in several directions. One extension would be to

better account for the potential costs of provisioning regimes. Pérez et al. (2008), in a study focusing on Spanish banks, and Bushman and Williams (2012), in a study of bank behavior across 27 countries, found that (discretionary) dynamic provisioning can also be used to smooth or disguise earnings. A bank’s management may indeed wish to avoid major changes in profitability levels and, therefore, may choose to increase provisions in times of higher profitability, so that the bank’s net income does not vary significantly from year to year. This could weaken market discipline, as transparency and comparability of financial statements may then be reduced. As a result, the cost of banking activity may increase and this would affect market interest rates—and, by implication, the behavior of output, prices, and other financial variables. Accounting for the potential costs of provisioning regimes (and thus decreasing marginal returns associated with a more aggressive use of them) may also restore a complementarity result between countercyclical reserve requirement rules and dynamic provisioning regimes.

Another extension would be to study the performance of, and interactions between, countercyclical capital rules (of the type advocated in the new Basel arrangement, see Basel Committee on Banking Supervision, 2011) and cyclically adjusted provisioning rules, as discussed in this paper. One element to account for in this discussion is the fact both capital and provisions may affect monitoring effort and the repayment probability through market signaling effects—but these effects may be of a different type. In addition, the new Basel capital regime allows loan loss reserves to be included in regulatory capital, up to certain limits. It is therefore possible that higher provisioning charges on new loans may cause a decline in banks’ capital, which for a given or desired leverage will restrain credit growth and mitigate systemic risk. Understanding this type of substitution effects is important for the optimal design of countercyclical financial regulation.

9 References

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Table 1
Benchmark Parameterization: Parameter Values

Parameter	Value	Description
<i>Households</i>		
β	0.99	Discount factor
ς	0.5	Elasticity of intertemporal substitution
η_N	1.5	Relative preference for leisure
η_x	0.01	Relative preference for money holdings
η_H	0.02	Relative preference for housing
ν	0.4	Share parameter in index of money holdings
<i>Production</i>		
θ	6.0	Elasticity of demand, intermediate goods
α	0.7	Share of labor in output, intermediate good
ϕ_F	74.5	Adjustment cost parameter, prices
δ_K	0.03	Depreciation rate of capital
Θ_K	30	Adjustment cost parameter, investment
<i>Banks</i>		
κ	0.2	Effective collateral-loan ratio
φ_1	0.03	Elasticity of repayment prob wrt cyclical output
φ_2	0.05	Elasticity of repayment prob wrt collateral-loan ratio
φ_3	0.2	Elasticity of repayment prob wrt loan rate
ζ^D	2.0	Elasticity of substitution, deposits
ζ^L	4.5	Elasticity of substitution, loans to CG producer
γ	0.01	Cost parameter, composite term
γ_D	0.1	Cost parameter, deposits
γ_L	0.1	Cost parameter, loans
<i>Central bank</i>		
μ^R	0.1	Reserve requirement rate
χ	0.8	Degree of interest rate smoothing
ε_1	1.5	Response of refinance rate to inflation deviations
ε_2	0.2	Response of refinance rate to output gap
ρ_{LR}	0.8	Persistence parameter, stock of loan loss provisions
<i>Government</i>		
ψ	0.2	Share of government spending in output
<i>Shocks</i>		
ρ^Q	0.8	Degree of persistence, repayment probability shock
ρ^H	0.7	Degree of persistence, housing demand shock

Table 2
Default Risk Shock: Asymptotic Standard Deviations of Key Variables
under Alternative Provisioning and Reserve Requirement Rules

	$\Lambda_1 = 0$	$\Lambda_1 = 1$	Opt. Λ_1	Opt. χ_2^R	Opt. Λ_2	Opt. Λ_2, θ_L
<i>Real sector</i>						
Output	0.0179	0.0128	0.0052	0.0177	0.0105	0.0101
Employment	0.0247	0.0178	0.0072	0.0245	0.0147	0.0143
Investment	0.0990	0.0712	0.0285	0.0988	0.0593	0.0575
Consumption	0.0073	0.0053	0.0021	0.0071	0.0049	0.0050
<i>Price inflation</i>	0.0027	0.0020	0.0007	0.0027	0.0019	0.0024
<i>Financial sector</i>						
Refinance rate	0.0027	0.0020	0.0008	0.0027	0.0017	0.0024
Loan rate	0.7714	0.7573	0.7068	0.7714	0.7516	0.7506
Bond rate	0.0017	0.0012	0.0005	0.0017	0.0015	0.0020
Real house prices	0.0515	0.0397	0.0285	0.0511	0.0296	0.0272
Repayment prob.	0.0140	0.0140	0.0142	0.0140	0.0140	0.0140
Loan-output ratio	0.0812	0.0584	0.0234	0.0810	0.0488	0.0475
Loan loss provisions	1.2968	1.3294	1.4466	1.2972	1.3829	1.3856
Loan loss reserves	0.1222	0.1252	0.1360	0.1223	0.1351	0.1362

Table 3
Asset Price Shock: Asymptotic Standard Deviations of Key Variables
under Alternative Provisioning and Reserve Requirement Rules

	$\Lambda_1 = 0$	$\Lambda_1 = 1$	Opt. Λ_1	Opt. χ_2^R	Opt. Λ_2	Opt. Λ_2, θ_L
<i>Real sector</i>						
Output	0.0007	0.0005	0.0002	0.0007	0.0004	0.0004
Employment	0.0010	0.0007	0.0003	0.0010	0.0006	0.0006
Investment	0.0038	0.0027	0.0011	0.0038	0.0023	0.0022
Consumption	0.0003	0.0002	0.0001	0.0003	0.0002	0.0002
<i>Price inflation</i>	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
<i>Financial sector</i>						
Refinance rate	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Loan rate	0.0297	0.0291	0.0286	0.0297	0.0289	0.0289
Bond rate	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001
Real house prices	4.0069	4.0068	4.0066	4.0069	4.0068	4.0068
Repayment prob.	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Loan-output ratio	0.0031	0.0022	0.0009	0.0031	0.0019	0.0018
Loan loss provisions	0.0499	0.0511	0.0530	0.0499	0.0520	0.0524
Loan loss reserves	0.0047	0.0048	0.0050	0.0047	0.0049	0.0049

Table 4
Optimal Reaction Parameters, Dynamic Provisioning Regime and Reserve Requirements Rule
Financial Volatility Measured in Terms of the Credit-Output Ratio and Real House Prices

χ_2^R	Λ_1										
	0	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0
Default risk shock											
0	1.0000	0.9704	0.9408	0.9136	0.9079	0.9093	0.9113	0.9134	0.9157	0.9180	0.9204
1	0.9999	0.9703	0.9408	0.9136	0.9079	0.9094	0.9113	0.9135	0.9157	0.9181	0.9205
2	0.9998	0.9702	0.9407	0.9136	0.9080	0.9094	0.9114	0.9136	0.9158	0.9182	0.9206
3	0.9997	0.9701	0.9407	0.9136	0.9080	0.9095	0.9115	0.9137	0.9160	0.9184	0.9208
4	0.9996	0.9701	0.9406	0.9136	0.9081	0.9096	0.9116	0.9138	0.9162	0.9186	0.9211
5	0.9996	0.9700	0.9406	0.9136	0.9081	0.9097	0.9118	0.9140	0.9164	0.9188	0.9213
6	0.9996	0.9700	0.9405	0.9136	0.9082	0.9098	0.9119	0.9142	0.9166	0.9191	0.9217
7	0.9995	0.9700	0.9405	0.9136	0.9083	0.9100	0.9121	0.9145	0.9169	0.9195	0.9221
8	0.9996	0.9700	0.9405	0.9136	0.9084	0.9101	0.9123	0.9147	0.9172	0.9198	0.9225
9	0.9996	0.9700	0.9405	0.9136	0.9085	0.9103	0.9126	0.9150	0.9176	0.9203	0.9230
10	0.9996	0.9700	0.9405	0.9136	0.9086	0.9105	0.9128	0.9154	0.9180	0.9207	0.9235
Asset price shock											
0	1.0000	0.9634	0.9288	0.9295	0.9400	0.9509	0.9620	0.9732	0.9847	0.9963	1.0080
1	0.9999	0.9633	0.9288	0.9295	0.9400	0.9508	0.9619	0.9732	0.9846	0.9961	1.0079
2	0.9997	0.9632	0.9288	0.9296	0.9400	0.9508	0.9619	0.9732	0.9845	0.9961	1.0078
3	0.9996	0.9631	0.9288	0.9296	0.9400	0.9509	0.9619	0.9732	0.9846	0.9961	1.0078
4	0.9995	0.9631	0.9288	0.9296	0.9401	0.9509	0.9620	0.9733	0.9847	0.9962	1.0079
5	0.9994	0.9630	0.9288	0.9297	0.9401	0.9510	0.9621	0.9734	0.9848	0.9964	1.0081
6	0.9994	0.9629	0.9288	0.9298	0.9402	0.9512	0.9623	0.9736	0.9850	0.9966	1.0084
7	0.9994	0.9629	0.9288	0.9299	0.9404	0.9513	0.9625	0.9738	0.9853	0.9969	1.0087
8	0.9993	0.9629	0.9288	0.9300	0.9405	0.9515	0.9627	0.9741	0.9856	0.9973	1.0092
9	0.9993	0.9629	0.9288	0.9301	0.9407	0.9517	0.9630	0.9744	0.9860	0.9978	1.0097
10	0.9993	0.9629	0.9288	0.9302	0.9408	0.9520	0.9633	0.9748	0.9865	0.9983	1.0102

Note: Entries in this table represent financial volatility, measured in terms of the credit-output ratio and real house prices, with weights of 0.8 and 0.2 respectively, relative to the benchmark case where there are no rules under operation, that is, $\chi_2^R = \Lambda_1 = 0$.

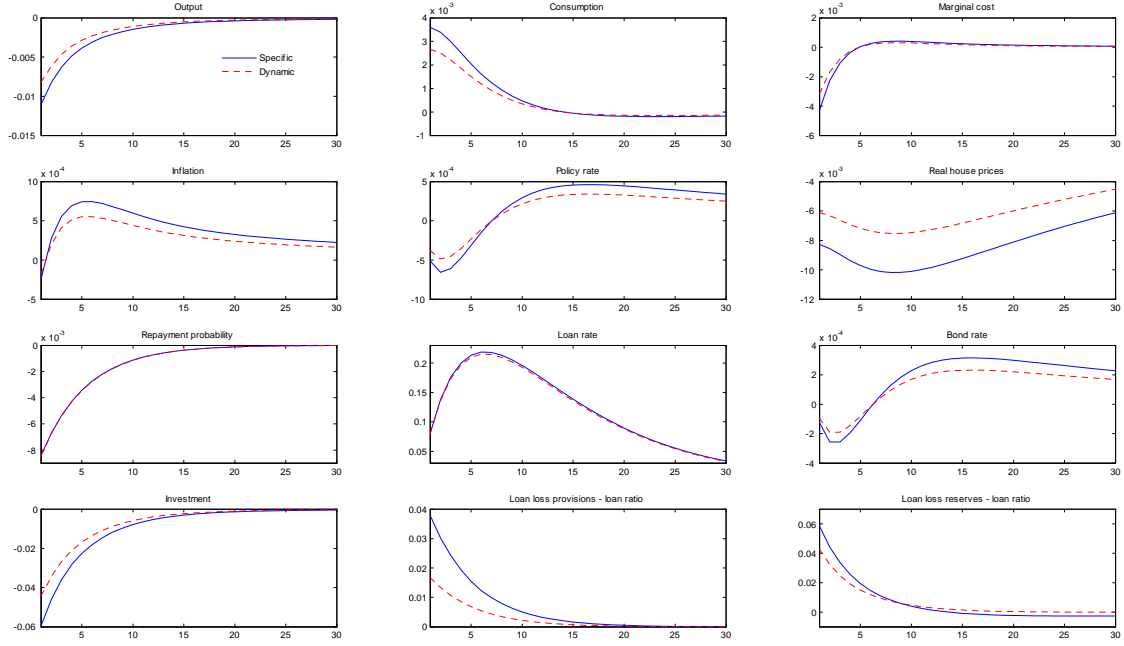
Source: Authors' calculations.

The diagram illustrates the flow of capital, goods, and services within a financial system. The entities involved are Households, Commercial banks, Central bank and regulator, Capital good producer, Government, Intermediate good producers, and Final good producer.

Flows and Interactions:

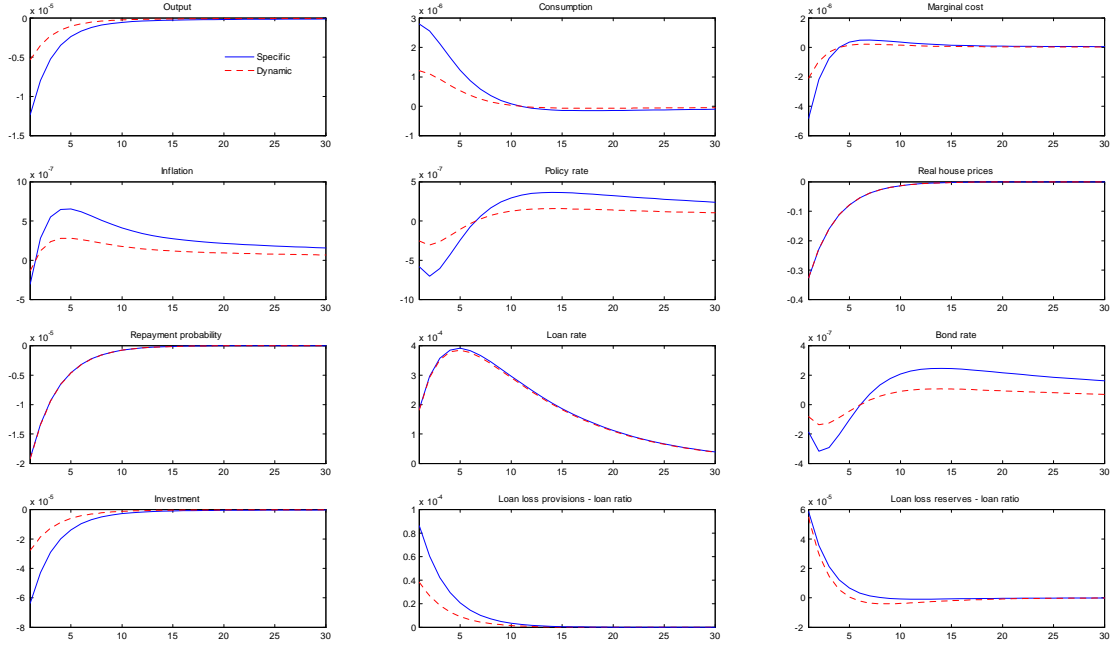
- Households** provide *Real estate* and *House prices* to the **Capital good producer**. They also provide *Collateral* to **Commercial banks** and *Labor* to **Intermediate good producers**.
- Commercial banks** receive *Deposits* from **Households** and provide *Loans* to the **Capital good producer**. They also receive *Public bonds* from the **Government** and provide *Borrowing* to the **Central bank and regulator**.
- The **Central bank and regulator** impose *Loan loss provisioning rules* and *Required reserves* on **Commercial banks**.
- The **Capital good producer** provides *Physical capital* to **Intermediate good producers** and receives *Wages and profits* from them.
- The **Government** provides *Public bonds* to **Commercial banks** and *Spending* to **Final good producers**. It also receives *Price adjustment costs* from **Intermediate good producers**.
- Intermediate good producers** provide *Sales* to **Final good producers** and receive *Consumption* from them.
- Final good producers** provide *Consumption* to **Households**.

Figure 2
Experiment: Transitory Reduction in Repayment Probability
Specific and Cyclical Adjusted Provisioning Rules ($\Lambda_1 = 1.0$)
 (Deviations from steady state)



Note: Interest rates, inflation rate and the repayment probability are measured in absolute deviations, that is, in the relevant graphs a value of 0.05 for these variables corresponds to a 5 percentage point deviation in absolute terms.

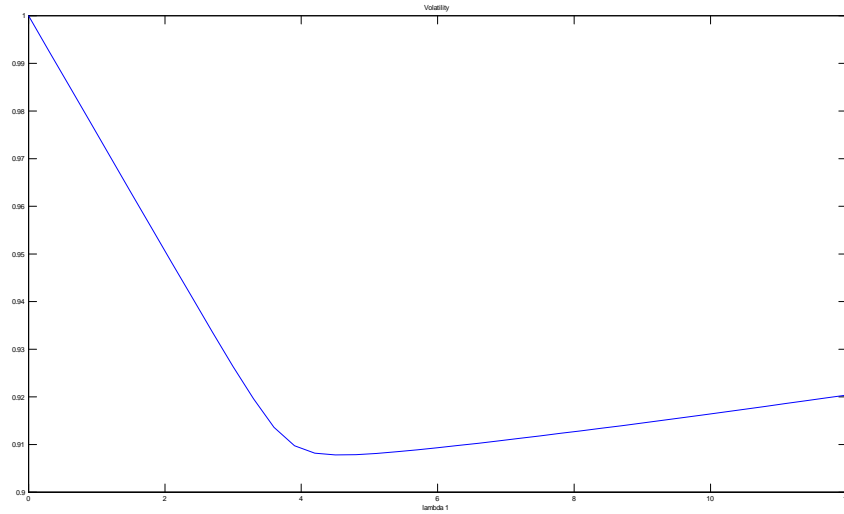
Figure 3
Experiment: Transitory Negative Asset Price Shock
Specific and Cyclical Adjusted Provisioning Rules ($\Lambda_1 = 1.0$)
(Deviations from steady state)



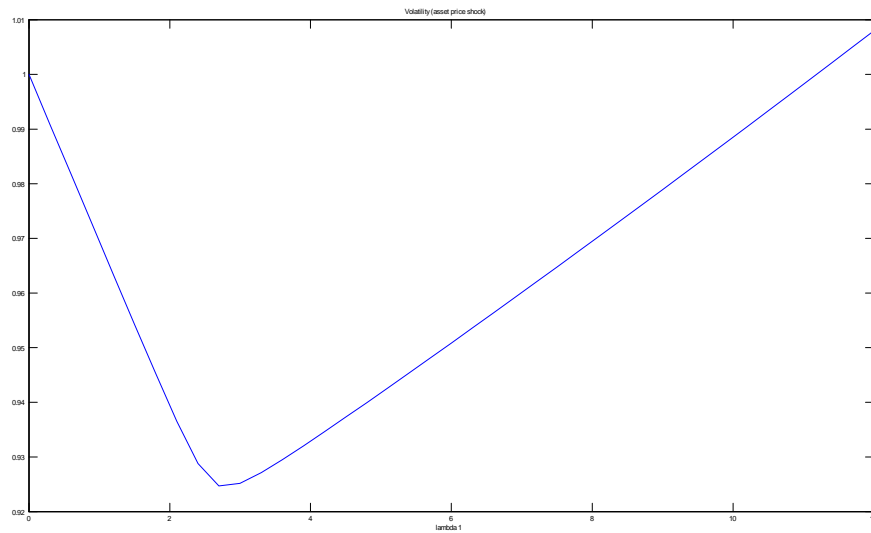
Note: Interest rates, inflation rate and the repayment probability are measured in absolute deviations, that is, in the relevant graphs a value of 0.05 for these variables corresponds to a 5 percentage point deviation in absolute terms.

Figure 4
Financial Volatility and Optimal Reaction Parameter Λ_1 ,
Cyclical Adjusted Provisioning Rule

Transitory Increase in Default Risk



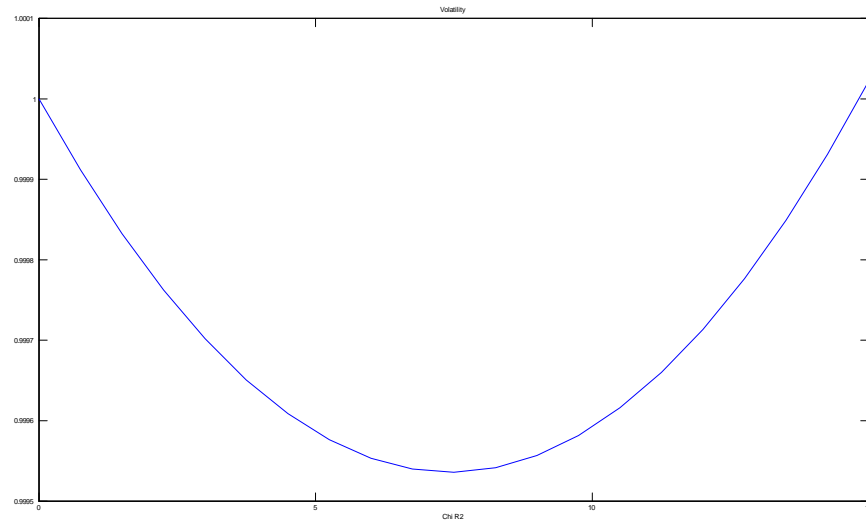
Transitory Negative Asset Price Shock



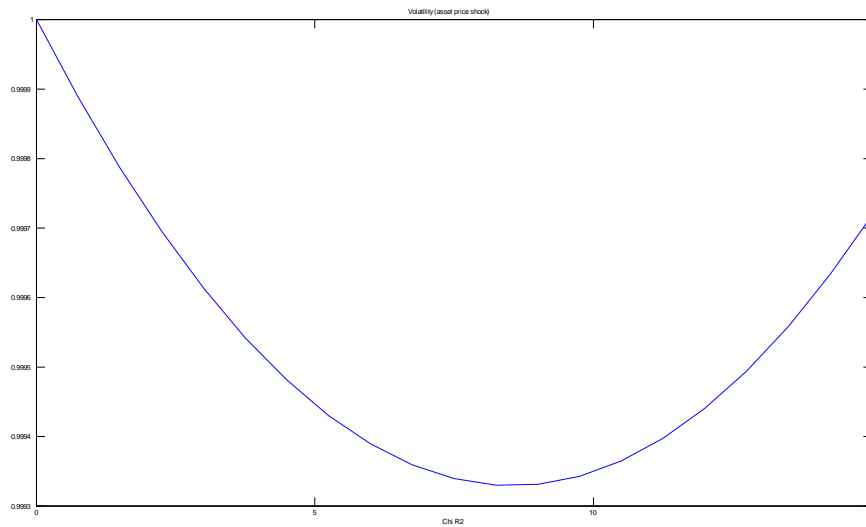
Note: Λ_1 measures the response to deviations in the repayment probability in the cyclically adjusted provisioning rule. The vertical axis measures financial volatility, defined in terms of an average of the volatilities of the credit-output ratio and real house prices.

Figure 5
Financial Volatility and Optimal Reaction Parameter χ_2^R ,
Reserve Requirement Rule

Transitory Increase in Default Risk

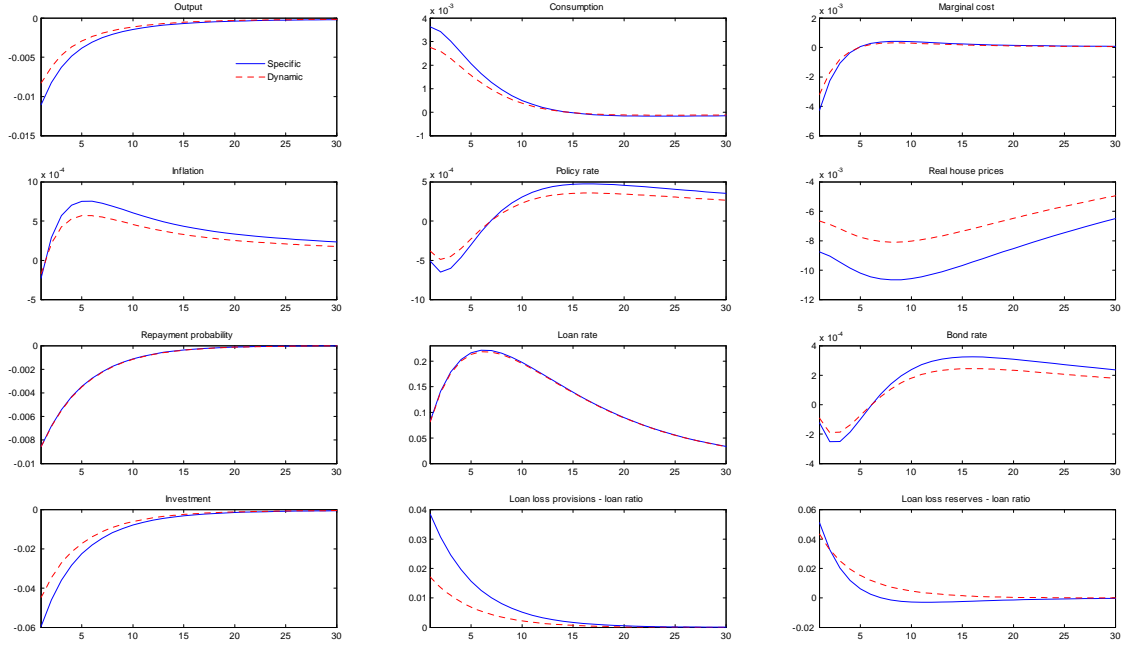


Transitory Negative Asset Price Shock



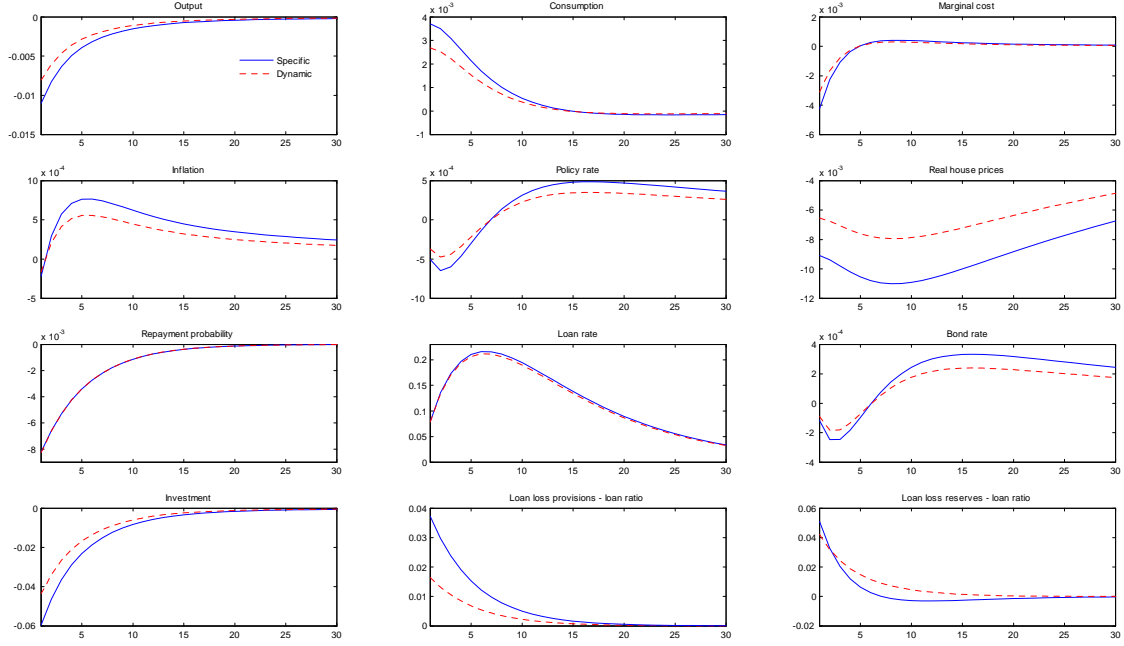
Note: χ_2^R measures the response to the credit-output ratio in the countercyclical reserve requirement rule. The vertical axis measures financial volatility, defined in terms of an average of the volatilities of the credit-output ratio and real house prices.

Figure 6
Experiment: Transitory Reduction in Repayment Probability
Cyclical Adjusted Provisioning Rule ($\Lambda_1 = 1.0$) and $\varphi_4 = 0.4$
(Deviations from steady state)



Note: Interest rates, inflation rate and the repayment probability are measured in absolute deviations, that is, in the relevant graphs a value of 0.05 for these variables corresponds to a 5 percentage point deviation in absolute terms.

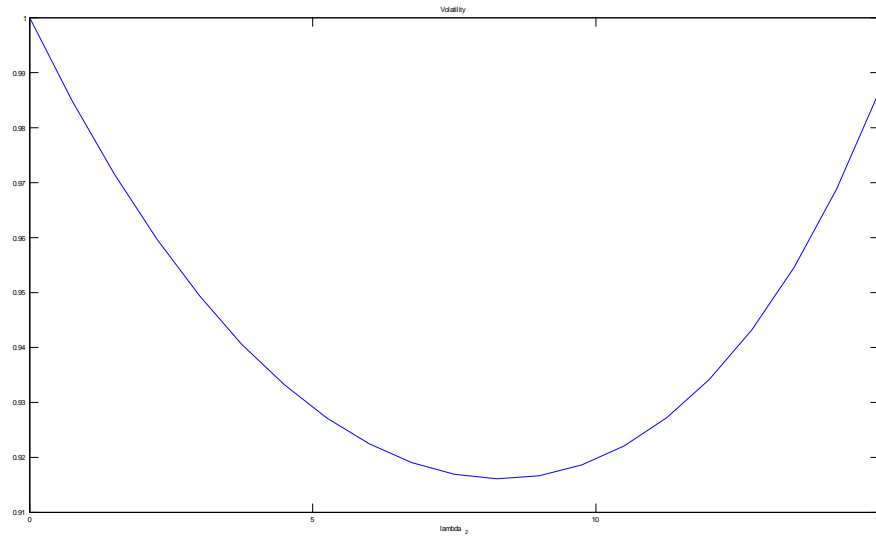
Figure 7
Experiment: Transitory Reduction in Repayment Probability
Cyclical Adjusted Provisioning Rule ($\Lambda_1 = 1.0$) and $\varphi_4 = -0.4$
(Deviations from steady state)



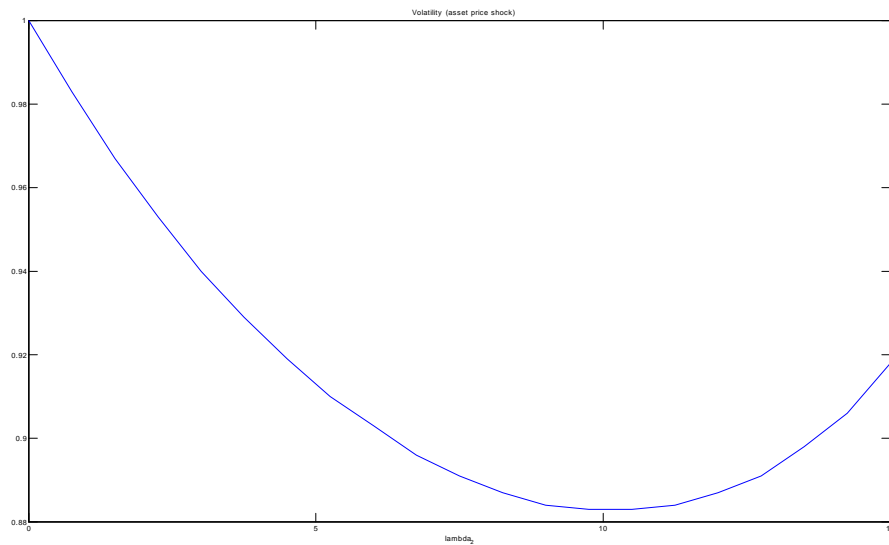
Note: Interest rates, inflation rate and the repayment probability are measured in absolute deviations, that is, in the relevant graphs a value of 0.05 for these variables corresponds to a 5 percentage point deviation in absolute terms.

Figure 8
Financial Volatility and Optimal Reaction Parameter Λ_2 ,
Cyclical Adjusted Provisioning Rule: Response to Cyclical Output

Transitory Increase in Default Risk



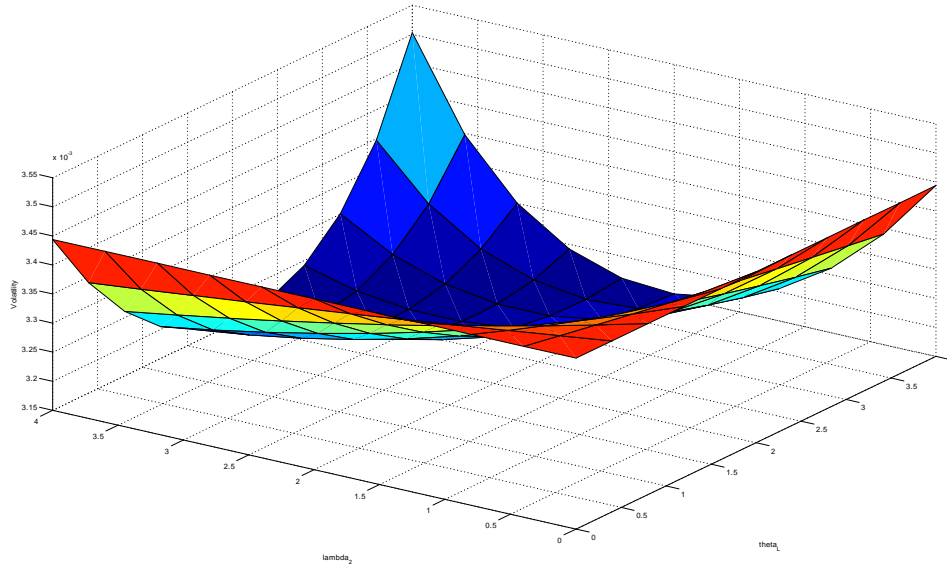
Transitory Negative Asset Price Shock



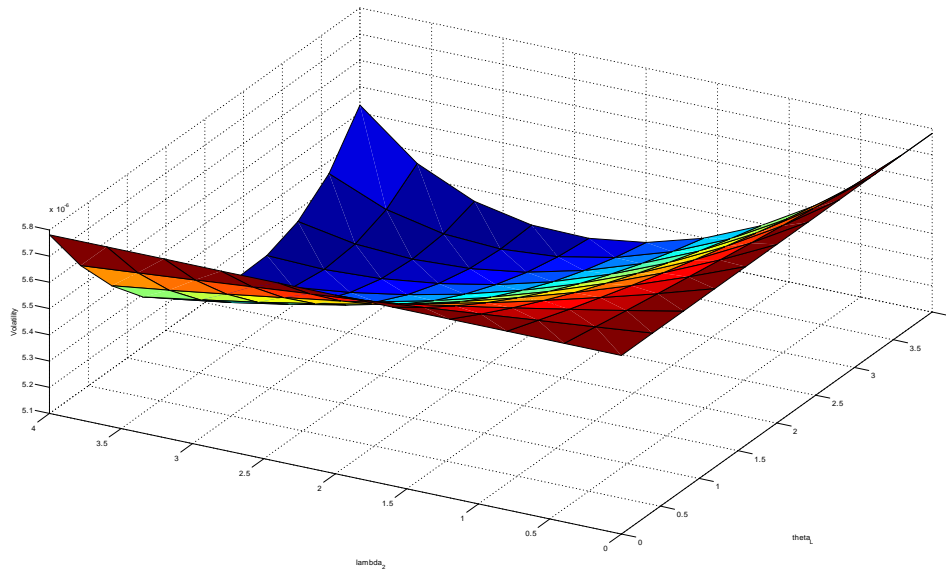
Note: Λ_2 measures the response to deviations in the cyclical output in the cyclically adjusted provisioning rule. The vertical axis measures financial volatility, defined in terms of an average of the volatilities of the credit-output ratio and real house prices.

Figure 9
Financial Volatility and Optimal Reaction Parameter Λ_2 and θ^L ,
Cyclical Adjusted Provisioning Rule: Response to Cyclical Output

Transitory Increase in Default Risk



Transitory Negative Asset Price Shock



Note: Λ_2 and θ^L measure the response to deviations in the cyclical output in the cyclically adjusted provisioning rule. The vertical axis measures financial volatility, defined in terms of an average of the volatilities of the credit-output ratio and real house prices.