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Capital Regulation, Monetary Policy and Financial Stability

P.-R. Agénor*, K. Alper**, and L. Pereira da Silva***

Abstract

This paper examines the roles of bank capital regulation and monetary policy in mitigating procyclicality and promoting macroeconomic and financial stability. The analysis is based on a dynamic stochastic model with imperfect credit markets. Macroeconomic (financial) stability is defined in terms of the volatility of nominal income (real house prices). Numerical experiments show that even if monetary policy can react strongly to inflation deviations from target, combining a credit-augmented interest rate rule and a Basel III-type countercyclical capital regulatory rule may be optimal for promoting overall economic stability. The greater the degree of interest rate smoothing, and the stronger the policy-maker's concern with macroeconomic stability, the larger is the sensitivity of the regulatory rule to credit growth gaps.

JEL Classification Numbers: E44, E51, F41.

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Preserving financial stability is so closely related to the standard goals of monetary policy (stabilizing output and inflation) that it... seems somewhere between foolish and impossible to separate the two functions.

Alan S. Blinder, *How Central should the Central Bank Be?* (2010, p. 12).

Ensuring financial stability requires a redesign of macroeconomic as well as regulatory and supervisory policies with an eye to mitigating systemic risks. For macroeconomic policies, this means leaning against credit and asset price booms; for regulatory and supervisory policies, it means adopting a macroprudential perspective.

Bank for International Settlements, *Annual Report 2009* (p. 14).

1 Introduction

The recent crisis in global financial markets has led to a substantial number of proposals aimed at strengthening the financial system and at encouraging more prudent lending behavior in upturns. Many of these proposals aim to mitigate the alleged procyclical effects of Basel II capital standards. Indeed, several observers have argued that by raising capital requirements in a contra-cyclical way, regulators could help to choke off asset price bubbles—such as the one that developed in the US housing market—before a crisis occurs. A recent proposal along these lines, put forward by Goodhart and Persaud (2008), involves essentially adjusting the Basel II capital requirements to take into account and act at the relevant point in the economic cycle.[1] In particular, in the Goodhart-Persaud proposal, the capital adequacy requirement on mortgage loans would be linked to the rise in both mortgage lending and house prices.[2] The Turner Review (See Financial Services Authority (2009)) also favors countercyclical capital requirements, and so do Brunnermeier et al. (2009), who propose to adjust capital adequacy requirements over the cycle by two multiples—the first related to above-average growth of credit expansion and leverage, the second related to the mismatch in the maturity of assets and liabilities. Although not as explicit, Blinder (2010) has also endorsed the view that central banks should try to limit credit-based bubbles through regulatory instruments (rather than interest rates) and refers to it as possibly becoming the "new consensus" on how to deal with asset-price bubbles. At the policy level, there has been concrete progress toward establishing new standards in this area; the Basel Committee on Banking Supervision (BCBS) has developed a countercyclical framework that involves adjusting bank capital in response to excess growth in credit

[1] Buiter (2008) extended the Goodhart-Persaud proposal by suggesting that capital and liquidity requirements be applied to all highly leveraged financial institutions, not only banks.

[2] Goodhart and Persaud argue that their proposal could be introduced under the second pillar of Basel II. While Pillar 1 consists of rules for requiring minimum capital against credit, operational and market risks, Pillar 2 is supposed to take into account all the additional risks to which a bank is exposed to, in order to arrive at its actual capital needs. However, by using only Pillar 2 at the discretion of local regulators it can allow banks to engage in regulatory arbitrage.

to the private sector, which it views as a good indicator of systemic risk. On November 12, 2010, G20 leaders adopted BCBS's proposal to implement a countercyclical capital buffer ranging from 0 to 2.5 percent of risk-weighted assets, as part of the new Basel III framework.

At the same time, the global financial crisis has led to renewed calls for central banks (and regulators) to consider more systematically potential trade-offs between the objectives of macroeconomic stability and financial stability, or equivalently whether the central bank's policy loss function (and therefore its interest rate response) should account explicitly for a financial stability goal. The issue is not new; it has long been recognized, for instance, that an increase in interest rates aimed at preventing the development of inflationary pressures may, at the same time, heighten uncertainty and foster volatility in financial markets. The debate (which predates the recent crisis) has focused on the extent to which monetary policy should respond to perceived misalignments in asset prices, such as real estate and equity prices.[3] In that context, several observers have argued that trying to stabilize asset prices *per se* is problematic for a number of reasons—one of which being that it is almost impossible to know for sure whether a given change in asset values results from changes in underlying fundamentals, nonfundamental factors, or both. By focusing on the *implications* of asset price movements for credit growth and aggregate demand, the central bank may be able to focus on the adverse effects of these movements—without getting into the tricky issue of deciding to what extent they represent changes in fundamentals.

This paper is an attempt to address both sets of issues in a unified framework. We examine the role of both monetary policy and a capital regulation rule that bears close similarity with some recent proposals to mitigate the procyclical tendencies of financial systems, and evaluate their implications for macroeconomic stability and financial stability. We do so under a Basel II-type regime, with endogenous risk weights on bank assets. Among the issues that we attempt to address are the following: to promote financial stability, how should countercyclical bank capital requirement rules be designed? Instead of adding a cyclical component to prudential regulation, shouldn't policymakers use monetary policy to constrain credit growth, as opposed to "leaning against (price) bubbles" directly? To what extent should regulatory policy and monetary policy be combined to ensure both macroeconomic and financial stability? Put differently, are these policies complementary or substitutes?

Quantitative studies of these issues are important for a number of reasons. Regarding the design of countercyclical bank capital rules, several observers have noted that there are indeed significant potential practical problems associated with their implementation—including the period over which relevant financial indicators (credit growth rates, for that matter) should be calculated. More important perhaps is the possibility that these rules may operate in counterintuitive ways, depending on the degree of financial sector imperfections. In particular, in countries where bank credit

[3] See, for instance, Chadha et al. (2004), Filardo (2004), Akram et al. (2006), Faia and Monacelli (2007), and Akram and Eitrheim (2008). Wadhwani (2008) provides a brief overview of the literature.

plays a critical role in financing short-term economic activity (as is often the case in developing economies), a rule that constrains the growth in overall credit could entail a welfare cost. At the same time, of course, to the extent that it succeeds in reducing financial volatility and the risk of a full-blown crisis, it may also enhance welfare. The net benefits of countercyclical bank capital rules may therefore be ambiguous in general and numerical evaluations become essential.

Regarding the role of monetary policy, the key issue is whether a central bank with a preference for output and price stability can improve its performance with respect not only to these two objectives but also to financial stability, by responding to excessive movements in credit and/or asset prices in addition to fluctuations in prices and activity. In a relatively complex model, understanding the conditions that may lead to trade-offs among objectives often requires quantitative experiments.

To conduct our analysis, we extend the New Keynesian model described in Agénor et al. (2009). Important features of that model are that it accounts explicitly for a variety of credit market imperfections and bank capital regulation.[4] A housing sector is introduced, and the role of real estate as collateral examined. Specifically, we establish a direct link between house prices and credit growth via their impact on collateral values and interest rate spreads on loans: higher house prices enable producers to borrow and invest more, by raising the value of the collateral that they can pledge and improving the terms at which credit is extended. This mechanism is consistent with the evidence suggesting that a large value of bank loans to (small) firms, in both industrial and developing countries, is often secured by real estate. To capture financial instability, we focus initially on the behavior of real house prices.[5] This is also in line with the literature suggesting that financial crises are often preceded by unsustainable developments in the real estate sector and private sector credit.

The paper continues as follows. Section II presents the model. We keep the presentation very brief, given that many of its ingredients are described at length in Agénor et al. (2009); instead, we focus on how the model presented here departs from that paper, especially with respect to the financial sector and countercyclical policy rules. The equilibrium is characterized in Section III. Key features of the steady state and the log-linearized version, as well as a brief discussion of an illustrative calibration, are discussed in Section IV. We present in Section V the impulse response functions associated with our base experiment: a temporary, positive housing demand shock. Section VI discusses two alternative countercyclical rules, involving an augmented monetary

[4] There is a small but growing literature on the introduction of capital regulation in New Keynesian models with banking; recent papers include Aguiar and Drumond (2007), Gerali et al. (2009), Dib (2009, 2010), Hirakata et al. (2009), and Meh and Moran (2010). Some contributions have also attempted to integrate countercyclical regulatory rules in this type of models; they include Covas and Fujita (2010), Kannan et al. (2009), Levieuge (2009), Angelini et al. (2010), Angeloni and Faia (2010), and Darracq Pariès et al. (2010). However, as is made clear later, our approach differs significantly from all of these contributions, making comparisons difficult.

[5] The concept of financial stability has remained surprisingly elusive in the existing literature; see Goodhart (2006). Our focus in this paper is on an operational, quantitative measure of financial instability.

policy rule and a capital regulatory rule, both defined in terms of deviations in credit growth and aimed at promoting financial stability. Section VII investigates whether the use of these rules (taken in isolation) generates gains in terms of both financial and macroeconomic stability, that is, whether they entail a trade-off among objectives; to do so we present simulation results of the same housing demand shock under both types of rules, for some specific parameter values. Section VIII discusses optimal policy rules, when the objective of the central bank is to minimize volatility in a measure of "economic stability," defined as a weighted average of separate measures of macroeconomic stability and financial stability. Section IX provides some sensitivity analysis. The last section provides a summary of the main results and discusses the implications of our analysis for the ongoing debate on reforming bank capital standards.

2 Outline of the Model

The core model presented in this paper departs from Agénor, Alper, and Pereira da Silva (2009) essentially by introducing a housing market and linking it with collateral and loans for investment purposes. To save space, this section provides only a brief outline of the model in most respects—except for bank regulation and the optimization problem of the bank, for which a more formal analysis is presented.[6]

We consider a closed economy populated by six types of agents: infinitely-lived households, intermediate good (IG) producers, a final good (FG) producer, a capital good (CG) producer, a monopoly commercial bank, the government, and the central bank, whose mandate also includes bank regulation. The final good is homogeneous and can be used either for consumption or investment, although in the latter case additional costs must be incurred.

There are two types of households, constrained and unconstrained.[7] *Constrained households* do not participate in asset markets and follow a rule-of-thumb which involves consuming all their after-tax disposable wage income in each period. They also supply labor inelastically. *Unconstrained households* consume, can trade in asset markets and hold financial assets (including nominal debt issued by the bank), and supply labor to IG producers. As in Iacoviello (2005), Silos (2007), and Iacoviello and Neri (2008), housing services are assumed to be proportional to their stock, which enters directly in the utility function. These households also make their housing stock available, free of charge, to the CG producer, who uses it as collateral against which it borrows from the bank to buy the final good and produce capital. At the beginning of the period, unconstrained households choose the real levels of cash, deposits, bank debt, government bonds, and labor supply to IG firms. They receive all the profits

[6] A detailed, formal presentation of the model is available in the working paper version of this article, which is available upon request.

[7] As discussed later, the distinction between these two types of households is useful to undersand the dynamics of consumption following housing demand shocks. See Agénor and Montiel (2008) for a discussion of why consumption smoothing may be imperfect in the context of developing countries.

made by the IG producers, the CG producer, and the bank, and pay a lump-sum tax.

Optimization yields a standard Euler equation and a standard labor supply function, which relates hours worked positively to the real wage and negatively to consumption. It also yields three asset demand equations: the first relates the real demand for cash positively to consumption and negatively to the opportunity cost of holding money, measured by the interest rate on government bonds; the second relates the real demand for deposits positively to consumption and the deposit rate, and negatively to the bond rate; and the third is the demand for bank debt, V_t^d, which is given by

$$\frac{V_t^d}{P_t} = \Theta_V^{-1}(\frac{i_t^V - i_t^B}{1 + i_t^B}), \tag{1}$$

where $\Theta_V > 0$ denotes an adjustment cost parameter, P_t the price of the final good, i_t^B the bond rate, and i_t^V the rate of return on bank debt. Thus, the demand for bank debt depends positively on its rate of return and negatively on the bond rate. Similarly, there is a demand function for housing services, from which it can be established that a positive shock to preferences for housing leads (all else equal) to a rise in today's demand for housing.

The *FG producer*'s optimization problem is specified in standard fashion. The final good, which is allocated to private consumption, government consumption, and investment, is produced by assembling a continuum of imperfectly substitutable intermediate goods. The FG producer sells its output at a perfectly competitive price. Given the intermediate-goods prices and the final-good price, it chooses the quantities of intermediate goods that maximize its profits.

IG producers produce, using capital and labor, a distinct perishable good that is sold on a monopolistically competitive market. At the beginning of the period, each IG producer rents capital from the CG producer and borrows to pay wages in advance. Loans contracted for the purpose of financing working capital (which are short-term in nature) do not carry any risk, and are therefore made at a rate that reflects only the marginal cost of borrowing from the central bank, i_t^R, which we refer to as the refinance rate. These loans are repaid at the end of the period. IG producers solve a two-stage problem. In the first stage, taking input prices as given, they rent labor and capital in perfectly competitive factor markets so as to minimize real costs. This yields the optimal capital-labor ratio. In the second stage, each IG producer chooses a sequence of prices so as to maximize discounted real profits, subject to adjustment costs à la Rotemberg (1982). The solution gives the adjustment process of the nominal price.

The *CG producer* owns all the capital in the economy and uses a linear technology to produce capital goods. At the beginning of the period, it buys the final good from the FG producer. These goods must be paid in advance; to purchase final goods, the CG producer must borrow from the bank. At the end of the period, loans are paid in full with interest. Thus, the total cost of buying final goods for investment purposes includes the lending rate, i_t^L. The CG producer combines investment goods and the existing capital stock to produce new capital goods, subject to adjustment costs. The new capital stock is then rented to IG producers. The CG producer chooses the level of the capital stock (taking the rental rate, the lending rate, and the price of the final good as given) so as to maximize the value of the discounted stream of dividend payments (nominal profits) to the household. The first-order condition for maximization shows that the expected rental rate of capital is a function of the current and expected loan rates, the latter through its effect on adjustment costs in the next period.

The *commercial bank* (which is owned by unconstrained households) also supplies credit to IG producers, who use it to finance their short-term working capital needs. Its supply of loans is perfectly elastic at the prevailing lending rate. To satisfy capital regulations, it issues nominal debt at the beginning of time t, once the level of (risky) loans is known.[8] It pays interest on household deposits (at rate i_t^D), the liquidity that it borrows from the central bank (at rate i_t^R), and its debt. The maturity period of both categories of bank loans and the maturity period of bank deposits by unconstrained households is the same. In each period, loans are extended prior to activity (production or investment) and paid off at the end of the period. At the end of each period, the bank is liquidated and a new bank opens at the beginning of the next; thus, all its profits are distributed, bank debt is redeemed, and new debt is issued at the beginning of the next period to comply with prudential regulatory rules.

Formally, and abstracting from required reserves and holdings of government bonds, the bank's balance sheet is

$$L_t^F = D_t + V_t + L_t^B, \tag{2}$$

where D_t is household deposits, L_t^F total loans, L_t^B borrowing from the central bank (which covers any shortfall in resources) and V_t total capital held by the bank, given by

$$V_t = V_t^R + V_t^E, \tag{3}$$

with V_t^R denoting capital requirements and V_t^E excess capital.

Given that L_t^F and D_t are determined by private agents' behavior, the balance sheet constraint (2) can be used to determine borrowing from the central bank:

$$L_t^B = L_t^F - D_t - V_t. \tag{4}$$

The bank is subject to risk-based capital requirements, imposed by the central bank. It must hold an amount of capital that covers an endogenous percentage of its risky loans.[9] Loans for working capital needs bear no risk and are subject to a zero

[8] Thus, capital consists therefore, in the Basel terminology, solely of "supplementary" or "tier 2" capital; there is no "core" or "tier 1" capital, that is, ordinary shares. In practice, to meet capital requirements banks have often issued hybrid securities that are more like debt than equity. Data from the International Monetary Fund show that at the end of 2008 the average ratio of equity made up of issued ordinary shares to assets was only 2.5 percent for European banks and 3.7 percent for US banks. However, under the new Basel III regime, the definition of capital in terms of common equity has been considerably tightened.

[9] Because the bank is liquidated at the end of each period, it does not accumulate capital through retained earnings. This is in contrast to Angelini et al. (2010), for instance.

weight in calculating capital requirements. Thus, with σ_t^F denoting the risk weight on loans to the CG producer, capital requirements are given by

$$V_t^R = \rho_t \sigma_t^F L_t^{F,I}, \tag{5}$$

where $\rho_t \in (0,1)$ is the "overall" capital ratio, defined later, and $L_t^{F,I}$ loans for investment. As in Agénor and Pereira da Silva (2009), and in line with the "foundation" variant of the Internal Ratings Based (IRB) approach of Basel II, we relate the risk weight to the repayment probability of the CG producer estimated by the bank, $q_t^F \in (0,1)$, because it reflects its perception of default risk:[10]

$$\sigma_t^F = (\frac{q_t^F}{\tilde{q}^F})^{-\phi_q}, \tag{6}$$

where $\phi_q > 0$ and $\tilde{q}^F$ is the steady-state value of q_t^F. In the steady state, the risk weight is therefore normalized to unity.[11]

The bank is risk-neutral and chooses both the deposit and lending rates, and excess capital, so as to maximize the present discounted value of its real profits.[12] Because the bank is liquidated and debt is redeemed at the end of each period, this optimization program boils down to a period-by-period maximization problem, subject to several constraints—the loan demand function from the CG producer, total credit, the balance sheet constraint (4), the definition of total capital (3), and the capital requirement constraint (5). In addition, the bank internalizes the fact that the demand for loans by the CG producer (supply of deposits by unconstrained households) depends negatively (positively) on the lending (deposit) rate, and takes the repayment probability of the CG producer, the value of collateral, capital requirements, prices and the refinance rate as given.

Expected, end-of-period profits in real terms are given by

$$(1+i_t^R)(\frac{L_t^{F,W}}{P_t}) + q_t^F(1+i_t^L)(\frac{L_t^{F,I}}{P_t}) + (1-q_t^F)\kappa p_t^H \bar{H} + \mu d_t \tag{7}$$

[10] Under the IRB approach, the estimated credit risk—and the associated risk weights—are assumed to be a function of four parameters: the probability of default (PD), the loss given default, the exposure at default, and the loan's maturity. Banks adopting the *advanced* variant of this approach must provide all four of these parameters from their own internal ratings models; those adopting the *foundation* variant provide only the PD parameter, with the other three parameters set extenally by regulators. Appendix C in Agénor, Alper, and Pereira da Silva (2009) provides a justification for the reduced-form, constant elasticity specification shown in (6), based on Basel II formulas. See also Angeloni and Faia (2010), Covas and Fujita (2010), and Darracq Pariès et al. (2010).

[11] The Standardized Approach in Basel II can be modeled by making the risk weight a function of the output gap, under the assumption that ratings are procyclical, in a manner similar to Zicchino (2006) and Angeloni and Faia (2010), for instance. See Drumond (2009) and Panetta et al. (2009) for a discussion of the evidence on this issue.

[12] To simplify matters, we solve only for the loan rate applicable to the CG producer. In principle, even if loans to IG producers carry no risk and are extended at the marginal cost of funds (the refinance rate), it should be assumed that the bank also determines it as part of its optimization problem—in which case the elasticity of the demand for working capital loans would affect the markup over the refinance rate. For simplicity, we have assumed directly that the cost of these loans is only i_t^R.

$$-(1+i_t^D)d_t - (1+i_t^R)(\frac{L_t^B}{P_t}) - (1+i_t^V)(\frac{V_t}{P_t}) + 2\gamma_{VV}(\frac{V_t^E}{P_t})^{\phi_E},$$

where $\kappa \in (0,1)$, $\gamma_{VV} \geq 0$, $\phi_E \in (0,1)$, and $\bar{H}$ the exogenous supply of housing.[13] The second term in this expression on the right-hand side, $q_t^F(1+i_t^L)P_t^{-1}L_t^{F,I}$, represents expected repayment on loans to the CG producer if there is no default. The third term represents what the bank expects to earn in case of default, that is, "effective" collateral, given by a fraction $\kappa \in (0,1)$ of "raw" collateral, that is, the housing stock. Coefficient κ can be viewed as a measure of efficiency of enforcement of debt contracts (see Djankov et al. (2008)) or an inverse measure of anticreditor bias in the judicial system (see Cavalcanti (2010)). Note also that collateral is "marked to market," a practice that has become prevalent in recent years and tends to magnify procyclicality in leverage.

The fourth term, μd_t, represents the reserve requirements held at the central bank and returned to the bank at the end of the period (prior to its closure). The term $(1+i_t^D)d_t$ represents repayment of deposits (principal and interest) by the bank, whereas the term $(1+i_t^R)P_t^{-1}L_t^B$ represents gross repayments to the central bank. The term $(1+i_t^V)V_t$ represents the value of bank debt redeemed at the end of the period plus interest.[14] The last term, $2\gamma_{VV}(V_t^E/P_t)^{\phi_E}$, captures the view that maintaining a positive capital buffer generates some benefits—it represents a signal that the bank's financial position is strong, and reduces the intensity of regulatory scrutiny (or degree of intrusiveness in the bank's operations), which in turn reduces the pecuniary cost associated with providing the information required by the supervision authority; the restriction $\phi_E < 1$ ensures a sensible solution (see Agénor et al. (2009)).[15]

The first-order conditions for maximization give

$$i_t^D = (1+\frac{1}{\eta_D})^{-1} i_t^R, \tag{8}$$

[13] Housing supply could be endogenized by adding a construction sector to the model. This would reduce the volatility of housing prices, by allowing the housing stock to respond to demand shocks. However, given the time frame of the model, the assumption of exogenous supply is quite reasonable.

[14] In the full version of the model presented in the working paper version of this article, we add a linear term in V_t, to capture the cost associated with issuing shares, which includes the cost of underwriting, issuing brochures, etc. The cost of issuing equity could of course be defined in a more general way, to account for the fact that *a*) a positive capital buffer provides a signal to markets that the bank is healthy, and *b*) in recessions (expansions), market funding is more difficult (easier) to obtain.

[15] Angelini et al. (2010) assume that the cost of deviating from the required capital-assets ratio is symmetric; they do not capture therefore the benefits of capital buffers. In Dib (2009, 2010), holding bank capital in excess of the required level also generates gains. An alternative approach, which has yet to be implemented (as far as we know) in New Keynesian models of the type discussed here, would be to introduce a "precautionary" demand for excess capital along the lines proposed by Repullo and Suarez (2009). In their framework, banks are unable to access equity markets in every period; by holding capital buffers today, they mitigate the possibility that their ability to lend in the future may be compromised by shocks to their earnings or aggregate economic conditions.

$$1 + i_t^L = \frac{(1 - \rho_t \sigma_t)(1 + i_t^R) + \rho_t \sigma_t (1 + i_t^V)}{(1 + \eta_F^{-1}) q_t^F}, \tag{9}$$

$$\frac{V_t^E}{P_t} = (\frac{\gamma_{VV}}{i_t^V - i_t^R})^{1/\phi_E}, \tag{10}$$

where η_D is the interest elasticity of the supply of deposits to the deposit rate and η_F the interest elasticity of the CG demand for loans (or investment) to the lending rate.

Equation (8) shows that the equilibrium deposit rate is a markup over the refinance rate. Equation (9) indicates that the gross lending rate depends negatively on the repayment probability, and positively on a weighted average of the marginal cost of borrowing from the central bank (at the gross rate $1 + i_t^R$) and the cost of issuing debt. Weights on each component of funding costs are measured in terms of the ratio of required capital to (risky) loans, $\rho_t \sigma_t$ and $1 - \rho_t \sigma_t$.

Equation (10) indicates that an increase in the cost of issuing debt, i_t^V, reduces excess capital, whereas an increase in γ_{VV} raises excess capital. With $\gamma_{VV} = 0$, holding capital beyond what is required brings no benefit, so $V_t^E = 0$ for all t. Finally, an increase in required capital, by raising the cost of issuing bank debt i_t^V, has an indirect, negative effect on the desired level of excess capital. There is therefore some degree of substitutability between the two components of bank capital.

As in Agénor et al. (2009), the repayment probability q_t^F is taken to depend positively on the effective collateral-CG loan ratio (which mitigates moral hazard on the part of borrowers), the cyclical position of the economy (as measured by the output gap), and the bank's capital-risky assets ratio, which increases incentives for the bank to screen and monitor its borrowers:

$$q_t^F = (\frac{\kappa P_t^H \bar{H}}{L_t^{F,I}})^{\varphi_1} (\frac{V_t}{L_t^{F,I}})^{\varphi_2} (y_t^G)^{\varphi_3}, \tag{11}$$

with $\varphi_i > 0$ $\forall i$ and $y_t^G = Y_t / \bar{Y}_t$ is the output gap, with $\bar{Y}_t$ denoting the frictionless level of aggregate output.[16] Our specification is thus consistent with the "double moral hazard" framework developed in Chen (2001), Aikman and Paustian (2006), and Meh and Moran (2010), among others, according to which banks have greater incentives to screen and monitor borrowers when more of their capital (relative to their outstanding loans) is at stake.[17] The novelty here is that we assume explicitly that greater monitoring translates into a higher probability of repayment.[18] Indeed, equations (9) and (11)

[16] This "semi reduced-form" approach to modeling the loan spread has been adopted in some other contributions, such as Cúrdia and Woodford (2009).

[17] However, there are significant differences in the way bank capital is modeled; here, bank capital is motivated by regulatory requirements, rather than by a "pure" moral hazard problem. Also, in Meh and Moran (2010) for instance, bank capital consists mostly of retained earnings.

[18] Allen et al. (2009) and Mehran and Thakor (2009) provide rigorous micro foundations for the link between bank capital and monitoring. In Allen et al. (2009) a monopoly bank holds capital because it strengthens its monitoring incentive and increases the borrower's success probability, whereas in Mehran and Thakor (2009) bank capital increases the future survival probability of the bank (as in Repullo and Suarez (2009)), which in turn enhances the bank's monitoring incentives. The reduced-form approach that we use can be viewed as a convenient shortcut for macroeconomic analysis.

imply a negative relationship between the capital-risky assets ratio and bank lending spreads; direct support for this link is provided by Fonseca et al. (2010), in a study of pricing behavior by more than 2,300 banks in 92 countries over the period 1990-2007. Note also that if net worth values are procyclical, both the collateral and the output gap effects are consistent with the evidence suggesting that price-cost margins in banking, or lending spreads, behave countercyclically (see for instance Aliaga-Díaz and Olivero (2010)), and Fonseca et al. (2010, Tables 6 and 9)). Thus, in the model the "bank capital channel" operates through two effects on the lending rate: a cost effect (through i_t^V) and an incentive monitoring effect (through q_t^F).

The *central bank*'s assets consist of a fixed stock of government bonds, and loans to the commercial bank, L_t^B, whereas its liabilities consists of currency supplied to (unconstrained) households and firms. Any income made by the central bank from bond holdings and loans to the commercial bank is transferred to the government at the end of each period. Monetary policy is operated by fixing the refinance rate, i_t^R, and providing uncollateralized loans (at the discretion of the commercial bank) through a standing facility.[19] In the baseline experiment, the refinance rate is determined by a contemporaneous, Taylor-type policy rule:

$$i_t^R = \chi i_{t-1}^R + (1-\chi)[\tilde{r} + \pi_t + \varepsilon_1(\pi_t - \pi^T) + \varepsilon_2 \ln y_t^G] + \epsilon_t, \tag{12}$$

where $\tilde{r}$ is the steady-state value of the real interest rate on bonds, $\pi^T \geq 0$ the central bank's inflation target, $\chi \in (0,1)$ a coefficient measuring the degree of interest rate smoothing, and $\varepsilon_1, \varepsilon_2 > 0$ the relative weights on inflation deviations from target and the output gap, respectively, and ϵ_t is a stochastic shock, which follows a first-order autoregressive process.

Finally, the *government* purchases the final good and issues nominal riskless one-period bonds. It collects tax revenues and all interest income that the central bank makes from its lending to the commercial bank and its holdings of government bonds. It adjusts lump-sum taxes to balance its budget.

Flows between agents (abstracting from the difference between constrained and unconstrained households) and the links between regulatory capital, the repayment probability, and the lending rate, are summarized in Figures 1 and 2.

[19]Standing facilities are now commonly used in both high- and middle-income countries to create (narrow) corridors to bound departures of short-term money market interest rates from target, with open-market operations used for the secondary objective of smoothing liquidity and moderating interest rate fluctuations. These facilities make the quantity of central bank cash endogenous, by providing unlimited access—subject to collateral requirements and institutional rules on who is eligible to maintain current balances with the central bank—to extra cash at the posted interest rate. For simplicity, we abstract from collateral requirements (typically low-risk and low-yield assets such as government securities), open-market operations, and consider a zero-width band around the target rate.

3 Equilibrium

In a symmetric equilibrium, firms producing intermediate goods are identical. Equilibrium conditions must be satisfied for the credit, deposit, goods, labor, housing, bank debt, and cash markets. Because the supply of loans by the commercial bank, and the supply of deposits by households, are perfectly elastic at the prevailing interest rates, the markets for loans and deposits always clear. Equilibrium in the goods markets requires that production be equal to aggregate demand. The equilibrium condition of the market for bank debt is obtained by equating (1) and (3):

$$V_t^d = V_t^R + V_t^E. \tag{13}$$

4 Steady State and Calibration

The steady-state of the model is derived in Appendix A. With an inflation target π^T equal to zero, the steady-state inflation rate $\tilde{\pi}$ is also zero. Beyond standard results (on the steady-state value of the marginal cost, for instance), the key results on the steady-state values of interest rates are as follows (with $\tilde{\sigma}^F = 1$, by implication of (6)):

$$\tilde{\imath}^B = \tilde{\imath}^R = \frac{1}{\beta} - 1 = \tilde{r}, \quad \tilde{\imath}^D = (1 + \frac{1}{\eta_D})^{-1}\tilde{\imath}^R,$$

$$\tilde{\imath}^V > \tilde{\imath}^B, \quad \text{for } \Theta_V > 0$$

and

$$1 + \tilde{\imath}^L = \frac{(1-\rho)(1+\tilde{\imath}^R) + \rho(1+\tilde{\imath}^V)}{(1+\eta_F^{-1})\tilde{q}^F}.$$

From these equations it can be shown that $\tilde{\imath}^B > \tilde{\imath}^D$. We also have $\tilde{\imath}^V > \tilde{\imath}^B$ for $\Theta_V > 0$ because holding bank debt is subject to a cost; from the perspective of the household, the rate of return on that debt must therefore compensate for that and exceed the rate of return on government bonds. Of course, when $\Theta_V = 0$, then $\tilde{\imath}^V = \tilde{\imath}^B$. From the above results, and because $\tilde{\imath}^B > \tilde{\imath}^D$, we also have $\tilde{\imath}^V > \tilde{\imath}^D$ for $\Theta_V > 0$; bank capital is more costly than deposits (or, equivalently, households demand a liquidity premium), as in Aguiar and Drumond (2007). The reason here is that holding bank debt is costly.

To analyze the response of the economy to shocks, we log-linearize the model around a nonstochastic, zero-inflation steady state. The log-linearized equations are summarized in Appendix B. A key property of the model is that deviations of real investment from its steady-state level depend on deviations in the lending rate, which depend themselves on deviations in the capital-risky assets ratio. Thus, regulatory policy, just like monetary policy, has a direct effect on aggregate demand.

The calibration of the model, which we view as illustrative, is described in detail in Appendix C. Table 1 summarizes parameter values.[20] A few parameters are worth

[20] A more complete table is provided in the working paper version of this article.

noting here; in particular, the adjustment cost parameter for holdings of bank debt, Θ_V, is set at 0.3. The adjustment cost for transforming the final good into investment, Θ_K, is set at 14. The elasticities of the repayment probability with respect to the collateral-risky loans ratio, the bank capital-risky assets ratio, and cyclical output are set at $\varphi_1 = 0.03$, $\varphi_2 = 0.0$, and $\varphi_3 = 0.15$, respectively.[21] Thus, in the benchmark calibration, we abstract from the "monitoring incentive effect" of the bank capital channel identified earlier. The elasticities of the risk weight with respect to the repayment probability, φ_q, as well as the cost parameter γ_{VV} are set at low values, 0.05 and 0.004, respectively. Because γ_{VV} is a parameter that could potentially influence in important ways the transmission effects of capital requirements (and thus the performance of the countercyclical regulatory rule), we will later consider alternative values. Our specification of the risk weight (6) implies that its value is unity in the steady state; we set the overall capital adequacy ratio ρ to 0.08. We also calibrate the excess capital-risky assets ratio to be equal to 0.04. This implies that the steady-state ratio of total bank capital to risky loans is set at about 12 percent (so that $\tilde{V}^E/\tilde{V}^R = 0.53$), in line with the evidence reported in Agénor and Pereira da Silva (2009). For the monetary policy rule, we set $\varepsilon_1 = 1.2$, $\varepsilon_2 = 0.2$, and $\chi = 0.0$ initially. Our calibration also implies a total (corporate) credit-to-output ratio of about 60 percent, which is consistent with data for several middle-income countries where financial intermediation is bank-based and consumer lending remains limited. The proportion of constrained households is set to 0.3; this is close to the average estimate of Coenen and Straub (2005), who found that the proportion of constrained households in the Euro area varies between 0.25 and 0.37.[22] For the degree of persistence of the housing demand shock, we assume a value of 0.6.

5 Housing Demand Shock

To illustrate the functioning of the model when concerns with financial stability are absent, we consider as a base experiment a positive temporary shock to housing preferences that translates into an impact increase in real house prices of 1.6 percentage points. The results are summarized in Figure 3.[23]

[21] Higher values of φ_1 destabilize the model very quickly. While this may not be inconsistent with recent facts, in the model this is also related to the fact that only housing is used as collateral. If physical capital could also be used for that purpose, it would be possible to increase φ_1 quite substantially, as can be inferred from the results in Agénor and Alper (2009).

[22] This value is substantially lower than some of the results reported in Agénor and Montiel (2008). However, much of the early literature relates to developing countries in general (including therefore low-income countries) and does not account for the financial liberalization that has occurred in many middle-income countries over the past two decades.

[23] Our goal is to illustrate the dynamics induced by a "fundamental" shock to asset prices, rather than unsustainable changes in expectations. Although the size and the persistence of the effect of our shock on house prices is not comparable to the much more persistent movements in these prices observed during typical booms, the qualitative effects are quite similar to those of a "standard" house price bubble. A more formal attempt to model asset price bubbles, involving more persistent shocks,

The immediate effect of the shock is to raise housing prices. In turn, this raises the value of collateral and thus the repayment probability. The lending rate therefore drops, thereby stimulating investment in the first period. The increase in aggregate demand is matched by an increase in supply (given sticky prices) and this stimulates the demand for labor. Over time, the increase in investment raises the capital stock; this raises the marginal product of labor and therefore gross wages. At the same time, the increase in the capital stock tends to lower the rental rate of capital.

The increase in output tends to raise immediately the policy rate; combined with the increase in the gross wage, this tends to raise the effective cost of labor for the producers of intermediate goods.[24] Because the rental rate of capital does not change on impact (due to the one-period lag in capital accumulation), marginal costs unambiguously increase in the first period. Inflation therefore rises, putting further upward pressure on the policy rate. Over time, the reduction in the rental rate of capital induced by the boom in investment tends to lower marginal costs and inflation.

The higher policy rate (which translates into a higher deposit rate) is also accompanied by a higher interest rate on government bonds. The reason is that the increase in the deposit rate raises demand for these assets; this translates into a reduction in bank borrowing from the central bank. The reduction in money supply must be matched by a lower demand for currency, which is brought about by a higher bond rate. This leads to a shift in consumption from the present to the future for unconstrained consumers, who do not benefit directly from the collateral effect induced by higher house prices because they do not borrow from the banking system; moreover, the intertemporal effect in consumption dominates any wealth effect associated with a positive (but temporary) housing price shock. This downward effect dominates the positive response of spending by constrained consumers (given the increase in their labor income), so that aggregate consumption falls.[25] This mitigates the increase in aggregate demand induced by the initial investment boom. The drop in consumption reduces the marginal utility of leisure and induces unconstrained households to supply more labor, thereby mitigating the upward pressure on real wages.

The increase in the repayment probability lowers the risk weight under the Basel II-type regulatory capital regime that we consider, which tends to reduce capital requirements. However, the increase in risky assets (loans to the CG producer) dominates, which implies that required capital increases; in turn, this tends to raise the rate of return on bank debt. Given that the policy rate increases, the net effect on the demand for excess bank capital is ambiguous in general; given our calibration, it actu-

could follow along the lines of Bernanke and Gertler (1999), as done in Levieuge (2009).

[24]Recall that the effective cost of labor for IG producers is the gross refinance rate $1 + i_R$ times the gross wage.

[25]The fall in consumption, which lowers the demand for currency, attenuates the initial increase in the bond rate. A positive response of aggregate consumption could be obtained by increasing significantly the share of unconstrained households, compared to the base calibration. However, a consumption boom is *not* a stylized fact associated with periods of sustained increases in house prices; see Detken and Smets (2004) International Monetary Fund (2009).

ally increases. The increase in the cost of issuing bank debt mitigates the downward impact on the lending rate associated with the collateral effect.

In sum, the results of this experiment suggest that the model is consistent with the view that a demand-induced boom in housing prices may lead, through a financial accelerator mechanism that operates through collateral values and borrowing costs, to rapid increases in investment, an expansion in output, inflationary pressures, and debt accumulation. Conversely, a bust in housing prices, through the same asset price channel, can lead to a credit crunch, a contraction in output and investment, and deflation. Because our analysis focused on a temporary shock, the simulation results do not identify explicitly any tendency for instability; however, it is clear from our description of the transmission mechanism that a shock of sufficient duration could well induce unsustainable movements in real and financial variables, and thus economic instability, in the absence of a timely policy response. We now turn to an examination of the policies that could help to mitigate *financial* instability, and the extent to which doing so may entail trade-offs with respect to *macroeconomic* stability.

6 Policy Rules for Economic Stability

We now consider two alternative approaches to mitigating financial instability, in line with some recent proposals. The first involves adjusting the refinance rate in response to a financial stability indicator, whereas the second focuses on reducing the degree of procyclicality of the financial system through discretionary regulation of bank capital, in line with the new Basel III regime.

6.1 An Augmented Interest Rate Rule

In the first approach that we consider, the central bank adjusts its policy rate directly in response to changes in an indicator of financial stability. Specifically, we replace the interest rate rule (12) by the augmented rule

$$i_t^R = \chi i_{t-1}^R + (1-\chi)[\tilde{r} + \pi_t + \varepsilon_1(\pi_t - \pi^T) + \varepsilon_2 \ln y_t^G \tag{14}$$

$$+\varepsilon_3(\Delta \ln L_t^{F,I} - \Delta \ln \tilde{L}^{F,I})] + \epsilon_t,$$

where $\Delta \ln L_t^{F,I}$ is the growth rate of nominal credit to the CG producer, and $\Delta \ln \tilde{L}^{F,I}$ is the steady-state value of that variable. Thus, in line with the discussion in the introduction, the central bank sets its refinance rate in part to "lean against the wind." Following a positive shock to housing prices for instance, and an increase in collateral values, the lending rate drops and stimulates investment; an increase in the refinance rate tends to mitigate the drop in the cost of bank borrowing and therefore to dampen the investment boom. We can analyze the performance of alternative interest rate rules (that is, different values of $\varepsilon_3 > 0$) in terms of specific indicators of macroeconomic stability and financial stability, and compare them to the base case where $\varepsilon_3 = 0$.

6.2 A Countercyclical Regulatory Capital Rule

The second rule can be introduced by decomposing the overall capital ratio, ρ_t, into a "deterministic" component, ρ^D, and a cyclical component, ρ_t^C:

$$\rho_t = \rho^D + \rho_t^C. \tag{15}$$

Thus, the component ρ^D can be viewed as the minimum capital adequacy ratio imposed under Pillar 1 of the Basel regime, whereas the component ρ_t^C can be viewed as the "discretionary" adjustment that now forms part of the Basel III regime.[26] The experiment presented in the previous section assumed that $\rho_t^C = 0$ and $\rho_t = \rho^D$ $\forall t$.

Adjustment of the cyclical component follows a simple dynamic rule; we relate it only to deviations of the growth rate of real credit to the CG producer from its steady-state value:

$$\rho_t^C = \theta^C(\Delta \ln l_t^{F,I} - \Delta \ln \tilde{l}^{F,I}), \tag{16}$$

where $l_t^{F,I} = L_t^{F,I}/P_t$ and $\theta^C > 0$ the adjustment parameter.[27] Thus, the macroprudential rule is designed so as to directly counter the easing of lending conditions that induces borrowers to take on more debt as house prices increase.

Suppose that in period t there is an increase in housing prices, due to a demand shock. As discussed earlier, the rise in the value of collateral tends to raise the repayment probability immediately, which reduces the lending rate and stimulates borrowing for investment by the CG producer. The increase in house prices is therefore procyclical. A rule like (16), by imposing higher capital requirements, tends to raise directly the cost of issuing debt by the bank, thereby mitigating the initial expansionary effect associated with higher collateral values. Thus, it dampens procyclicality of the financial system. It is consistent with the spirit, if not the letter, of some of the recent proposals to amend or reform Basel II capital standards, such as Goodhart and Persaud (2008), as mentioned in the introduction, and the recently-adopted rule under Basel III.[28]

Nevertheless, in the general equilibrium framework, whether the effect on the lending rate is positive or negative depends also on the *net* effect on the repayment probability, which depends (as noted earlier) not only on the collateral-CG loan ratio, but also on the cyclical position of the economy and the bank capital-risky assets ratio. In particular, under the risk-sensitive regulatory regime that we consider, the increase in the repayment probability induced by the improvement in the collateral-risky loans ratio lowers the risk weight and tends to reduce capital requirements. If the countercyclical regulatory rule is not too aggressive (in the sense that θ^C is not too high),

[26] In the ongoing debate about the implementation of Basel III, there is still discussion as to whether the countercyclical component should be made mandatory or left to the discretion of local regulators. See the final section for some further comments.

[27] Although the rule for ρ_t^C is not a backward-looking rule, we assume that the bank takes ρ_t as given when solving its optimization problem. Thus, the bank pricing rules derived earlier remain unchanged.

[28] The second dimension of the rule proposed by Brunnermeier et al. (2009), related to the mismatch in the maturity of assets and liabilities, cannot be implemented in our setup.

the capital-risky assets ratio will fall, and this will tend to mitigate the initial rise in the repayment probability and the drop in the loan rate. If so, then, the monitoring incentive effect will operate in the same direction as the cost effect. By contrast, if the regulatory rule is very aggressive (high θ^C), total capital may increase by more than the increase in risky loans, and this may lead to a *higher* repayment probability and a *lower* lending rate, making the regulatory rule (16) *more*, rather than less, procyclical. Thus the conflicting effects of the two dimensions of the bank capital channel may make the policy counterproductive. Alternatively, if the benefit from holding capital buffers (as measured by γ_{VV}) is not too large, the regulatory capital rule may be even more effective. To assess the most likely outcomes requires numerical simulations, based on some optimality criteria.

6.3 Stability Measures and Policy Loss Function

We assume in what follows that the central bank is concerned with two objectives, macroeconomic stability and financial stability. Both concepts, as noted earlier, can be defined in different ways; in this paper, we define macroeconomic stability in terms of the coefficient of variation of nominal income (thereby imposing implicitly equal weights on output and price volatility) and financial stability in terms of the coefficient of variation of real housing prices.[29] In addition, we also define a *composite index of economic stability*, defined with two sets of weights: first with equal weight 0.5 to each objective of stability, and second with a weight of 0.8 for macroeconomic stability and 0.2 for financial stability. Let $V(x_t)$ denote the volatility of x_t; formally, this is equivalent to defining the central bank's instantaneous policy loss function Λ_t as

$$\Lambda_t = (1 - \zeta^F)V(P_tY_t) + \zeta^F V(p_t^H), \tag{17}$$

with $\zeta^F = 0.5, 0.2$.[30]

7 Model Dynamics and Policy Trade-offs

Before we study optimal policies, we begin with a simple examination of how the two rules (14) and (16) operate, independently of each other. Figure 4 shows how the two rules affect our separate measures of (in)stability when the underlying shock is the same as described earlier—a positive shock to housing preferences. The figure suggests that there is no trade-off among policy objectives: a more aggressive response to credit growth gaps leads, in either case, to a monotonic reduction in *both* indicators

[29] In turn, coefficients of variations are based on the asymptotic (unconditional) variances of the relevant variable.

[30] A quadratic term in the change in the policy rate, $V(i_t^R - i_{t-1}^R)$, to capture the cost attached to nominal interest rate fluctuations. Because this would lead to more persistence, we account for that cost directly by considering different values of χ in our experiments.

of volatility.[31] Thus, from the perspective of either policy objective, monetary and countercyclical regulatory policies appear to be substitutes, rather than complements.[32] However, the curves have a convex shape, which indicates that the marginal benefit of either policy diminishes as it becomes more aggressive. Indeed, the upper panels suggest that beyond a value of $\varepsilon_3 = 0.6$, the gain in terms of reduced volatility become smaller; a similar result holds in the lower panels for θ^C above 4.[33]

The next step is to examine to what extent their combination leads to lower variability in either target. Figure 5 shows 3D diagrams of macroeconomic and financial stability indicators (measured as described earlier), as well as inflation in the price of the final good and the output gap, and *changes* in policy and lending rates, for ε_3 varying between 0 and 2.5 (Northwest horizontal axis) and for θ^C varying between 0 and 10 (Northeast horizontal axis). The outer contour of each graph corresponds to the convex curves shown in Figure 4. The figures suggest clearly that, given our base calibration, the marginal contribution of the regulatory capital rule, once an augmented interest rate is in place, decreases rapidly, in terms of either macroeconomic stability and financial stability.

The results with respect to our index of economic stability are shown in Figure 6, again for ε_3 varying between 0 and 2.5 and for θ^C varying between 0 and 10. The conclusion that can be inferred from the graph is the same as before: given our base calibration, the marginal contribution of the regulatory capital rule to economic stability decreases rapidly once the augmented interest rate rule is used. Put differently, countercyclical bank regulation may not provide very large benefits, if monetary policy can be made more reactive to an indicator of financial stability. However, to the extent that monetary policy is constrained (because the central bank fears destabilizing markets by raising interest rates too sharply while inflation remains subdued, for instance), there may be some degree of complementarity between the two rules: a countercyclical regulatory rule can help to improve outcomes with respect to both objectives. Put differently, the convexity of the curves shown in Figures 4 and 6 suggests that, if there is a cost in implementing large changes in the policy rate, it may be optimal to combine the two policies.

[31] Although not reported, the volatility of the refinance rate falls as well, as either policy rule becomes more aggressive. This is because a model with forward-looking private agents, such as this one, has strong expectational effects—households anticipate a stronger reaction from the central bank and factor it into their decision-making process. The result is that monetary policy works partly through the threat of a stronger response, instead of actually delivering that stronger response.

[32] Note that the absence of trade-offs relates only to policy responses with respect to housing demand shocks and depends on the fact that we abstract from output-inflation trade-offs, by focusing on the volatility of nominal income.

[33] The working paper version of this illustrates the dynamics of a housing demand shock for these two values of ε_3 and θ^C.

8 Optimal Policies

We now consider how the parameters ε_3 and θ^C in the two rules (14) and (16) can be determined optimally, so as to minimize economic instability (17). As can be inferred from Figures 4 and 5, the fact that there is no tradeoff among policy objectives, and that the augmented interest rate rule is more powerful in mitigating volatility, means that, in general if there is no restriction on the value of ε_3 the optimal policy always implies setting $\theta^C = 0$. To generate a role for regulatory policy, suppose that the central bank chooses not to react beyond a certain point to changes in credit growth, out of concern that large *changes* in interest rates can generate instability. To account for this, we perform a set of experiments in which we arbitrarily limit the value of ε_3 to a "plausible" upper limit, which we set at 2.5. At the same time, we impose a higher limit on the parameter θ^C, equal to 10. Thus, our analysis is best described as a search for "constrained" optimal policies, with a relatively less aggressive potential response of monetary policy to credit growth gaps.

Table 2 reports the results. We calculate optimal values based on different sets of two other key parameters: the response of the policy rate to deviations of inflation from target, ε_1, and the degree of persistence in the policy rate, χ. In addition to the baseline value $\varepsilon_1 = 1.2$, we consider two other values, 1.5 and 1.8, which capture a more aggressive stance toward inflation. For the smoothing parameter we consider, in addition to the baseline value $\chi = 0.0$, values of $\chi = 0.4$ and $\chi = 0.8$; again, these alternative values capture the view that underlying preferences reflect a concern with movements in policy rates that are too large, possibly because the central bank believes that large movements can destabilize financial markets.[34] We calculate the value of the loss function (17) for all values of ε_3 varying between 0 and 2.5, and θ^C varying between 0 and 10. We perform a grid search at intervals of 0.0125 for ε_3 and 0.5 for θ^C, which is quite large but sufficient to illustrate our main points.

The results can be summarized as follows. First, if monetary policy can react strongly to inflation deviations from its target value, the best policy is to follow an aggressive augmented interest rate rule—regardless of the degree of persistence in the policy rate. By contrast, if monetary policy cannot react sufficiently strongly to inflation deviations from targets (because the central bank fears destabilizing markets by raising interest rates too sharply), combining a credit-augmented interest rate rule and a countercyclical capital regulatory rule is optimal for promoting economic stability. Second, the greater the degree of interest rate smoothing, the stronger should be the countercyclical regulatory response—regardless of how strongly monetary policy can react to inflation. In fact, with a multi-period loss function (as opposed to the instantaneous specification in (17)), and depending on the discount rate, the fact that the volatility of the change in the lending rate increases at first with increases in ε_3 (as shown in Figure 5) could militate even more strongly in favor of the regulatory rule.

[34] Alternatively, high persistence in the policy rate is viewed as desirable because, as argued by Woodford (1999), it allows the government to commit to future inflation targets.

Third, the stronger the policymaker's concern with *macroeconomic* stability (compared to financial stability), the stronger should be the sensitivity of countercyclical regulation to real credit growth gaps.

The first two results suggest that monetary and regulatory policies are complementary rather than substitutes; even with aggressive responses to inflation and credit growth gaps, it is optimal to rely also on the countercyclical regulatory rule as the degree of interest rate smoothing increases. The third result is somewhat counterintuitive; one would have expected that the stronger the concern with *financial* instability, the stronger reliance should be on countercyclical capital regulation. The reason is that, in our base calibration, the countercyclical regulatory rule has quite a powerful effect on stabilizing aggregate demand (through capital formation) and output; this is because we assumed that *all* purchases of goods for investment purposes must be financed in advance, through bank loans. In turn, movements in output tend to dominate changes in inflation and therefore account for most of the changes in the index of macroeconomic instability.

9 Sensitivity Analysis

To assess the sensitivity of the previous results, we consider several additional experiments: a higher elasticity of the repayment probability to the capital-risky assets ratio, an alternative measure of financial instability (the credit-to-GDP ratio), the introduction of the real (rather than nominal) credit growth gap in the interest rate rule, and an alternative loss function—more in line with an inflation targeting regime—that attaches more weight to inflation in the index of macroeconomic stability.

9.1 Response to Capital-Risky Assets Ratio

For the first experiment, we account for a monitoring incentive effect of the bank capital channel (as described earlier) by increasing the elasticity φ_2 from its initial value of zero to 0.05. This alternative value is within the two-standard error confidence interval for the elasticity of the bank loan spread with respect to the capital-risky assets ratio estimated by Fonseca et al. (2009) for developing countries.

The results are summarized in Table 3. They indicate that a stronger bank capital channel (operating through a monitoring incentive effect) strengthens the countercyclical regulatory rule in the presence of risk-sensitive weights. The reason is that following the housing price shock and the initial increase in the repayment probability (as discussed earlier), the weight on risky assets in our Basel II-type regime tends to fall; this lowers capital requirements and therefore tends to reduce the capital-risky assets ratio. In turn, this mitigates the bank's incentives to monitor and *reduces* the repayment probability—thereby offsetting the initial increase in that variable and dampening the initial drop in the lending rate. Thus, a stronger bank capital channel (operating through monitoring and screening incentives) makes the countercyclical regulatory rule more effective.

9.2 Alternative Measure of Financial Instability

In the third experiment, we consider an alternative to real house prices as a measure of financial instability, namely, the credit-to-GDP ratio. Empirical studies of banking crises in developing countries have documented that large increases in that ratio often precede the occurrence of these crises (see Demirguc-Kunt and Detragiache (2005) and Agénor and Montiel (2008)).[35] The results (which are not shown here to save space) remain qualitatively very similar to those reported in Table 2.

9.3 Real or Nominal Credit Growth?

As an alternative to *nominal* credit growth, we tried to insert the growth rate of *real* credit in the interest rate rule. Nominal credit growth includes an inflationary component; thus, the benefits of responding to that variable via an interest rate rule might result from that component. By using real credit growth, our goal is to see whether responding to another real variable (in addition to the output gap) changes our base results.

Our simulations (which are again not reported to save space) show that this change in the interest rate rule improves with respect to both stability objectives; both macroeconomic and inflation volatility are reduced compared to the base case with nominal credit growth. But this modification does not alter the main conclusions initially presented regarding the optimality of the augmented interest rate and the regulatory rules.

9.4 Alternative Loss Function

In the foregoing discussion, the indicator of macroeconomic stability that we used was based on the volatility of nominal income, as shown in (17). However, the focus on nominal income is not necessarily consistent with inflation targeting, which is the underlying regime upon which the policy reaction function (12) is based.

Accordingly, we replace the policy loss function (17) by a function that explicitly distinguishes between the volatility of inflation deviations from target (which is zero here) and the volatility of the output gap:

$$\Lambda_t = (1 - \zeta^F)[V(\pi_t) + \zeta^Y V(y_t^G)] + \zeta^F V(p_t^H),$$

with $\zeta^Y > 0$ and as before $\zeta^F \in (0, 1)$. A "standard" inflation targeting regime corresponds therefore to $\zeta^F = 0$.

[35] Another proxy for financial (in)stability, as proposed by Granville and Mallick (2009), is the volatility of the deposit-loan ratio. For more micro-based approaches to measuring financial instability, see De Graeve, Kick, and Koetter (2008), Blavy and Souto (2009), and Segoviano and Goodhart (2009).

Table 5 reports the results with values of ζ^Y equal to 0.2 and 0.5, which captures the idea that the central bank is more concerned with fluctuations in inflation as opposed to output volatility and for $\zeta^F = 0.2$, which corresponds to the case where the central bank is only mildly concerned with financial stability. Comparing Tables 2 and 5 suggests again a somewhat counterintuitive result: even though the concern with financial instability is not as strong as in the base case, and the central bank is now more concerned with inflation volatility than fluctuations in the output gap, the optimal policy is still to rely on countercyclical capital regulation if manipulating the policy rate is constrained—the more so if the degree of persistence in the policy rate is high. The reason again is that raising the capital buffer in response to the growth in investment loans has a sizable impact on aggregate demand—and thus on macroeconomic stability.

10 Summary and Policy Implications

The purpose of this paper has been to examine the roles of monetary policy and bank capital regulatory policy in mitigating procyclicality and promoting macroeconomic and financial stability. The analysis was based on a dynamic, structural optimizing macroeconomic model with imperfect credit markets and Basel-type bank capital regulation, with both cost and monitoring incentive effects. The model incorporates also an asset price-financial accelerator mechanism, by which induced changes in asset prices affect the value of the collateral pledged by borrowers and hence the cost of loans. Macroeconomic stability is initially defined in terms of the volatility of nominal income, whereas financial stability is defined initially in terms of the variability of real house prices. Our basic experiment showed that a positive housing demand shock, through its effect on collateral values, leads to a credit expansion and an investment boom. This is consistent with the evidence and provides the proper "background" for discussing the roles of monetary and regulatory policies in achieving economic stability.

We next considered two policy rules aimed at mitigating financial instability: a credit-augmented interest rate rule and a Basel III-type countercyclical regulatory capital rule, both based on a "credit growth gap" measure. The premise for the first rule is that a central bank's response to credit growth may serve to stabilize market conditions (namely, the lending rate), by offsetting the expansionary (balance sheet) effect induced by a positive shock to asset prices. The second rule is motivated by the view that capital regulation should be operated in a more flexible manner to account for changes in systemic risk over the business cycle. In both cases, the underlying view is that the expansion of credit is an essential ingredient in the build-up of imbalances in the financial system.

Numerical experiments showed, first, that there are no trade-offs between macroeconomic and financial stability objectives when each instrument is used in isolation. Second, if monetary policy cannot react sufficiently strongly to inflation deviations from targets—due to concerns about interest rate volatility feeding uncertainty about economic fundamentals, or because of fears that sharp changes in interest rates while inflation is low could induce volatility in price expectations and destabilize markets, for instance—combining a credit-augmented interest rate rule and a countercyclical capital regulatory rule is optimal for mitigating economic instability. This result also holds if monetary policy can respond aggressively to inflation, as long as the degree of interest rate smoothing is high. Third, the greater the concern with macroeconomic stability (compared to financial instability) is, the larger the role of countercyclical regulation. Although somewhat counterintuitive, this last result reflects the fact that in our framework capital regulation is a very effective tool for constraining the growth in aggregate demand, because all investment is financed through bank loans. Various sensitivity tests help to qualify somewhat theses results but do not alter them in fundamental ways.

Our results are useful in the context of the current debate on the role of monetary policy in fostering financial stability and on reforming bank capital standards. First, some observers have argued that, to the extent that credit growth affects output (as is the case in our model), there may be no reason for monetary policy to react above and beyond what is required to stabilize output and inflation. Our results suggest that this precept is not generally true. Second, as noted in the introduction, the in November 2010 the G20, under proposition by the Basel Committee on Banking Supervision, adopted a countercyclical capital buffer rule based on a credit-to-GDP gap measure. The fundamental idea underlying countercyclical regulation is that financial markets, left to themselves, are inherently procyclical. But even though (excessive) risk becomes apparent in bad times, it is mainly generated in boom times. Thus, the time for regulators to intervene is precisely during good times, to prevent excessive risk taking and moderate the growth in bank credit. By operating in a countercyclical fashion, financial regulation therefore helps ensure that banks build up resources in good times, to help cushion adverse shocks in bad times. At the same time, it is important to implement countercyclical regulation through relatively simple rules that cannot be easily changed by regulators so they will not become "captured" by the general "exuberance" that characterizes booms nor by vested interests (see Brunnermeier et al. (2009)). Our analysis suggests, however, that the benefits of these rules may also be less than believed if monetary policy can endogenously respond to (excessive) credit growth. It also casts doubt on the wisdom of making a countercyclical capital requirement component mandatory under Pillar 1 of the new Basel III regime; large structural differences across countries may make the attempt to impose a uniform rule problematic.

The analysis can be extended in several directions. First, as noted earlier, although financial instability is commonly associated with periods of booms and busts in asset prices and credit, there is no widely accepted definition and (hence) indicator of financial stability; in our analysis we focused initially on a single indicator, real house prices, and then considered the credit-to-GDP ratio. However, alternative indicators are possible, as suggested by the empirical evidence.[36] More generally, it could be argued that financial instability is associated with fluctuations in several financial and real economic variables rather than in just asset prices. Financial stability may therefore be difficult to assess by merely focusing on a single or a limited set of either financial or real economic variables. A useful extension would be consequently to consider broad (or composite) indicators and examine how our results are altered. In particular, one could combine real house prices with a credit growth gap measure and bank lending rates, to derive a *composite* indicator of financial instability, with weights on each individual variable based on the literature that measures the relative importance of each in predicting either banking crises (see Demirguc-Kunt and Detragiache (2005), and Agénor and Montiel (2008)) or periods of financial stress (see Misina and Tkacz (2009)).

Second, in the definition of our countercyclical regulatory capital rule, we included only loans to capital goods producers, on the ground that loans for working capital needs are not risky. In practice, however, a legitimate question is whether such a distinction between components of credit can be meaningfully implemented, given well-known fungibility problem and the risk that differences in regulation may encourage banks to engage in distortive practices (see Hilbers et al. (2005)). This is a particularly important consideration for middle-income countries, where the institutional and regulatory environment is often weak to begin with. If so, then, there may be little choice but to apply the regulatory rule on *total* credit—with possible adverse welfare effects, in countries where working capital needs represent a large share of bank loans.

Third, a more formal analysis of optimal rules, based on conditional discounted utility of the different categories of agents, would allow a more comprehensive study of the welfare effects of a credit-responsive monetary policy and countercyclical regulatory capital rules, in the presence of both macroeconomic and financial stability objectives.[37]

Finally, we must point out that our assessment of the benefits of countercyclical regulatory rules did not address implementation issues. In general, the implementation of macroprudential regulation requires stronger coordination (in countries where they are independent to begin with) between central banks and supervisory authorities. The issue of how best to achieve such coordination in practice remains a matter of debate. Another practical issue to consider is the extent to which the introduction of macroprudential rules may adversely affect the anti-inflation credibility of the central bank—a particularly important concern in countries where such credibility remains precarious. The risk is that the announcement of greater reliance on macroprudential regulation give rise to expectations that the central bank may now pursue a more

[36] See Segoviano and Goodhart (2009). In De Graeve et al. (2008) for instance, financial stability is defined and measured as a bank's probability of distress according to the supervisor's definition of problem banks used for supervisory policy.

[37] Faia and Monacalli (2007) for instance found that monetary policy should respond to increases in asset prices by *lowering* interest rates. In addition, when monetary policy responds strongly to inflation, the marginal welfare gain of responding to asset prices vanishes. However, Angeloni and Faia (2010) found opposite results.

accommodative monetary policy in the face of inflationary pressures, thereby weakening its credibility. A transparent communications strategy that clarifies the nature of macroprudential rules and the way they are expected to operate, while emphasizing the fundamental complementarity between the "traditional" objectives of monetary policy and the goal of financial stability, may thus be essential.

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Table 1
Benchmark Calibration: Parameter Values

Parameter	Value	Description
Household		
β	0.93	Discount factor
ς	0.6	Elasticity of intertemporal substitution
η_N	1.5	Relative preference for leisure
η_x	0.02	Relative preference for money holdings
η_H	0.02	Relative preference for housing
ν	0.82	Share parameter in index of money holdings
Θ_V	0.3	Adjustment cost parameter, holdings of bank debt
$\varkappa$	0.3	Share of constrained households
Production		
θ	10.0	Elasticity of demand, intermediate goods
α	0.65	Share of labor in output, intermediate good
ϕ_F	74.5	Adjustment cost parameter, prices
δ	0.01	Depreciation rate of capital
Θ_K	14	Adjustment cost parameter, investment
Bank		
κ	0.06	Effective collateral-loan ratio
γ_K	0.0	Weight of capital stock in total collateral
φ_1	0.03	Elasticity of repayment prob wrt collateral
φ_2	0.0	Elasticity of repayment prob wrt capital-risky assets ratio
φ_3	1.5	Elasticity of repayment prob wrt cyclical output
φ_q	0.05	Elasticity of the risk weight wrt prob of repayment
γ_B	0.05	Cost of adjustment, bond holdings
γ_V	0.08	Cost of issuing bank capital
γ_{VV}	0.004	Benefit of holding excess bank capital
ρ^D	0.08	Capital adequacy ratio (deterministic component)
Central bank		
μ	0.1	Reserve requirement rate
χ	0.0	Degree of interest rate smoothing by central bank
ε_1	1.5	Response of refinance rate to inflation deviations
ε_2	0.15	Response of refinance rate to output gap
Shocks		
ρ^ϵ	0.6	Degree of persistence, monetary policy shock
ρ^H, σ_{ξ^H}	$0.6, 0.002$	Persistence/standard dev, housing demand shock

Table 2
Optimal Policy Parameters, ε_3, θ^C: Base Case

	ε_1		
χ	1.2	1.5	1.8
		$\zeta^F = 0.5$	
0.0	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.8	$2.5, 10.0$	$2.5, 8.0$	$2.5, 1.5$
		$\zeta^F = 0.8$	
0.0	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 10.0$	$2.5, 0.5$	$2.5, 0.0$
0.8	$2.5, 10.0$	$2.5, 8.5$	$2.5, 2.0$

Note: the first number in the double entries is ε_3, the second θ^C.

Table 3
Optimal Policy Parameters, ε_3, θ^C: $\varphi_2$increases to 0.05

	ε_1		
χ	1.2	1.5	1.8
		$\zeta^F = 0.5$	
0.0	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.8	$2.5, 10.0$	$2.5, 10.0$	$2.5, 2.0$
		$\zeta^F = 0.8$	
0.0	$2.5, 10.0$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 10.0$	$2.5, 0.5$	$2.5, 0.0$
0.8	$2.5, 10.0$	$2.5, 10.0$	$2.5, 2.5$

Note: the first number in the double entries is ε_3, the second θ^C.

Table 4
Optimal Policy Parameters: γ_V increases to 0.14

	ε_1		
χ	1.2	1.5	1.8
		$\zeta^F = 0.5$	
0.0	$2.5, 7.5$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 7.5$	$2.5, 0.0$	$2.5, 0.0$
0.8	$2.5, 8.0$	$2.5, 5.5$	$2.5, 1.0$
		$\zeta^F = 0.8$	
0.0	$2.5, 8.0$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 8.0$	$2.5, 0.5$	$2.5, 0.0$
0.8	$2.5, 8.0$	$2.5, 5.5$	$2.5, 1.5$

Note: the first number in the double entries is ε_3, the second θ^C.

Table 5
Optimal Policy Parameters: Alternative Policy Loss Function
($\zeta^F = 0.2$, and $\zeta^Y = 0.2$, 0.5)

	ε_1		
χ	1.2	1.5	1.8
		$\zeta^Y = 0.5$	
0.0	$2.5, 7.5$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 8.0$	$2.5, 0.0$	$2.5, 0.0$
0.8	$2.5, 10.0$	$2.5, 5.5$	$2.5, 1.0$
		$\zeta^Y = 0.2$	
0.0	$2.5, 6.5$	$2.5, 0.0$	$2.5, 0.0$
0.4	$2.5, 6.5$	$2.5, 0.0$	$2.5, 0.0$
0.8	$2.5, 8.5$	$2.5, 4.5$	$2.5, 0.5$

Note: the first number in the double entries is ε_3, the second θ^C.

Figure 1
Flows between Agents

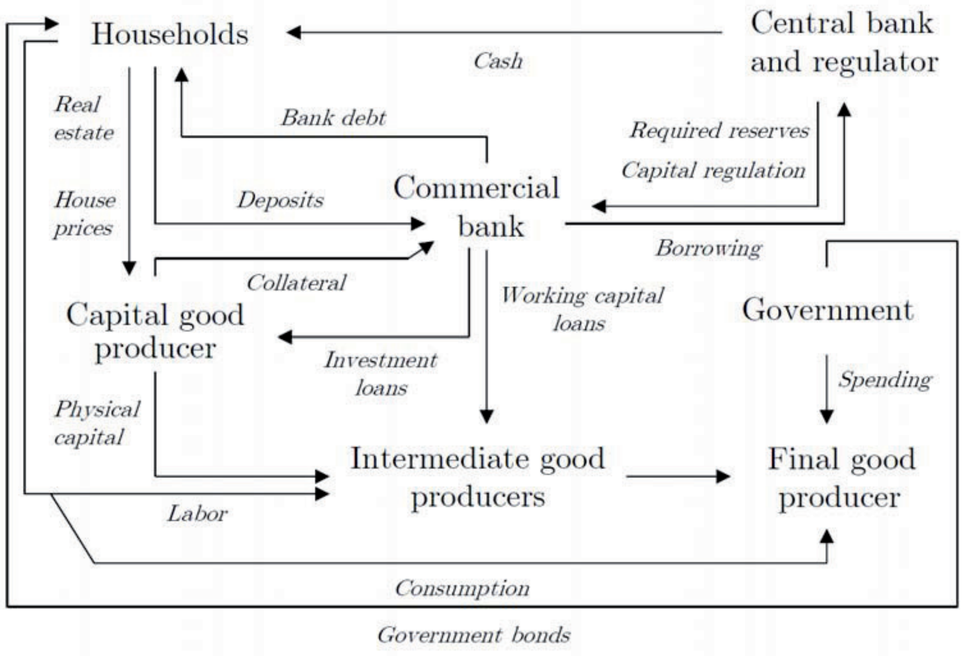


Figure 2
Regulatory Capital, Repayment Probability, and Lending Rate

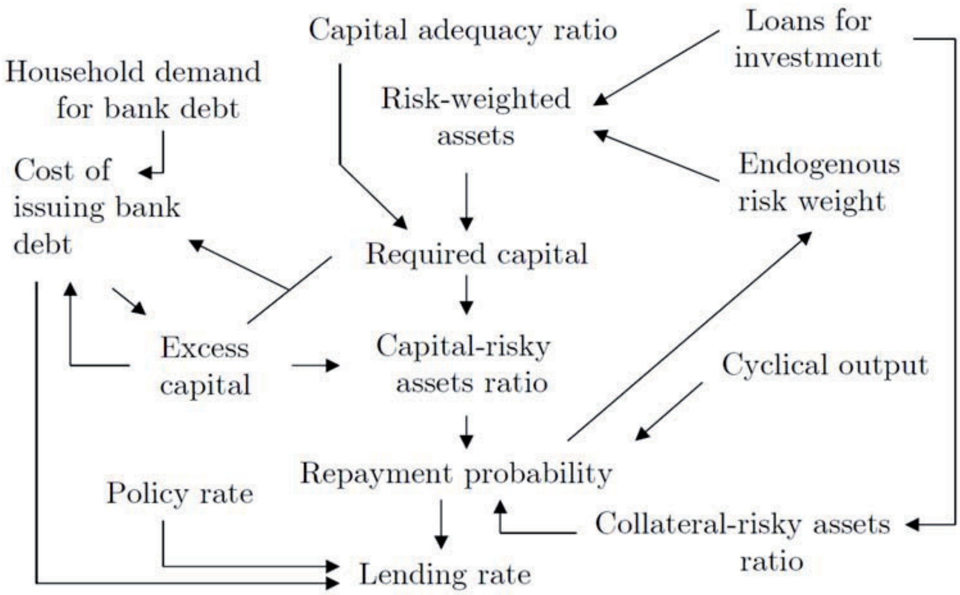
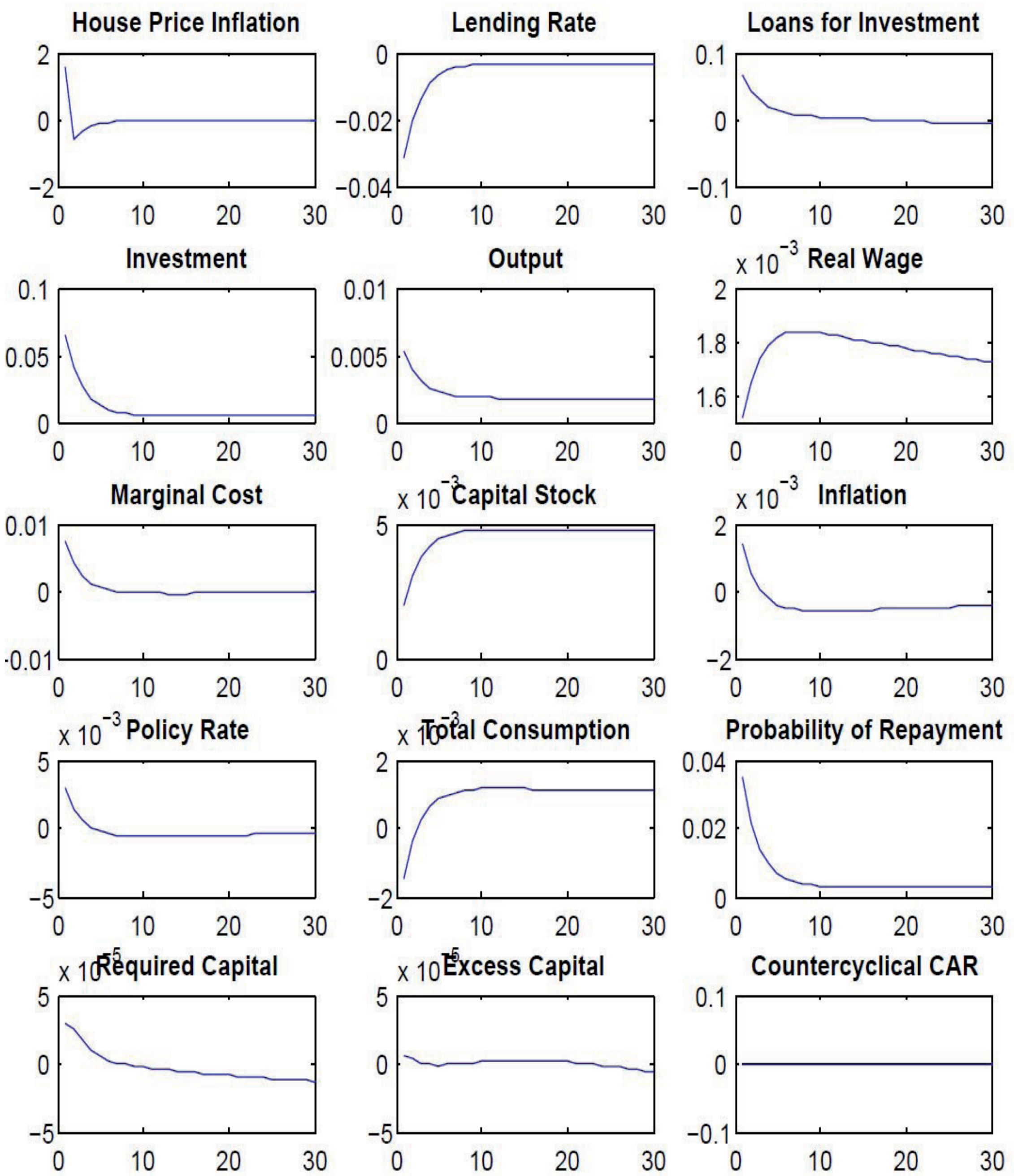


Figure 3
Base Experiment: Positive Housing Demand Shock
(Deviations from Steady State)

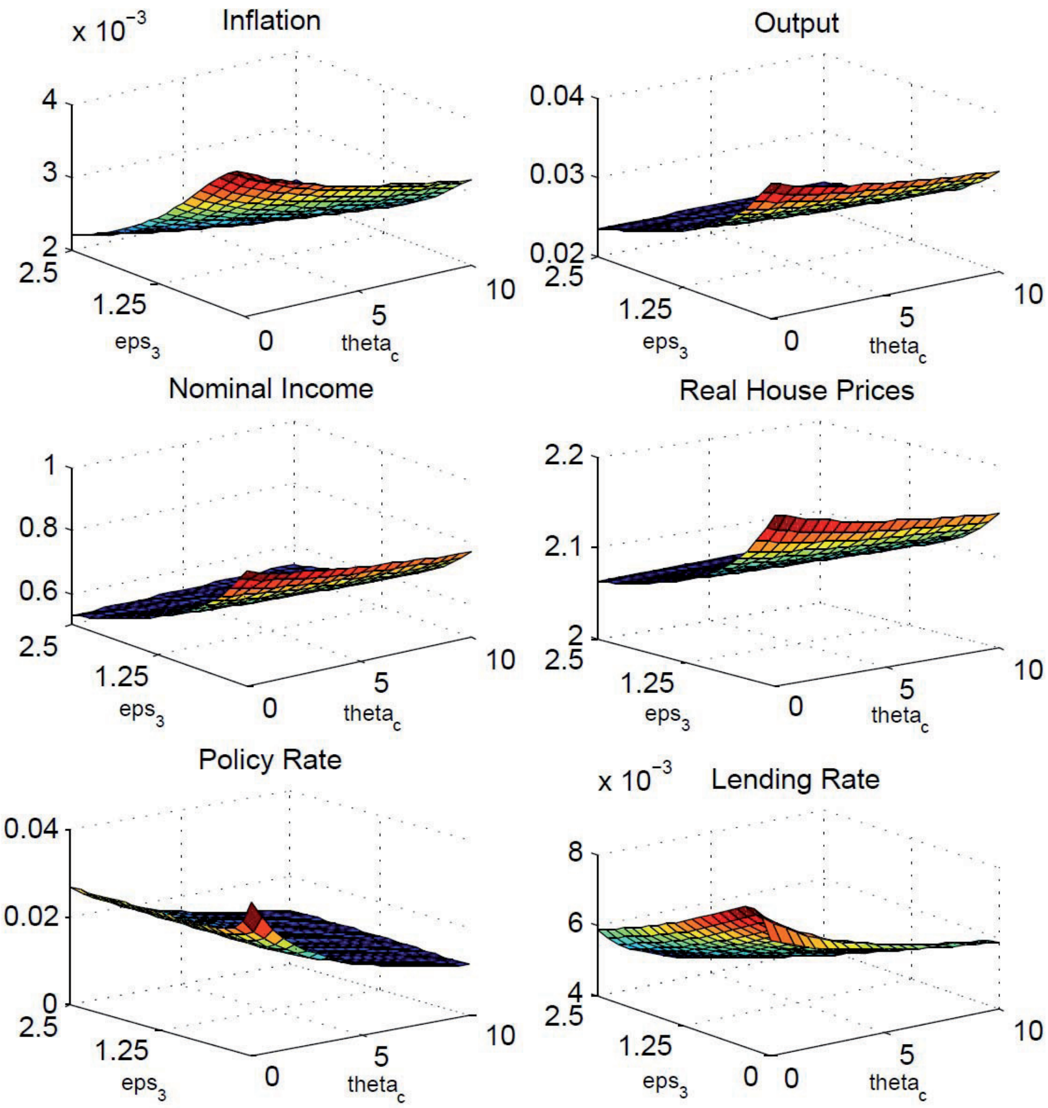


Note: Interest rates, inflation rate and the repayment probability are measured in absolute deviations, that is, in the relevant graphs a value of 0.05 for these variables corresponds to a 5 percentage point deviation in absolute terms.

Figure 4
Credit-Based Interest Rate and Regulatory Capital Rules:
Impact on Macro Stability and Financial Stability
(Housing Demand Shock)

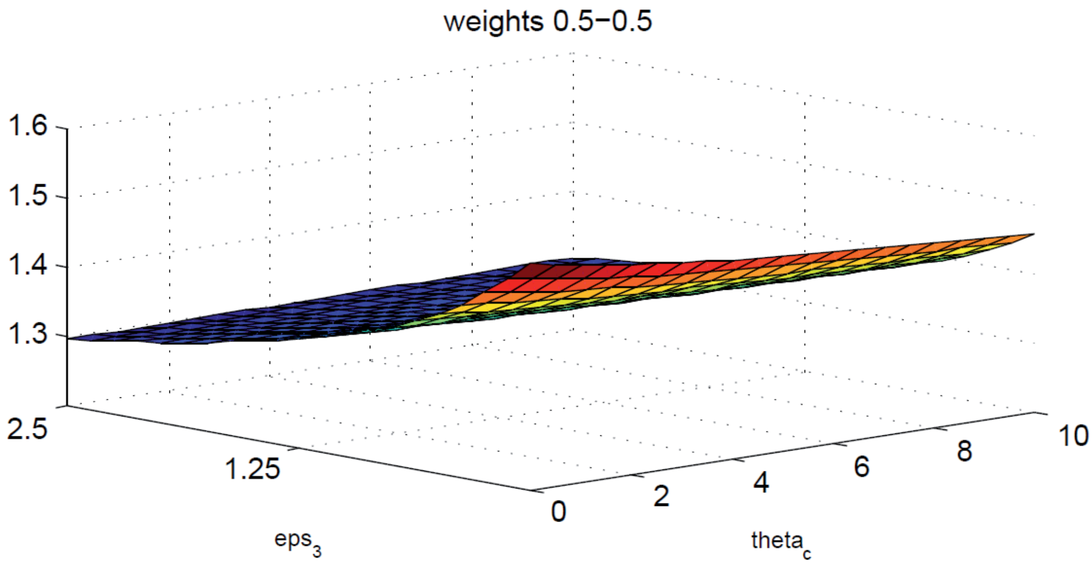
Note: On the horizontal axis are the coefficients of credit growth in the relevant policy rule (interest rate rule in the upper two graphs, regulatory capital rule in the lower two graphs), ε_3 and θ^C (see equations (61) and (63)), whereas on the vertical axis is the coefficient of variation of the relevant variable.

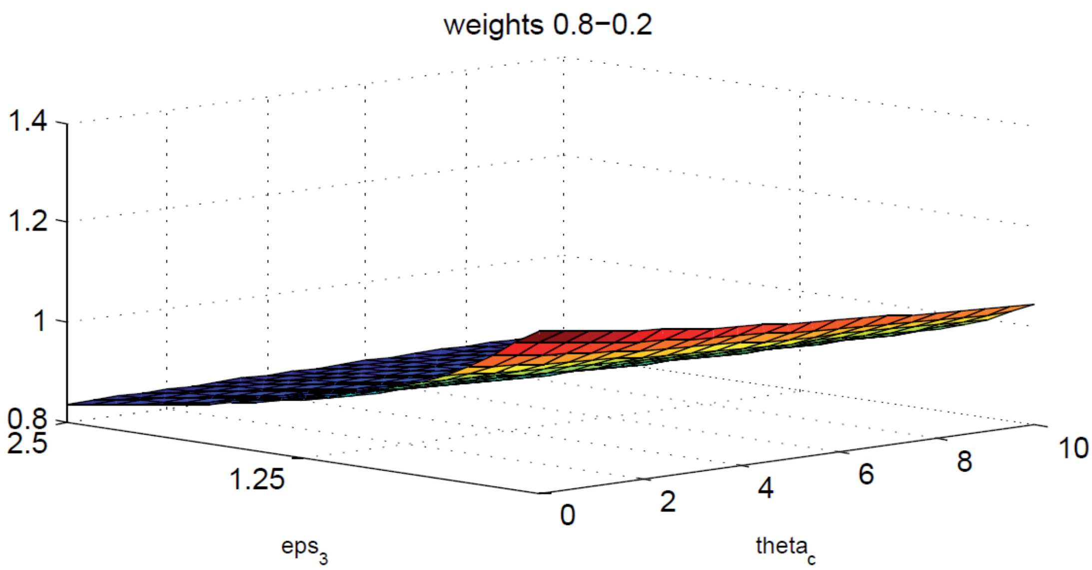
Figure 5
Housing Demand Shock: Policy Rules
and Macroeconomic-Financial Stability Trade-offs



Note: On the horizontal axes are the coefficients of credit growth in the relevant policy rule (interest rate rule on the Northwest axis, regulatory capital rule on the Northeast axis), whereas on the vertical axis is the coefficient of variation of the relevant variable. For interest rates, the volatility of the *change* in the variable is reported.

Figure 6
Housing Demand Shock: Policy Rules and Composite Index of Economic Stability





Note: See note to Figure 5.

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