Banking competition, collateral constraints and optimal monetary policy*

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Abstract

We analyze optimal monetary policy in a model with two distinct financial frictions: monopolistically competitive banks that charge endogenous lending spreads, and collateral constraints. We show that welfare maximization is equivalent to stabilization of four goals: inflation, output gap, the 'consumption gap' between borrowers and savers, and a 'housing gap' that measures the distortion in the distribution of the collateralizable asset between both groups. Collateral constraints create a trade-off between

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stabilization goals. Following both productivity and financial shocks, and relative to strict inflation targeting, the optimal policy implies sharper movements in the policy rate, aimed primarily at reducing fluctuations in asset prices and hence in borrowers' net worth. The policy trade-offs become amplified as banking competition increases, due to the fall in lending spreads and the resulting increase in borrowers' leverage.

Keywords: banking competition, lending spreads, collateral constraints, monetary policy, linear-quadratic method

JEL codes: E32, E52, G10, G21

1 INTRODUCTION

Both optimal monetary policy and the macroeconomic effects of financial frictions have attracted much attention in recent times. An increasing amount of research effort is being devoted to exploring the connections between both fields in the context of modern dynamic stochastic general equilibrium (DSGE) models. In this vein, this paper analyzes optimal monetary policy in a model economy featuring two distinct financial frictions. First, credit flows are intermediated by a banking sector characterized by monopolistic competition, which gives rise to endogenous interest rate spreads. Second, borrowers are subject to collateral constraints.

As regards the former, a vast empirical literature has documented both the existence of imperfect competition in the banking sector and its impact on the cost and quantity of bank lending, in the US and other industrialized economies.[1] In particular, market power has been found to be one of the major determinants of the spread between lending rates and deposit rates.[2] Regarding collateral constraints, the strand of literature following Kiyotaki and Moore (1997) has stressed the importance of the link between the value of borrowers' collateral and their access to funds in amplifying the economy's response to shocks (e.g. Iacoviello, 2005).

The purpose of this paper is to help us understand the implications of imperfect banking competition and collateral constraints in bank lending for the optimal conduct of monetary policy. Specifically, we consider an economy populated by households and entrepreneurs, where the former are relatively more patient and therefore act as savers. We assume that savers do not lend directly to borrowers and, instead, they provide banks with deposits that are then used to make loans to entrepreneurs. Banks are assumed to have some monopolistic power in the loans market that allows them to charge a positive lending spread on the

[1] See e.g. Barth, Caprio and Levine (2003), Strahan (2003), Claessens and Laeven (2004, 2005), Claessens (2009) and Dick and Lehnert (2010).

[2] See e.g. Saunders and Schumacher (2000) and Dick and Lehnert (2010) for the US, and Guiso, Sapienza and Zingales (2007) and Maudos and Fernández de Guevara (2004) for some European countries.

deposit rate. In particular, following Andrés and Arce (2012), we assume that a fixed number of identical banks compete to attract investors as in the spatial competition model of Salop (1979).[3] A fixed stock of real estate is traded between households, who use it for residential purposes, and entrepreneurs, who use it as a productive input. Entrepreneurs face constraints that limit their borrowing capacity to a fraction (the 'pledgeability ratio') of the expected resale value of their commercial real estate. In equilibrium, lending spreads depend negatively on the expected evolution of real estate prices, the pledgeability ratio and the degree of banking competition. Finally, our economy features two familiar nominal frictions: nominal (non-state-contingent) debt and staggered nominal price adjustment à la Calvo (1983).

Our main objective is to understand the nature of the optimal monetary policy in this framework. With this aim we follow the welfare-based linear-quadratic approach pioneered by Rotemberg and Woodford (1997).[4] We show that the central bank's quadratic welfare criterion features four stabilization goals: inflation, the output gap, the difference in consumption between borrowers and savers (or *consumption gap*) and the difference between residential property and its efficient level (or *housing gap*). The first two, inflation and the output gap, are related to the existence of staggered price adjustment and are therefore standard in the New Keynesian literature. The last two are novel and are directly related to the existence of collateral constraints. Regarding the consumption gap, collateral constraints prevent borrowers from smoothing their consumption the way savers do. In particular, entrepreneurs' consumption is shown to be proportional to their net worth, which in turn is fairly sensitive to real estate prices. This gives rise to inefficient risk sharing between both consumer groups. Regarding the housing gap, the distribution of real estate between both groups is generally inefficient, because entrepreneurs' demand for real estate is distorted by

[3]Salop's circular-city model is a workhorse framework in the microeconomic banking literature. See for instance Chiappori et al (1995), Freixas and Rochet (1997), Dell'Ariccia (2001) and Repullo (2004).

[4]See Woodford (2003), and Benigno and Woodford (2003, 2012) for extensive applications of the linear-quadratic approach to the study of optimal monetary policy. As in Rotemberg and Woodford (1997), we assume that in the steady state the welfare-relevant variables are at their efficient levels.

its role as a collateralizable asset.

The existence of binding collateral constraints makes it unfeasible for the central bank to stabilize all four goals simultaneously. Once the equilibrium conditions are linearized, the consumption gap arises as a cost-push term in the New Keynesian Phillips curve, thus creating an endogenous trade-off between inflation and output gap. We also show that the central bank can reduce fluctuations in the consumption gap by allowing for unanticipated changes in inflation (which affect real debt repayments through the usual debt-deflation mechanism) and for changes in the output gap (which affects entrepreneurs' profits).

In order to illustrate the optimal monetary policy, we calibrate our model economy and simulate the effects of a fall in TFP, as an example of non-financial shock, and a fall in the pledgeability ratio, as an example of financial shock. The latter represents a tightening of borrowing constraints, and can be thus interpreted as a 'credit crunch'. In both cases, and relative to a benchmark of strict inflation targeting,[5] we find that the optimal policy engineers a sharper cut in the policy rate. This buffers the fall in demand for commercial real estate (hence narrowing the housing gap) and in real estate prices. Both effects in turn limit the fall in entrepreneur net worth, which narrows the consumption gap. The optimal policy also allows for an unanticipated increase in inflation upon impact and a transitory increase in the output gap, both of which further help stabilize entrepreneurial net worth. Intuitively, by reacting rapidly and aggressively under the optimal rule, the central bank tries to avoid a large initial fall in entrepreneurs' net wealth, the effects of which are very persistent due to the presence of borrowing constraints.

As to the endogenous reaction of the lending spreads, the latter turns out to be relatively small following a productivity shock, due to mutually counteracting movements in the policy rate and asset prices. A credit-crunch, on the other hand, triggers a non-negligible countercyclical increase in spreads that hampers stabilization policy.

In addition to cyclical fluctuations in the spreads, changes in their *average* level may

[5]Strict inflation targeting is the optimal monetary policy in the standard New Keynesian framework in the absence of exogenous cost-push shocks and steady state distortions.

also have important effects on the economy's behavior. In particular, we are interested in understanding how the degree of banking competition affects the severity of the trade-offs just discussed. Indeed, the literature has documented an increase in banking competition in the US and in Europe in the last few decades,[6] which naturally raises the question as to how this may have affected the effectiveness of monetary policy. With this goal in mind, we consider a counter-factual scenario in which the banking sector becomes perfectly competitive. We find that welfare losses due to fluctuations around the steady state are *higher* with perfect banking competition, both under the optimal commitment and, especially, under suboptimal policy rules such as strict inflation targeting. The reason is that, as lending spreads fall, credit becomes cheaper and entrepreneurs become more leveraged. This makes their net worth more sensitive to fluctuations in real estate prices, which in turn amplifies fluctuations in the consumption and housing gaps. The previous mechanism operates regardless of the nature of shocks. However, in the case of financial shocks it is counteracted by an opposing force. When banks have market power, exogenous variations in the pledgeability ratio have a direct countercyclical effect on lending margins. Under perfect competition, lending margins become zero, and thus the amplifying effect of their counter-cyclical response disappears.

Finally, we look for a simple targeting rule that approximates well the optimal policy. We first note that in our model real estate prices have an important effect on the transmission of shocks. On the one hand, entrepreneurs' expenditure decisions are very sensitive to current real estate prices due to their effect on their net worth. On the other hand, expected changes in real estate prices are a key determinant of equilibrium lending margins. These observations suggest considering simple rules that capture the central bank's concern for stabilizing the actual and expected evolution of asset prices, together with the usual concern for inflation stabilization. In this vein, we find that a simple rule that relates current inflation negatively with current and expected changes in real estate prices performs well in the face of both financial and non-financial shocks. This suggests that, to the extent that fluctuations in

[6] See e.g. Dick and Lehnert (2010) and Guiso, Sapienza and Zingales (2007).

the price of collateralizable assets cause large distortions in the consumption and investment decisions of financially constrained agents, then the monetary authority has a rationale for taking into account such asset price fluctuations in its policy decisions.

Our paper is related to several strands of the theoretical literature on financial frictions and the macroeconomy. Starting with the hypothesis of imperfect banking competition, Hülsewig et al. (2009) and Gerali et al. (2010) also feature economies with an imperfectly competitive banking sector in a New Keynesian setup. In these studies, banks compete à la Dixit-Stiglitz (implying constant interest-rate elasticity of loan demand) and nominal interest rates adjust in a staggered fashion. We depart from the assumption of interest rate stickiness and allow for fully flexible rates. We also consider a context in which the demand for loans exhibits an endogenously-varying interest rate elasticity, as in Andrés and Arce (2012).[7] This latter feature implies that lending margins also vary endogenously. This modelling choice allows us to analyze the potential interactions between lending margins and other macroeconomic variables in the model, including real estate prices, pledgeability ratios and policy interest rates. These links are an important channel through which bank competition affects the economy's reaction to different shocks and the optimal monetary policy response.

Our analysis is also linked to Cúrdia and Woodford (2009; CW, for short). These authors study the design of linear-quadratic optimal monetary policy in a New Keynesian model in which a positive spread between lending and deposit rates arises due to a costly intermediation technology.[8] We differ from CW in two important respects regarding the nature of credit frictions. First, we model credit spreads as arising endogenously in an environment in which banks enjoy some monopolistic power in the loans market. Second, we subject borrowers to collateral constraints. The combination of both frictions implies that equilibrium

[7] Also within the New Keynesian paradigm, Kimball (1995) and Levin et al. (2007) motivate demand functions with varying price-elasticity on the basis of quasi-kinked demand curves. Although the underlying mechanism that gives rise to varying interest-rate elasticity in our framework differs significantly, we also find that this feature is a relevant determinant of aggregate fluctuations and optimal monetary policy.

[8] See also Cúrdia and Woodford (2010) for a related analysis.

lending margins depend on key determinants of loan demand, such as borrowers' ability to pledge collateral and the expected evolution of asset prices. CW find that the presence of credit fictions does not make a significant difference for the design of optimal monetary policy relative to the standard New Keynesian framework. By comparison, the optimal policy in our model features sizable deviations from strict inflation targeting. Key to this different finding is the presence of collateral constraints. The latter give rise to the risk-sharing considerations discussed above; the sharp movements in the policy rate aimed at improving such risk-sharing lead to relatively large fluctuations in the output gap and inflation. As in CW, we find that endogenous fluctuations in the spread exert a rather small influence on monetary policy design. However, in our framework the interaction between imperfect banking competition and collateral constraints opens an additional channel through which lending spreads affect monetary policy. As explained before, a reduction in average spreads due to stronger competition worsens the policy trade-offs through a leveraged-based amplification effect.

Also related is the work of Carlstrom, Fuerst and Paustian (2010), who study the linear-quadratic optimal monetary policy in a simple framework in which risk-neutral entrepreneurs must commit some collateral in order to produce. In their framework, the multiplier that captures the tightness of the collateral constraint plays a similar role to that of the consumption gap in our framework: a stabilization goal, and an endogenous output-inflation trade-off. However, entrepreneurs do not consume in equilibrium, such that consumption risk sharing does not play a role in their analysis. This leads to different quantitative policy implications. Whereas the optimal policy remains close to strict inflation targeting in Carlstrom et al. (2010), inflation displays relatively large fluctuations under the optimal rule in our model.

Monacelli (2007) analyzes the nonlinear Ramsey optimal monetary policy problem in a model with collateral constraints and quadratic price adjustment costs. In contrast, we follow the linear-quadratic approach to monetary policy analysis, which allows us to obtain intuitive expressions for the central bank's stabilization goals and trade-offs. De Fiore, Teles and Tristani (2011) explore optimal monetary rules in a model where firms' assets and liabilities are denominated in nominal terms and predetermined. Our model also incorporates predetermined nominal debt. However, our focus is rather on the consequences of other types of frictions, especially collateral constraints and endogenous lending spreads, for the optimal conduct of monetary policy. Finally, De Fiore and Tristani (2009) explore optimal monetary policy in an environment where lending spreads are the result of costly state verification problems, as in the financial accelerator theory in Bernanke and Gertler (1989). In all these studies, financial intermediaries are either abstracted from or introduced in such a way that they are not a source of additional frictions in the transmission mechanism.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 analyzes the efficient equilibrium, which provides a helpful normative benchmark. In section 4, we derive the central bank's quadratic welfare criterion and discuss some of the trade-offs among stabilization goals. In section 5 we calibrate our model and perform a number of quantitative exercises, in order to illustrate the workings of optimal and suboptimal monetary rules. Section 6 concludes.

2 MODEL

In this section we describe a model economy that relies on Iacoviello (2005) and Andrés and Arce (2012). The population of consumers, whose size is normalized to 1, is composed of two types of agents: there is a fraction ω of infinitely-lived households and a fraction $1-\omega$ of entrepreneurs. For the latter, we adopt a variant of the Blanchard-Yaari model of overlapping generations. In particular, entrepreneurs face a probability δ of dying at the end of each period. When an entrepreneur dies, she is replaced at the beginning of the following period by a newly-born entrepreneur who assumes the technology, assets and liabilities of the gone one. A positive death probability makes entrepreneurs relatively more impatient when discounting future utility flows than households. This gives rise to equilibrium credit flows from households to entrepreneurs. Such credit flows are intermediated by monopolistically competitive banks. A sector of monopolistic final goods producers transforms the homogenous intermediate good produced by the entrepreneurs into differentiated final goods, which are then sold to consumers. We now analyze the problem of each type of agent.

2.1 Households

The representative household maximizes the following welfare criterion,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\log c_t - \frac{(l_t^s)^{1+\varphi}}{1+\varphi} + \vartheta_t \log h_t \right),$$

where c_t are units of a Dixit-Stiglitz basket of final consumption goods, l_t^s is labor supply, h_t are units of housing, ϑ_t is an exogenously time-varying weight on utility from housing services, and $\beta \in (0,1)$ is the household's subjective discount factor. Maximization is subject to the following budget constraint expressed in real terms,

$$w_t l_t^s + \frac{\Omega_t^b + \Omega_t^f}{\omega P_t} + \frac{s_t}{\omega} + \frac{R_{t-1}^D}{\pi_t} d_{t-1} = c_t + p_t^h \left[\left(1+\tau^h\right) h_t - h_{t-1} \right] + d_t,$$

where w_t is the hourly wage, Ω_t^b and Ω_t^f are lump-sum aggregate nominal profits from the banking and final goods sectors, respectively, and s_t are real lump-sum aggregate subsidies from the government. We assume that nominal, risk-free, one-period bank deposits are the only financial asset available to households, where d_t is the real value of deposits at the end of period t, R_t^D is the gross nominal deposit rate and $\pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate, where P_t is the Dixit-Stiglitz aggregate price index. Households can also buy and sell real estate at a unit price p_t^h (measured in terms of consumption goods). End-of-period housing wealth is taxed at the rate τ^h (the role of which is discussed later on). We assume that real estate does not depreciate. The first order conditions of this problem can be expressed as

$$w_t = c_t \left(l_t^s\right)^{\varphi}, \tag{1}$$

$$\frac{1}{c_t} = \beta R_t^D E_t \left\{ \frac{1}{c_{t+1}} \frac{P_t}{P_{t+1}} \right\}, \tag{2}$$

$$\frac{\left(1+\tau^h\right) p_t^h}{c_t} = \frac{\vartheta_t}{h_t} + \beta E_t \frac{p_{t+1}^h}{c_{t+1}}. \tag{3}$$

2.2 Entrepreneurs (intermediate good producers)

Entrepreneurs produce a homogenous intermediate good that is sold under perfect competition to a final goods sector. They operate a Cobb-Douglas production technology,

$$y_t = e^{a_t} \left(l_t^d\right)^{1-\nu} \left(h_{t-1}^e\right)^{\nu}, \tag{4}$$

where y_t is output of the intermediate good, l_t^d is labor demand, h_{t-1}^e is the stock of commercial real estate, and $a_t = \rho_a a_{t-1} + \varepsilon_t^a$ is an exogenous (log)TFP process, with $\varepsilon_t^a \sim iid(0, \sigma_a)$. Entrepreneurs also demand consumption goods and loans. The budget constraint of the representative entrepreneur is given by

$$b_t + (1-\tau^e)\left(p_t^I y_t - w_t l_t^d\right) = c_t^e + p_t^h (h_t^e - h_{t-1}^e) + \frac{R_{t-1}^L}{\pi_t} b_{t-1}, \tag{5}$$

where b_t is the real value of one-period nominal loans at the end of period t, R_t^L is the gross nominal loan rate, p_t^I is the real price of the intermediate good, τ^e is a tax rate on entrepreneur profits (the role of which is explained below) and c_t^e is entrepreneur consumption.

Banks impose a collateral constraint on entrepreneurs: the nominal loan gross of interest payments cannot exceed a certain fraction (the *pledgeability ratio*) of the expected nominal resale value of the entrepreneur's real estate holdings. The collateral constraint can be expressed in real terms as,

$$b_t \leq m_t E_t \frac{\pi_{t+1}}{R_t^L} p_{t+1}^h h_t^e, \tag{6}$$

where $m_t = m \exp(z_t^m)$ is the exogenously time-varying pledgeability ratio, and $z_t^m = \rho_m z_{t-1}^m + \varepsilon_t^m$, $\varepsilon_t^m \sim iid(0, \sigma_m)$.

In the spirit of Salop's (1979) model of spatial competition, we assume that entrepreneurs and banks are uniformly distributed on a circle of length one. In order to obtain a loan, an entrepreneur located at point $k \in (0,1]$ must travel to a bank, incurring a utility cost $\alpha d_t^{k,i}$, where $d_t^{k,i}$ is the distance between the entrepreneur's location and the chosen bank (denoted by i).[9]

As explained before, entrepreneurs face a constant probability δ of dying at the end of each period, as in the Blanchard-Yaari model of overlapping generations. An entrepreneur thus maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t (1-\delta)^t (\log c_t^e - \alpha d_t^{k,i}),$$

subject to (4), (5) and (6). The first order conditions of this problem are

$$w_t = p_t^I (1-\nu) \frac{y_t}{l_t^d}, \tag{7}$$

$$\frac{1}{c_t^e} = \beta^e R_t^L E_t \left\{ \frac{1}{c_{t+1}^e} \frac{P_t}{P_{t+1}} \right\} + \xi_t, \tag{8}$$

$$\frac{p_t^h}{c_t^e} = E_t \frac{\beta^e}{c_{t+1}^e} \left\{ (1-\tau^e) p_{t+1}^I \nu \frac{y_{t+1}}{h_t^e} + p_{t+1}^h \right\} + \xi_t m_t E_t \frac{\pi_{t+1}}{R_t^L} p_{t+1}^h, \tag{9}$$

where $\beta^e \equiv \beta(1-\delta)$ is the entrepreneur's discount factor adjusted for the survival probability, ξ_t is the Lagrange multiplier on the collateral constraint and $p_t^I \nu y_t / h_{t-1}^e$ is the marginal revenue product of commercial real estate.[10] When binding ($\xi_t > 0$), the collateral constraint

[9] This simple device is meant to motivate the existence of some monopoly power on the part of banks. See Andrés and Arce (2012) for a discussion on the foundations of this assumption.

[10] The entrepreneur's problem also involves an optimal choice of lending bank, i. This choice is discussed in detail in Andrés and Arce (2012). More relevant for our purpose are the implications of that choice for equilibrium lending spread, which is discussed in section 2.3.

has two effects on the entrepreneur's decisions. First, it prevents them from smoothing their consumption the way households do (equation 8). Second, it increases the marginal value of real estate due to its role as collateral (equation 9), thus distorting entrepreneurs' demand for commercial property relative to a frictionless environment.[11]

Equations (8) and (2) imply that in the steady state the borrowing constraint is binding ($\xi_{ss} > 0$, where the ss subscript denotes steady state values) if and only if $\beta R^D_{ss} > \beta^e R^L_{ss}$, which holds under our subsequent calibration. Provided that the fluctuations in the relevant variables around their steady state are sufficiently small, the borrowing constraint will also bind along the dynamics; that is, equation (6) will hold with equality.[12] In that case, it is possible to show that entrepreneur consumption equals[13]

$$c^e_t = (1 - \beta^e) \left[(1 - \tau^e) \nu p^I_t y_t + p^h_t h^e_{t-1} - \frac{R^L_{t-1}}{\pi_t} b_{t-1} \right]. \tag{10}$$

That is, the entrepreneur always consumes a fraction $1 - \beta^e$ of her real *net worth*, which is the sum of after-tax real profits, $(1 - \tau^e) \nu p^I_t y_t$, and commercial real estate wealth, $p^h_t h^e_{t-1}$, minus real debt repayments, $R^L_{t-1} b_{t-1} / \pi_t$.

2.3 Banks

Banks are assumed to intermediate all credit flows between households (savers) and entrepreneurs (borrowers). We assume that banks are perfectly competitive on the deposits market, and so they take as given the nominal deposit rate, R^D_t, which is set by the central bank. However, competition in the loans market is imperfect, so that each bank enjoys some monopolistic power. In order to model imperfect competition in the loans market we use a version of Salop's (1979) circular-city model. A discrete number n of banks are located symmetri-

[11] The entrepreneur's decisions are also distorted by the existence of a positive lending spread. Indeed, as we show later on, in equilibrium we have $R^L_t > R^D_t$.

[12] Simulations available upon request show that the collateral constraint binds at all times in all our subsequent numerical simulations.

[13] See the proof in Appendix A.1.

cally on the unit circle and their position is time-invariant, whereas entrepreneurs' locations vary each period according to an *iid* stochastic process.[14] Bank $i \in \{1, 2, ..., n\}$ chooses the gross nominal interest rate on its loans, $R_t^L(i)$, to maximize

$$E_t \sum_{s=0}^{\infty} \beta^s \frac{c_t}{c_{t+s}} \frac{\Omega_{t+s}(i)}{P_{t+s}}$$

where $\beta^s c_t/c_{t+s}$ is the time $t+s$ stochastic discount factor of the households (who are assumed to own the banks) and $\Omega_{t+s}(i)$ is the bank's nominal profit flow. Denoting by $B_t(i)$ and $D_t(i)$ the nominal stock of loans and deposits of bank i at the end of time t, respectively, we can write its flow of funds constraint as

$$\Omega_t(i) + B_t(i) + R_{t-1}^D D_{t-1}(i) = R_{t-1}^L(i) B_{t-1}(i) + D_t(i).$$

Further, bank i must also obey the balance-sheet identity, $D_t(i) = B_t(i)$. This implies that period t nominal profits are simply $\Omega_t(i) = \left(R_{t-1}^L(i) - R_{t-1}^D\right) B_{t-1}(i)$. To solve for the bank's optimal loan rate, it is convenient to express its loan volume in real terms as

$$\frac{B_t(i)}{P_t} = b_t(i)\tilde{b}_t(i),$$

where $b_t(i)$ is the *intensive* business margin (the size of each loan) and $\tilde{b}_t(i)$ is the *extensive* business margin (the number of customers, or market share).[15] The first order condition of this problem can be written as

$$R_t^L(i) = R_t^D + \frac{1}{\Lambda_t(i) + \tilde{\Lambda}_t(i)}, \tag{11}$$

where $\Lambda_t(i) \equiv \left[-\partial b_t(i)/\partial R_t^L(i)\right]/b_t(i)$ and $\tilde{\Lambda}_t(i) \equiv [-\partial \tilde{b}_t(i)/\partial R_t^L(i)]/\tilde{b}_t(i)$ are the semi-elasticities of the intensive and the extensive business margins, respectively. Thus the spread

[14] This last assumption removes the possibility that banks exploit strategically the knowledge about the current position of each entrepreneur to charge higher rates in the future.

[15] See Andrés and Arce (2012) for analytical derivations of both business margins.

between the lending and the deposit rate is a positive function of the bank's market power, as measured by the inverse of the sum of semi-elasticities of individual loan size and market share.

As shown in Andrés and Arce (2012), in a symmetric equilibrium (i.e. $R_t^L(i) = R_t^L \; \forall i$), the optimal nominal loan rate can be expressed as

$$R_t^L = R_t^D + \frac{R_t^D - m_t E_t\left(\pi_{t+1} p_{t+1}^h / p_t^h\right)}{\eta m_t E_t\left(\pi_{t+1} p_{t+1}^h / p_t^h\right) - R_t^D} R_t^D, \tag{12}$$

where

$$\eta \equiv 1 + \frac{n}{\alpha} \frac{\beta^e}{1 - \beta^e}.$$

Therefore, the lending spread is decreasing in the pledgeability ratio, m_t, the expected growth in nominal real-estate prices, $E_t\left(\pi_{t+1} p_{t+1}^h / p_t^h\right)$, and the degree of banking competition, as captured by the ratio n/α; and it is increasing in the nominal deposit rate, R_t^D. The intuition for these effects is the following. A rise in the pledgeability ratio or in expected asset price inflation increases entrepreneurs' borrowing capacity, according to equation (6) (holding with equality); similarly, a fall in the deposit rate leads *ceteris paribus* to a fall in the loan rate, which also increases borrowing. As their indebtedness rises, entrepreneurs' demand for loans becomes more elastic, which reduces banks' market power and compresses lending spreads. Similarly, as entrepreneurs become more indebted, the utility cost of servicing the debt becomes more important in the choice of bank relative to the distance utility cost. As a result, small changes in loan rates lead to large flows of customers in search for the lowest loan rate. This increases the elasticity of the extensive business margin and hence pushes lending spreads down. Finally, an increase in the degree of banking competition (i.e. a rise in n/α) compresses lending spreads through an increase in the elasticity of banks' market share with respect to the lending rate.

In the symmetric equilibrium, each bank has $\tilde{b}_t(i) = (1-\omega)/n$ customers and each loan equals $b_t(i) = b_t$ in real terms, for all $i \in \{1, 2, ..., n\}$. Therefore, aggregate real profits in the banking sector equal $\Omega_t^b/P_t = (1-\omega)\left(R_{t-1}^L - R_{t-1}^D\right) b_{t-1}/\pi_t$.

2.4 Final goods producers

There exist a measure-one continuum of firms that purchase the intermediate good from entrepreneurs and transform it one-for-one into differentiated final good varieties. For these firms, the real price of the intermediate good, p_t^I, represents the real marginal cost. Cost minimization by consumers implies that each final good producer $j \in [0,1]$ faces the following demand curve for its product variety,

$$y_t^f(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} y_t^f, \tag{13}$$

where $P_t(j)$ is the firm's nominal price, $\varepsilon > 1$ is the elasticity of substitution between final good varieties and

$$y_t^f = \omega c_t + (1-\omega) c_t^e \tag{14}$$

is the aggregate demand for final goods. As is standard in the New Keynesian literature, we assume staggered nominal price adjustment à la Calvo (1983). Letting θ denote the constant probability of non-adjustment, the optimal price decision of price-setting firms is given by

$$E_t \sum_{s=0}^{\infty} (\beta\theta)^s \frac{c_t}{c_{t+s}} \left\{ (1+\tau) \frac{\tilde{P}_t}{P_{t+s}} - \frac{\varepsilon}{\varepsilon - 1} p_{t+s}^I \right\} P_{t+s}^{\varepsilon} y_{t+s}^f = 0, \tag{15}$$

where $\tau > 0$ is a subsidy rate on the revenue of final goods producers (the role of which is explained below) and $\tilde{P}_t$ is the optimal price decision. Under Calvo price adjustment, the aggregate price index evolves as follows,

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta) \tilde{P}_t^{1-\varepsilon}\right]^{1/(1-\varepsilon)}. \tag{16}$$

Aggregate nominal profits in the final goods sector equal $\Omega_t^f = \int_0^1 \left[(1+\tau) P_t(j) - P_t p_t^I\right] y_t^f(j) dj$.

2.5 Market clearing

Total supply of the intermediate good equals $(1-\omega)\, y_t$. Total demand from final good producers equals $\int_0^1 y_t^f(j)dj$, where each firm's demand is given by (13). Equilibrium in the intermediate good market therefore requires

$$(1-\omega)\, y_t = \Delta_t y_t^f, \tag{17}$$

where $\Delta_t \equiv \int_0^1 \left(P_t(j)/P_t\right)^{-\varepsilon} dj$ is a measure of price dispersion in final goods. Notice that price dispersion increases the amount of the intermediate good that must be produced in order to satisfy a certain level of final consumption demand.

Equilibrium in the real estate market requires

$$\bar{h} = \omega h_t + (1-\omega)\, h_t^e, \tag{18}$$

where $\bar{h}$ is the fixed aggregate stock of real estate. The labor market equilibrium condition is

$$\omega l_t^s = (1-\omega)\, l_t^d. \tag{19}$$

2.6 Fiscal and monetary authorities

The fiscal authority passively rebates its flow surplus to households in a lump-sum manner (if such surplus is negative, then it represents a lump-sum tax). Letting s_t denote the aggregate real fiscal surplus, the latter equals

$$s_t = \tau^h \omega p_t^h h_t + \tau^e (1-\omega) \left(p_t^I y_t - w_t l_t^d\right) - \tau \int_0^1 \frac{P_t(j)}{P_t} y_t^f(j)dj.$$

The model is closed by means of a monetary policy rule. The latter can be a simple rule, such as strict inflation targeting, or a policy that is optimal with respect to some criterion. Sections 4 and 5 below are devoted to characterizing different types of policy rules and their effects on equilibrium allocations.

3 EFFICIENT EQUILIBRIUM

In this section we analyze the efficient equilibrium in our model, which will prove to be a useful benchmark for understanding the optimal monetary policy problem. The social planner maximizes the expected welfare of all agents, including those entrepreneurs that will be born in future periods. In each period, the mass $(1-\omega)\,\delta$ of disappearing entrepreneurs is replaced by an equal mass of newly-born entrepreneurs who are identical to the surviving ones. In this setup, it can be shown that the sum of the expected welfare of entrepreneurs living today and of those to be born in future periods can be expressed as the expected welfare of an infinitely-lived representative entrepreneur, $E_0 \sum_{t=0}^{\infty} \beta^t \log(c_t^e)$, times the entrepreneur population, $1-\omega$.[16] Therefore, the social welfare criterion is given by[17]

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \omega \left[\log(c_t) - \frac{(l_t^s)^{1+\varphi}}{1+\varphi} + \vartheta_t \log(h_t) \right] + (1-\omega) \log(c_t^e) \right\}.$$

The social planner maximizes the above expression subject to the aggregate resource constraints for real estate, equation (18), and for consumption goods,

$$(1-\omega)\, e^{a_t} \left(h_{t-1}^e\right)^{\nu} \left(\frac{\omega}{1-\omega} l_t^s \right)^{1-\nu} = \omega c_t + (1-\omega)\, c_t^e, \tag{20}$$

where we have used equation (19) to substitute for l_t^d in the production function. Using equations (20) and (18) to solve for c_t and h_t, respectively, the social-planner problem simplifies to the choice of the optimal state-contingent path of c_t^e, h_t^e and l_t^s. The first-order

[16] The proof can be found in Appendix A.2.

[17] Notice that in the first best equilibrium the social planner allocates consumption and real estate directly to households and entrepreneurs, withouth the need of bank intermediation. Therefore, in the efficient equilibrium entrepreneurs do not incur any distance utility costs.

conditions of this problem can be expressed as

$$c_t = c_t^e, \tag{21}$$

$$\beta E_t \frac{1}{c_{t+1}} \nu \frac{e^{a_{t+1}} \left(h_t^e\right)^\nu \left[\omega l_{t+1}^s / \left(1-\omega\right)\right]^{1-\nu}}{h_t^e} = \frac{\vartheta_t}{h_t}, \tag{22}$$

$$c_t \left(l_t^s\right)^\varphi = \frac{1-\omega}{\omega} \left(1-\nu\right) \frac{y_t}{l_t^s}. \tag{23}$$

Notice that equations (20) and (21) jointly imply $c_t = \left(1-\omega\right) e^{a_t} \left(h_{t-1}^e\right)^\nu \left[\omega l_t^s / \left(1-\omega\right)\right]^{1-\nu}$. Using this in equation (22), we have that the efficient distribution of the stock of real estate is given by

$$\frac{h_t^e}{h_t} = \frac{\beta\nu}{\left(1-\omega\right)\vartheta_t}. \tag{24}$$

This, combined with equation (18), implies the following solution for aggregate housing,

$$\omega h_t = \frac{\omega\vartheta}{\omega\vartheta + \beta\nu} \bar{h}. \tag{25}$$

Using equations (20) and (21) in equation (23), we obtain the following solution for efficient labor supply,

$$l_t^s = \left(\frac{1-\nu}{\omega}\right)^{1/(1+\varphi)} \equiv l^{s,*}. \tag{26}$$

The efficient level of output is then given by

$$y_t = e^{a_t} \left(h_{t-1}^e\right)^\nu \left(\frac{\omega}{1-\omega} l^{s,*}\right)^{1-\nu} \equiv y_t^*. \tag{27}$$

To summarize, the efficient equilibrium is characterized by full consumption risk sharing between households and entrepreneurs (equation 21), a distribution of real estate that changes only with shocks to preferences for housing (equation 24) and a constant level of labor supply (equation 26).[18] These features will help us understand the stabilization goals and trade-offs

[18]The fact that neither labor hours nor the distribution of real estate are affected by productivity shocks in the efficient equilibrium is due to our assumption of logarithmic utility of consumption. Deviating from

of monetary policy. We turn to this now.

4 OPTIMAL MONETARY POLICY

In order to analyze optimal monetary policy, we follow the welfare-based *linear-quadratic* approach pioneered by Rotemberg and Woodford (1997). This method consists of deriving a log-quadratic approximation of aggregate welfare (which represents the objective function of the central bank) and a log-linear approximation of the equilibrium conditions (which are the constraints on the central bank's optimization problem). As is well known, this method is helpful at clarifying the stabilization goals faced by the central bank and the various trade-offs among those goals. Indeed, the application of this method in our setup delivers a set of analytical results that facilitate greatly the interpretation of the subsequent numerical results.

4.1 Quadratic loss function

As emphasized by Benigno and Woodford (2012), the approximation of the aggregate welfare criterion must be purely quadratic (i.e. contain quadratic terms only) in order for the linear-quadratic approach to provide a correct welfare ranking (with an accuracy of up to second order) of alternative monetary policy rules. Derivation of a purely quadratic approximation is greatly simplified by the assumption of an efficient steady state for the welfare-relevant variables. As shown in Appendix A.3, steady-state efficiency for such variables can be implemented in our framework by making the following three assumptions. First, the subsidy rate on the revenue of final goods producers is given by

$$\tau = \frac{\varepsilon}{\varepsilon - 1} - 1 > 0.$$

the latter assumption would complicate the algebra without adding much to our main insights about the nature of optimal monetary policy.

Second, the tax rate on entrepreneur profits is given by

$$\tau^e = 1 - \frac{1-\omega}{(1-\beta^e)\,\nu}\frac{1-\beta^e - m\left(1/R^L_{ss} - \beta^e\right)}{1 - m/R^L_{ss}}.$$

Third, the tax rate on housing wealth is given by

$$\tau^h = \frac{\beta}{\beta^e}\frac{1-\beta^e - m\left(1/R^L_{ss} - \beta^e\right)}{1-\tau^e} - 1 + \beta.$$

The first assumption eliminates the monopolistic distortion in final goods markets, such that steady-state real marginal costs are unity ($p^I_{ss} = 1$). The second assumption guarantees efficient risk-sharing between households and entrepreneurs in the steady state ($c_{ss} = c^e_{ss}$). The third one implements the efficient steady-state distribution of real estate between commercial and residential uses ($h^e_{ss}/h_{ss} = \beta\nu/\left[(1-\omega)\,\vartheta\right]$). Under these assumptions, aggregate welfare can be approximated by[19]

$$\sum_{t=0}^{\infty}\beta^t\left\{\omega\left[\log c_t + \vartheta_t \log h_t - \frac{(l^s_t)^{1+\varphi}}{1+\varphi}\right] + (1-\omega)\log c^e_t\right\} = -\sum_{t=0}^{\infty}\beta^t L_t + t.i.p. + O^3,$$

where $t.i.p.$ are terms independent of policy,[20] O^3 are terms of order third and higher, and

$$L_t = \lambda_\pi \hat{\pi}^2_t + \lambda_y\left(\hat{y}_t - \hat{y}^*_t\right)^2 + \lambda_c\left(\hat{c}_t - \hat{c}^e_t\right)^2 + \lambda_h\left(\hat{h}_t - \hat{h}^*_t\right)^2 \qquad (28)$$

is a purely quadratic period loss function, where hats denote log-deviations from steady state and weight coefficients are given by

$$\lambda_\pi \equiv \frac{\varepsilon\theta}{(1-\theta)(1-\beta\theta)}, \lambda_y \equiv \frac{1+\varphi}{1-\nu}, \lambda_c \equiv \omega(1-\omega), \lambda_h \equiv \omega\vartheta\frac{\omega\vartheta + \beta\nu}{\beta\nu}.$$

[19] See the proof in Appendix B.

[20] Notice that the symmetric behavior of banks in the decentralized economy implies that the aggregate disutility flow incurred by the entrepreneurs when travelling to the banks is constant over time, as each entrepreneur simply chooses the closest bank to her location. In particular, it can be showed that $\int_0^1 d^k_t dk = 1/(4n)$. Therefore, the aggregate entrepreneurial disutility cost is independent of monetary policy.

The loss function illustrates the existence of four stabilization goals for the central bank. The first one is inflation. As is well known, under staggered price adjustment inflation creates inefficient price dispersion and hence a welfare loss. The second goal is the output gap, which is the difference between the actual and the efficient level of output. The latter is defined as

$$\hat{y}_t^* \equiv a_t + \nu \hat{h}_{t-1}^e,$$

which is simply the log-linear version of equation (27). Nominal price rigidities produce inefficient fluctuations in output, which generates in turn inefficient fluctuations in labor hours. These first two goals are standard in the New Keynesian model.

The third and fourth goals are directly related to the existence of financial frictions in this model. The third goal is the (log)difference in per capita consumption between households and entrepreneurs, i.e. between unconstrained and constrained consumers, which we may refer to as the *consumption gap*. This term captures the aggregate welfare losses produced by inefficient risk sharing between households and entrepreneurs, which is in turn the result of collateral constraints on entrepreneurs. The fourth goal is the (log)difference between the actual and the efficient level of housing, or *housing gap*, where

$$\hat{h}_t^* \equiv \frac{\beta\nu}{\omega\vartheta + \beta\nu} z_t^h \tag{29}$$

is efficient housing (see equation 25). Notice that, given the fixed supply of real estate, an inefficient level of housing is equivalent to an inefficient distribution of real estate between residential and commercial uses. In our framework, the real estate distribution becomes inefficient in response to shocks because entrepreneurs' demand for commercial property is distorted by its role as collateral in loan agreements. In particular, shocks that lower the expected price of commercial property also reduce its marginal collateral value, thus leading entrepreneurs to hold inefficiently low amounts of real estate.

4.2 Policy trade-offs

The second step of the linear-quadratic approach consists of log-linearizing the equilibrium conditions around the steady state. For brevity, the complete list of log-linear equations is deferred to Appendix C.[21] Here, we restrict our attention to those equations that are helpful for understanding the trade-offs among stabilization goals. We start by log-linearizing and combining equations (15) and (16), which yields

$$\hat{\pi}_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{p}_t^I + \beta E_t \hat{\pi}_{t+1}. \tag{30}$$

In order to find an expression for the real marginal cost, $\hat{p}_t^I$, we first log-linearize equations (1), (7) and (19), and combine them to get

$$\hat{c}_t + \varphi \hat{l}_t^s = \hat{p}_t^I + \hat{y}_t - \hat{l}_t^s. \tag{31}$$

That is, the labor supply schedule (the marginal rate of substitution between consumption and leisure) must intersect the labor demand schedule (the marginal revenue product of labor). Second, we log-linearize the production function and solve for labor hours, obtaining

$$\hat{l}_t^s = \frac{1}{1-\nu}\left(\hat{y}_t - \hat{a}_t - \nu \hat{h}_{t-1}^e\right) = \frac{1}{1-\nu}\left(\hat{y}_t - \hat{y}_t^*\right), \tag{32}$$

where in the second equality we have used the definition of efficient output. Third, we log-linearize the equilibrium conditions in the final goods and intermediate good markets,

[21] Simulation results not reported here indicate that the Ramsey optimal long-run gross rate of inflation is $\pi_{ss} = 1$, regardless of whether the steady state is assumed to be efficient or not. Therefore, our log-linearization is performed around a zero net inflation steady state. The reason for this result is essentially the same as the reason why the optimal long-run net rate of inflation is zero in the standard New Keynesian model, namely that the welfare losses of committing to positive inflation rates in the future outweigh the welfare gains of exploiting the short-run output-inflation trade-off when output is inefficiently low (see e.g. Woodford, 2003, ch. 6).

equations (14) and (17) respectively, and combine them into

$$\hat{y}_t = \omega \hat{c}_t + (1 - \omega)\, \hat{c}_t^e, \tag{33}$$

where we have used the fact that $(1 - \omega)\, y_{ss} = c_{ss} = c_{ss}^e$ and that $\hat{\Delta}_t$ is actually a second-order term (see the appendix). Combining equations (31) to (33), we can express real marginal costs as

$$\hat{p}_t^I = \frac{1 + \varphi}{1 - \nu} (\hat{y}_t - \hat{y}_t^*) + (1 - \omega)(\hat{c}_t - \hat{c}_t^e). \tag{34}$$

Using this in equation (30) yields the following *New Keynesian Phillips curve*,

$$\hat{\pi}_t = \kappa \frac{1 + \varphi}{1 - \nu} (\hat{y}_t - \hat{y}_t^*) + \beta E_t \hat{\pi}_{t+1} + \kappa (1 - \omega)(\hat{c}_t - \hat{c}_t^e), \tag{35}$$

where $\kappa \equiv (1 - \theta)(1 - \beta\theta)/\theta$. Equation (35) has the same form as the standard New Keynesian Phillips curve, with the exception of the last term on the right hand side, which is proportional to the consumption gap. Therefore, collateral constraints and the resulting inefficient risk-sharing create an endogenous trade-off between the output gap and inflation.[22] The reason is the following. From equation (31), real marginal costs $\hat{p}_t^I$ depend on labor hours and the difference between aggregate demand and household consumption. Because of inefficient risk sharing, fluctuations in aggregate demand and household consumption will be unequal. As a result, keeping labor hours constant (that is, closing the output gap) is not enough to prevent fluctuations in real marginal costs and hence in inflation.

From the preceding analysis, it follows that closing the consumption gap has several beneficial effects on aggregate welfare. First, it improves the trade-off between inflation and output gap. Second, since the consumption gap is itself a stabilization goal, closing it directly improves welfare. An additional normative reason for closing the consumption gap is

[22] Carlstrom, Fuerst and Paustian (2010) obtain a similar New Keynesian Phillips curve in the context of a model with collateral-constrained entrepreneurs, with the Lagrange multiplier associated to the collateral constraint (instead of our consumption gap) acting as endogenous cost-push term.

that it reduces the distortionary effects of collateral constraints on entrepreneurs' stochastic discount factor and hence on their valuation of future income streams from commercial property. This makes the real estate distribution more efficient over the cycle and thus helps closing the housing gap.

While desirable, consumption gap stabilization requires itself inefficient fluctuations in other stabilization goals. To see this, consider the log-linear approximation of the expression for entrepreneur consumption (equation 10) around the efficient steady state,

$$\hat{c}_t^e = (1-\beta^e)\left[\frac{(1-\tau^e)\,\nu}{1-\omega}\left(\hat{p}_t^I + \hat{y}_t\right) + \frac{p_{ss}^h h_{ss}^e}{c_{ss}^e}\left(\hat{p}_t^h + \hat{h}_{t-1}^e\right) - \frac{b_{ss}R_{ss}^L}{c_{ss}^e}\left(\hat{R}_{t-1}^L + \hat{b}_{t-1} - \hat{\pi}_t\right)\right], \tag{36}$$

where both sides have been normalized by c_{ss}^e and the steady-state condition $c_{ss}^e/y_{ss} = 1-\omega$ has been used. The binding collateral constraint (equation 6 holding with equality) can be approximated by $\hat{R}_t^L + \hat{b}_t = z_t^m + E_t\hat{p}_{t+1}^h + \hat{h}_t^e + E_t\hat{\pi}_{t+1}$. Substituting this into equation (36), using $b_{ss}R_{ss}^L = mp_{ss}^h h_{ss}^e$, and rearranging terms, we obtain

$$\begin{aligned}\hat{c}_t^e \;=\;& (1-\beta^e)\frac{(1-\tau^e)\,\nu}{1-\omega}\left(\hat{p}_t^I + \hat{y}_t\right) \\ &+ (1-\beta^e)\frac{p_{ss}^h h_{ss}^e}{c_{ss}^e}\left[\left(\hat{p}_t^h - mE_{t-1}\hat{p}_t^h\right) + (1-m)\,\hat{h}_{t-1}^e + m\left(\hat{\pi}_t - E_{t-1}\hat{\pi}_t\right) - mz_{t-1}^m\right].\end{aligned} \tag{37}$$

Therefore, entrepreneur profits $(\hat{p}_t^I + \hat{y}_t)$, quasi-surprises in real estate prices $(\hat{p}_t^h - mE_{t-1}\hat{p}_t^h)$, the stock of commercial property $(\hat{h}_{t-1}^e)$ and inflation surprises $(\hat{\pi}_t - E_{t-1}\hat{\pi}_t)$ are the endogenous determinants of entrepreneur consumption. The latter will therefore differ from household consumption, which is driven exclusively by intertemporal substitution considerations. In response to unexpected shocks, it is however possible for the central bank to bring entrepreneur and household consumption closer to each other. First, the central bank can use its interest rate policy to indirectly affect the path of real estate wealth. Second, it can allow for unanticipated inflation so as to affect the real value of debt repayments. Third, notice that entrepreneur profits can be expressed in terms of stabilization goals as follows,

$$\hat{p}_t^I + \hat{y}_t = \left(\frac{1+\varphi}{1-\nu} + 1 \right) (\hat{y}_t - \hat{y}_t^*) + (1-\omega)(\hat{c}_t - \hat{c}_t^e) + \hat{y}_t^*,$$

where we have used equation (34) to substitute for $\hat{p}_t^I$. Therefore, the central bank can also affect the output-gap $(\hat{y}_t - \hat{y}_t^*)$ in order to narrow the consumption gap.

To summarize, optimal monetary policy will involve a trade-off between all four stabilization goals in response to macroeconomic shocks. We now turn to the quantitative analysis of these trade-offs.

5 QUANTITATIVE ANALYSIS

5.1 Calibration

We calibrate our model to quarterly US data. The household discount factor, $\beta = 0.993$, is chosen such that the annual real interest rate equals 3%. The entrepreneur discount factor is set to $\beta^e = 0.95$, within the range of values for constrained consumers typically used in the literature.[23] The elasticity of output with respect to commercial real estate, ν, and the weight on housing utility, ϑ, are set to generate steady-state ratios of commercial and residential property wealth over annual output of 62% and 140%, respectively, in line with the values used by Iacoviello (2005). Regarding the banking parameters, what matters for the steady-state level of lending spreads is the ratio n/α. We set that ratio at 1.58 to obtain a steady-state annualized lending spread of 2.5%, which is the mid-point of the interval considered by Christiano et al. (2009) on the basis of some existing estimates of this variable for the US economy.

The size of the household population, $\omega = 0.979$, is chosen such that the tax rate on entrepreneur profits that implements the efficient steady state is zero.[24] The loan-to-value

[23] The entrepreneurs' survival probability can then be calculated as $1 - \delta = \beta^e/\beta = 0.957$.
[24] Alternatively, we could have calibrated ω empirically and then obtained τ^e from the formula in section

ratio is set to $m = 0.85$, as in Iacoviello and Neri (2010). The labor supply elasticity is set to one half, which is broadly consistent with micro evidence. The elasticity of demand curves is set to 6, which would imply a monopolistic mark-up of 20% in the absence of subsidies. The Calvo parameter implies a mean duration of price contracts of 3 quarters, consistent with recent micro evidence (Bils and Klenow, 2004, Nakamura and Steinsson, 2008). The tax rate on housing wealth that implements the efficient steady state is $\tau^h = 0.012$. The structural parameters imply weights (normalized by their sum) of $\lambda_\pi = 91.2\%$, $\lambda_y = 7.9\%$, $\lambda_c = 0.1\%$ and $\lambda_h = 0.8\%$ in the loss function.

TABLE 1 HERE

We use the (log)TFP series constructed by the CSIP-Federal Reserve Bank of San Francisco for the period 1984-2011, after removing a linear trend, to calibrate the (log)TFP process a_t; this yields $\rho_a = 0.93$ and $\sigma_a = 0.0067$. For the pledgeability ratio process, m_t, it is harder to find direct empirical counterparts; for the purpose of illustration, we choose $\rho_m = 0.75$ and $\sigma_m = 0.01/m$, such that shocks have a half-life of four quarters and a one-standard-deviation shock changes the pledgeability ratio by 1 percentage point.

Before proceeding to the normative analysis, it is interesting to ask how the model prediction regarding the cyclicality of lending margins compares with the evidence. For this purpose, we assume that monetary policy in the model follows a basic Taylor rule of the form $R_t^D = \beta^{-1}\pi_t^\phi \left(R_{t-1}^D \beta\right)^{\rho_R}$, and set the response coefficients to standard values: $\phi = 1.5$, $\rho_R = 0.8$. Table 2 shows the correlation between bank lending margins $(R_t^L - R_t^D)$ and output (y_t) in the model, as well as a range of empirical estimates of such correlation in the US economy.[25] As shown by the table, the model with both TFP and pledgeability ratio shocks produces a degree of counter-cyclicality in lending spreads within the empirical range.

4.1. Since the share of entrepreneurs in the population is fairly small, this alternative approach would produce a very similar calibration.

[25] Aliaga-Díaz and Olivero (2010) calculate correlations between GDP and different measures of bank lending margins that range from -0.31 to -0.21. Kollmann et al. (2011) obtain a correlation between GDP and loan spreads of -0.14 for the US economy. This yields a range of (-0.31, -0.14) for the simple correlation coefficient. Using different econometric techniques, Dueker and Thorton (1997), Mandelman (2006), Santos and Winton (2008) and Leuvensteijn et al. (2008) also find evidence of countercyclical bank lending spreads.

TABLE 2 HERE

5.2 Impulse-response analysis

In order to further investigate the nature of optimal monetary policy in this framework, we now analyze the economy's response to shocks under the optimal commitment. We consider both TFP shocks as well as pledgeability ratio shocks.[26] We also analyze the impulse-responses under a policy of strict inflation targeting ($\hat{\pi}_t = 0$). Such a policy has been shown to be optimal in the standard New Keynesian model in the absence of exogenous cost-push shocks and steady state distortions (see e.g. Woodford, 2003, ch. 6). By comparing both policies, we can illustrate the trade-offs that render inflation targeting suboptimal in this framework.

5.2.1 Productivity shocks

Figure 1 plots the economy's response to a 1% negative productivity shock. Let us focus first on the case of strict inflation targeting (dotted lines). The fall in TFP reduces the marginal product of commercial real estate. Entrepreneurs reduce their demand for commercial property, which leads to a persistent decline in real estate prices. Lower expected asset prices means that real estate is less valuable as a collateral, which further reduces demand for commercial real estate. Since productivity shocks do not affect the efficient real estate distribution, the fall in commercial property is mirrored by a symmetric increase in the housing gap. Also, lower profits and lower real estate wealth trigger a large reduction in entrepreneur net worth and therefore in entrepreneur consumption. Household consumption falls too, but it does so by a relatively small amount, thanks to households' ability to smooth consumption. As a result, the consumption gap increases sharply. In addition to lowering welfare directly, the consumption gap also shifts the New Keynesian Phillips curve upwards. In order to keep inflation at zero, the central bank is obliged to engineer a (small) drop in

[26] For brevity, we omit the results regarding the effects of shocks to the utility of housing services (ϑ_t). These results are available upon request from the authors.

the output gap. To summarize, strict inflation targeting produces inefficient fluctuations in the output gap and, especially, the consumption and housing gaps.

FIGURE 1 HERE

Relative to the situation under inflation targeting, the optimal policy (solid line) can improve matters by cutting the nominal interest rate more sharply on impact. This way, it undoes part of the reduction in entrepreneurs' demand for commercial real estate, thus narrowing the housing gap. It also buffers the drop in real estate prices. Thanks to the latter two effects, entrepreneurs' net worth and consumption fall substantially less, which narrows significantly the consumption gap. The aggressive policy response leads to a surprise increase in inflation (and in the output gap) on impact. This lowers welfare directly, but it also helps reduce the consumption gap, by reducing entrepreneurs' real debt burden (and increasing their profits). Calculations not reported here show however that most of the reduction in the consumption gap is due to the smaller drop in real estate wealth. The contraction in the consumption gap contains the upward shift in the New Keynesian Phillips curve, thus improving the trade-off between inflation and output gap. Indeed, both variables return to zero very quickly. Finally, the endogenous response in lending spreads (not shown in the figure) is very small under both policy regimes, with peak drops of 1 and 0.2 basis points, respectively. The reason is that the reaction of the two endogenous determinants of lending spreads in equation (12), expected inflation in real estate prices and the policy rate, tend to cancel each other out.[27]

5.2.2 Pledgeability ratio shocks

Figure 2 plots the impulse-responses to a 1pp fall in the pledgeability ratio. Again, we focus first on the case of inflation targeting (dotted lines). The fall in the pledgeability ratio reduces the marginal value of commercial real estate by reducing its value as collateral.

[27] For further discussion of these opposite-sign effects and the resulting low responsiveness of spreads following a productivity shock, see Andrés and Arce (2012).

Entrepreneurs respond by decreasing their demand for commercial real estate. This produces again a symmetric increase in the housing gap, because the efficient real estate distribution is independent of the pledgeability ratio. Regarding the other stabilization goals, the responses are of lesser importance. First, the absolute deviations of the consumption gap from its efficient value (zero) are smaller than in the case of a productivity shock. The reason is that the credit crunch has two opposing effects on entrepreneur net worth: on the one hand, the fall in the price and the quantity of real estate reduces entrepreneurial net worth; on the other hand, the credit crunch lowers their real debt burden in subsequent periods, thus improving their net worth (as the center right panel shows, the latter effect becomes dominant from the third period onwards). Second, since the consumption gap response is relatively small, the shift in the New Keynesian Phillips curve is small too, such that a tiny fall in the output gap is enough to keep inflation at zero.

FIGURE 2 HERE

Therefore, the optimal policy (solid lines) is primarily aimed at reducing the housing gap. In order to achieve this, the monetary authority resorts again to a sharper reduction in the policy rate. This way, it counteracts the negative effect of the credit crunch on entrepreneurs' demand for commercial property. As in the case of productivity shocks, this policy raises inflation and the output gap on impact, with both variables returning quickly to baseline. Notice finally that lending margins increase by about 20 basis points in annualized terms, which contrasts with their negligible response to productivity shocks. This is due to the fact that lending margins depend negatively on the pledgeability ratio, through the latter's effect on the elasticity of demand for funding. This countercyclical response of lending margins has the property of amplifying the negative effect of the credit crunch under both policy scenarios.

5.3 Welfare analysis

The previous section characterized the responses of the stabilization goals to productivity and pledgeability ratio shocks. These goals however enter with different weights in the loss function of the central bank, and therefore have different quantitative effects on welfare. We are ultimately concerned with the welfare implications of alternative monetary policy rules. This subsection quantifies the welfare losses that arise under different such rules.

5.3.1 Welfare losses under the baseline calibration

The first four columns of Table 3 display the standard deviation of the four stabilization goals, conditional on productivity shocks. As in the analysis of impulse responses, we consider the cases of inflation targeting and the optimal policy commitment. We also include output gap targeting ($\hat{y}_t = \hat{y}_t^*$), which is equivalent to inflation targeting in the standard New Keynesian model (in the absence of an exogenous output-inflation trade-off) but not in our framework, due to the presence of the consumption gap in the New Keynesian Phillips curve. The last column displays the implied average welfare loss, as a percent of steady-state consumption.

TABLE 3 HERE

As the table makes clear, a policy of strict inflation targeting implies large fluctuations in the consumption and housing gaps. Fluctuations in the output gap are rather small. These volatilities, together with the weights in the loss function, imply an average welfare loss of 0.05% of steady-state consumption. Regarding the case of output gap targeting, fluctuations in the consumption and housing gaps are of similar magnitude, whereas inflation has a standard deviation of 0.57% in annual terms. The implied average welfare loss (0.04%) is close to the one under inflation targeting. Finally, the optimal monetary policy balances all the trade-offs among goals, producing a welfare loss of just 0.01% of steady-state consumption. Importantly, optimal inflation volatility is relatively large, with a standard deviation of 0.54% in annual terms.

Table 4 shows the results conditional on shocks to the pledgeability ratio. Again, the larger fluctuations take place in the consumption and housing gaps. Under inflation and output-gap targeting, housing gaps are more volatile than consumption gaps. Since the former have a larger weight in the loss function, the optimal policy focuses on reducing fluctuations in the housing gap. This comes at the cost of larger fluctuations in all other goals. Under the optimal policy, inflation experiences again sizable fluctuations, with a standard deviation of 0.42% in annual terms.

TABLE 4 HERE

5.3.2 Optimal simple targeting rules

In the standard New Keynesian model without an exogenous trade-off between inflation and output ('cost-push' shocks), the targeting rule that implements the optimal monetary policy commitment is simply $\hat{\pi}_t = 0$, i.e. strict inflation targeting. In the presence of cost-push shocks, the targeting rule is a simple and intuitive expression linking inflation and output gap (see e.g. Woodford 2003, ch. 7). In our model, due to its larger scale and the presence of financial frictions, the optimal targeting rule is too complex to be implemented in practice. In order to make the optimal monetary policy operational, we look for a simple targeting rule that approximates well the optimal policy. An important feature of our analysis is that the real price of the collateralizable asset has an important effect on the transmission of shocks. On the one hand, consumption of the constrained agents is very sensitive to fluctuations in real estate prices. On the other hand, expected growth of real estate prices is one of the determinants of equilibrium lending margins. In response to an adverse shock that depresses real estate prices in a hump-shaped manner, both effects work towards amplifying its negative effects: actual reductions in asset prices lower entrepreneurial net worth and thus widen the consumption gap, whereas expected reductions cause a countercyclical increase in lending margins.

The previous argument suggests considering simple targeting rules that capture the central bank's concern for stabilizing the actual and expected evolution of asset prices, together with the usual concern for inflation stabilization. In particular, we consider the following family of simple targeting rules,

$$\hat{\pi}_t + \zeta \left(\hat{p}_t^h - \hat{p}_{t-1}^h + E_t \hat{p}_{t+1}^h - \hat{p}_t^h \right) = 0.$$

According to this rule, the central bank targets a weighted average of inflation, on the one hand, and the sum of current and expected growth rates in real estate prices, on the other.[28] In the special case of $\zeta = 0$, the rule collapses to strict inflation targeting. For each shock, we find the value of ζ that minimizes the average welfare loss. The last line of tables 3 and 4 display the results under our proposed rule, which we label as 'simple targeting rule'. Notice first that the optimal coefficient ζ is positive conditional on either type of shock. The intuition is simple. Following for instance an adverse shock, strict inflation targeting produces an excessively large fall in demand for commercial property together with a hump-shaped drop in real estate prices. In order to counteract these effects, the central bank finds it optimal to implement a more expansionary monetary policy, the by-product of which is to create inflation.[29] That is, actual and expected falls in real estate prices coincide in time with positive inflation.

Regarding the actual welfare losses, our simple rule is very close to the optimal policy in the case of productivity shocks (table 3). Indeed, the rule succeeds in reducing the volatility of the consumption and housing gaps, relative to the other two suboptimal policies. Conditional on pledgeability ratio shocks (table 4), welfare losses under our simple rule are

[28] We also considered a policy that set to zero the weights on the consumption and housing gaps in the quadratic loss function and minimized the resulting 'myopic' loss function. Although such a policy does not deliver a simple expression for the targeting rule either, it can shed light on the extent to which monetary policy should worry about the non-standard stabilization goals. We found that such a policy was much closer to inflation or output gap targeting than to the optimal policy in terms of welfare loss. This strongly suggests that the central bank should not obviate the goals arising from financial frictions in the conduct of monetary policy.

[29] For brevity of exposition we do not display here the impulse-responses under the optimal simple targeting rule. The latter are available upon request from the authors.

closer to (though still smaller than) those under the other suboptimal rules, although this is not surprising given the small welfare differences between the different policies in this case. The simple targeting rule does share with the optimal policy the feature of reducing the volatility of the housing gap while increasing fluctuations in the other goals. Interestingly, the optimal value of the weight coefficient, ζ, is very similar for both shocks, which guarantees that the same rule with a similar coefficient would perform well also unconditionally.

These results may shed some light on the debate as to whether central bankers should pay attention to asset prices when conducting monetary policy.[30] Our analysis suggests that, to the extent that fluctuations in asset prices cause large distortions in the spending decisions of collateral-constrained agents, then the monetary authority has a rationale for taking into account such asset price fluctuations in its policy decisions.

5.4 The effects of banking competition

The literature has documented an increase in banking competition in the US and in Europe in recent decades, which naturally raises the question as to how this development may have affected the effectiveness of monetary policy.[31] To isolate the effects of banking competition on the policy trade-offs in the model, we consider the limiting case of perfect banking competition ($\alpha = 0$, or $n \to \infty$). In the latter scenario, the steady-state loan rate, R^L_{ss}, falls from its baseline value to $R^D_{ss} = 1/\beta$, and the interest rate spread becomes zero.[32] Notice that, due to our assumption of steady-state efficiency, our analysis does not capture the potential steady-state welfare gains from stronger competition. Therefore, our results apply only to welfare losses due to fluctuations around an efficient steady state. The results are displayed in Tables 5 and 6.

TABLE 5 HERE

[30] See for instance Bernanke and Gertler (2001) and Cecchetti et al. (2003) for opposing views on this issue.

[31] See Andrés and Arce (2012) and the references therein.

[32] Given the change in the steady-state loan rate R^{ss}, we adjust the distortionary taxes τ^e and τ^h according to the formulas in section 4.1.

Conditional on productivity shocks (table 5), the policy trade-offs clearly worsen when the banking industry is more competitive. Under inflation and output-gap targeting, all stabilization goals other than the one being targeted become more volatile. As a result, average welfare losses increase. Regarding the optimal policy, the increase in inflation and output-gap volatility is partially offset by smaller fluctuations in the consumption and housing gaps. However, the large weights of the former two goals in the loss function (91.2% and 7.9%, respectively) imply an increase in average welfare loss. This increase is very small however. The same can be said about the simple targeting rule based on inflation and real estate prices, which remains close to the optimal policy in terms of welfare loss. We conclude that, conditional on productivity shocks, the transit to perfect banking competition makes the policy trade-offs more severe, but especially so for the suboptimal policy rules.

To understand these results, it is helpful to consider the steady-state effects of an increase in banking competition. We start by defining the *leverage ratio* as the ratio of borrowers' asset holdings over net worth (after consumption), $LR_t \equiv p_t^h h_t^e / \left(p_t^h h_t^e - b_t\right)$. Binding collateral constraints imply that, in the steady state, the leverage ratio equals

$$LR_{ss} = \frac{1}{1 - b_{ss}/\left(p_{ss}^h h_{ss}^e\right)} = \frac{1}{1 - m/R_{ss}^L}.$$

Therefore, the fall in loan rates produced by stronger banking competition increases the steady-state leverage ratio. Now consider equation (37), which determines the cyclical fluctuations in entrepreneur consumption. In the latter equation, the term capturing the sensitivity of entrepreneur consumption to real estate prices can be expressed as

$$\left(1 - \beta^e\right) \frac{p_{ss}^h h_{ss}^e}{c_{ss}^e} = \left(1 - \beta^e\right) \frac{\beta^e}{1 - \beta^e} \frac{p_{ss}^h h_{ss}^e}{p_{ss}^h h_{ss}^e - b} = \beta^e LR_{ss},$$

where we have used the fact that $c_{ss}^e = \left(1 - \beta^e\right) \left(p_{ss}^h h_{ss}^e - b_{ss}\right) / \beta^e$, which in turn stems from the fact that entrepreneurs devote a fraction $1 - \beta^e$ of their real net worth to consumption, c_{ss}^e, and the remaining fraction β^e to finance the unmortgaged part of their real estate holdings, $p^h_{ss} h^e_{ss} - b_{ss}$. Therefore, the increase in the steady-state leverage ratio amplifies the effect of fluctuations in real estate prices on entrepreneur consumption. *Ceteris paribus*, the increased volatility of entrepreneur consumption carries over to the consumption gap. As we have seen, this has a direct negative effect on welfare, but it also worsens the output-inflation trade-off (by causing larger shifts in the Phillips curve) and amplifies the distortions in the distribution of real estate through its effects on entrepreneurs' stochastic discount factor. Taking all these effects together, we have that the increase in banking competition tends to exacerbate the trade-offs of monetary policy and the associated welfare losses.

TABLE 6 HERE

Table 6 shows the effects of stronger banking competition conditional on pledgeability ratio shocks. The main message from the table is that the volatility of the different stabilization goals tends to increase but it does so by small amounts, and in some cases such volatilities actually fall. As a result, the effect on average welfare losses is negligible. The intuition for this can be found in the behavior of the lending spread. The latter responds countercyclically to pledgeability ratio shocks when banks have market power, thus amplifying the effects on the economy. However, under perfect banking competition lending spreads are zero, and so their amplifying role disappears. As the table makes clear, this basically neutralizes the amplifying effect of the leverage ratio on welfare losses.

6 CONCLUSIONS

In this paper we provide a theoretical framework for the analysis of optimal monetary policy in the presence of financial frictions, in the form of collateral constraints and a monopolistically competitive banking sector. In our economy consumers are divided into households and entrepreneurs, who act respectively as savers and borrowers. The resulting credit flows are intermediated by banks, which have some monopolistic power in the loans market and set optimal lending rates accordingly. The collateralizable asset, real estate, yields utility to households and productive returns to entrepreneurs. The latter face credit limits that link their borrowing capacity to the expected value of their real estate holdings.

We have shown that, under the assumption of steady state efficiency in the welfare-relevant variables and up to a second order approximation, welfare maximization is equivalent to stabilization of four goals: inflation, output gap, the consumption gap between households and entrepreneurs, and the distribution of real estate between both groups (or housing gap). Following both productivity and credit-crunch shocks (the latter in the form of exogenous changes in collateral requirements), the optimal monetary policy commitment implies a short-run trade-off between stabilization goals. Relative to strict inflation targeting, the optimal policy commitment changes the nominal policy rate more aggressively so as to avoid large fluctuations in asset prices and to engineer inflation surprises, with both effects aimed at avoiding excessive volatility of the non-standard goals.

We also find that a simple targeting rule that involves inflation and real estate prices yields welfare losses similar to those under the optimal policy. From a policy perspective, this suggests that, to the extent that fluctuations in assets prices cause distortions in the expenditure decisions of collateral-constrained agents, then the monetary authority has a rationale for taking into account such asset price fluctuations in its policy decisions.

Finally, we have studied how the degree of competition in the banking industry affects the trade-offs just discussed. We find that welfare losses due to cyclical fluctuations around the efficient steady state increase as the banking sector becomes more competitive. As banking competition increases, entrepreneurs become more leveraged and their net worth becomes more sensitive to asset prices. This mechanism is equally important regardless of the nature of the shocks. However, following pledgeability ratio shocks lending spreads respond countercyclically, thus amplifying their effects. Under perfect competition, spreads disappear and so does the latter amplification effect.

Our analysis gives some prominence to the consumption gap. We have assumed the existence of two consumer groups, households and entrepreneurs, whereby only the latter are credit constrained. Given the relatively small size of the entrepreneurial population, it would be interesting to extend the model to separate the household sector into savers and (credit-constrained) borrowers, as in Iacoviello (2005). This would increase the importance of the consumption gap.

APPENDIX A

A.1 The entrepreneur's consumption decision

Equations (8) and (9) in the text can be combined as follows,

$$\frac{p_t^h - \chi_t}{c_t^e} = \beta^e E_t \left\{ \frac{(1-\tau^e)\,\nu p_{t+1}^I y_{t+1}/h_t^e + p_{t+1}^h - R_t^L \chi_t/\pi_{t+1}}{c_{t+1}^e} \right\}, \tag{38}$$

where $\chi_t \equiv m_t E_t \pi_{t+1} p_{t+1}^h / R_t^L$. The latter definition allows us in turn to write the collateral constraint (equation 6) as

$$b_t = \chi_t h_t^e. \tag{39}$$

Define real net worth, nw_t, as the sum of after-tax real profits and beginning-of-period real estate wealth, minus real debt repayments,

$$\begin{aligned} nw_t &\equiv (1-\tau^e)\left(p_t^I y_t - w_t l_t^d\right) + p_t^h h_{t-1}^e - \frac{R_{t-1}^L}{\pi_t} b_{t-1} \\ &= (1-\tau^e)\,\nu p_t^I y_t + p_t^h h_{t-1}^e - \frac{R_{t-1}^L}{\pi_t}\chi_{t-1} h_{t-1}^e \\ &= \left[(1-\tau^e)\,\nu p_t^I y_t/h_{t-1}^e + p_t^h - \frac{R_{t-1}^L}{\pi_t}\chi_{t-1}\right] h_{t-1}^e, \end{aligned} \tag{40}$$

where in the first equality we have used (7) to substitute for $w_t l_t^d$ and (39) to substitute for b_{t-1}. We now guess that the entrepreneur consumes a fraction $1-\beta^e$ of her real net worth,

$$c_t^e = (1-\beta^e)\, nw_t. \tag{41}$$

Using (40) and (41) in equation (38), the latter collapses to

$$\frac{p_t^h - \chi_t}{c_t^e} = \frac{\beta^e}{1-\beta^e}\frac{1}{h_t^e}. \tag{42}$$

At the same time, the definition of real net worth and equation (39) allow us write the entrepreneur's budget constraint (equation 5) as

$$\chi_t h_t^e + nw_t = c_t^e + p_t^h h_t^e,$$

Combining the latter with equation (42), we finally obtain equation (41), which verifies our guess. QED.

A.2 Aggregation of entrepreneurs' welfare

Let $U_t^e \equiv \log(c_t^e)$ denote the consumption utility flow of entrepreneurs, and let

$$W_t^e \equiv E_t \sum_{s=0}^{\infty} \beta^s (1-\delta)^s U_{t+s}^e \tag{43}$$

denote the welfare of an entrepreneur living at time t. When formulating its optimal plan at time 0, the social planner considers the welfare of entrepreneurs living at time 0, W_0^e, as well as the welfare of those entrepreneurs that will be borned in future periods, $\{W_t^e\}_{t=1}^{\infty}$, where the welfare of each future cohort $t = 1, 2, ...$ is discounted by the factor β^t. The number of entrepreneurs being born at each time $t \geq 1$ is given by $(1-\omega)\delta$. Therefore, at time 0 the expected sum of current and future entrepreneurs' welfare is given by the constant entrepreneur population, $1-\omega$, times the term

$$V_0^e \equiv E_0 \left\{ W_0^e + \beta\delta W_1^e + \beta^2 \delta W_2^e + \beta^3 \delta W_3^e + ... \right\}$$

Using (43) and the law of iterated expectations, we can write

$$\begin{aligned}
V_0^e &= E_0\{[U_0^e + \beta(1-\delta)U_1^e + \beta^2(1-\delta)^2 U_2^e + \beta^3(1-\delta)^3 U_3^e + ...] \\
&\quad +\beta\delta[U_1^e + \beta(1-\delta)U_2^e + \beta^2(1-\delta)^2 U_3^e + ...] \\
&\quad +\beta^2\delta[U_2^e + \beta(1-\delta)U_3^e + ...] \\
&\quad +\beta^3\delta[U_3^e + ...] + ...\}
\end{aligned}$$

Therefore,

$$\begin{aligned}
V_0^e &= E_0\{U_0^e + \beta[(1-\delta)+\delta]U_1^e + \beta^2\left[(1-\delta)^2 + \delta(1-\delta) + \delta\right]U_2^e \\
&\quad +\beta^3\left[(1-\delta)^3 + \delta(1-\delta)^2 + \delta(1-\delta) + \delta\right]U_3^e + ...\} \\
&= E_0\left\{U_0^e + \sum_{t=1}^{\infty}\beta^t\left[(1-\delta)^t + \delta\sum_{s=0}^{t-1}(1-\delta)^s\right]U_t^e\right\}. \qquad (44)
\end{aligned}$$

The geometric progression $\sum_{s=0}^{t-1}(1-\delta)^s$ can be expressed as

$$\sum_{s=0}^{t-1}(1-\delta)^s = \frac{1-(1-\delta)^t}{1-(1-\delta)} = \frac{1-(1-\delta)^t}{\delta},$$

which implies

$$(1-\delta)^t + \delta\sum_{s=0}^{t-1}(1-\delta)^s = 1.$$

Using this in (44), we finally obtain

$$V_0^e = E_0\sum_{t=0}^{\infty}\beta^t U_t^e.$$

Therefore, at time 0 the expected sum of current and future entrepreneurs' welfare is given by $(1-\omega)V_0^e = (1-\omega)E_0\sum_{t=0}^{\infty}\beta^t\log(c_t^e)$, as claimed in the text. QED.

A.3 Implementation of the efficient steady state

Equations (1), (7) and (19) in the steady state jointly imply

$$c_{ss}\left(l_{ss}^{s}\right)^{\varphi}=\frac{1-\omega}{\omega}\left(1-\nu\right)p_{ss}^{I}\frac{y_{ss}^{s}}{l_{ss}^{s}}.$$

The latter corresponds to its efficient counterpart (the steady state of equation 23) only if $p_{ss}^{I}=1$. In the zero-inflation steady state, equation (15) becomes $1+\tau=\left[\varepsilon/\left(\varepsilon-1\right)\right]p_{ss}^{I}$, where τ is the subsidy rate on the revenue of final goods producers. Therefore, steady-state efficiency requires setting the subsidy rate to

$$\tau=\frac{\varepsilon}{\varepsilon-1}-1.$$

On the other hand, the steady-state counterpart of equation (10), rescaled by y_{ss}, is given by

$$\frac{c_{ss}^{e}}{y_{ss}}=\left(1-\beta^{e}\right)\left[\left(1-\tau^{e}\right)\nu+\left(1-m\right)\frac{p_{ss}^{h}h_{ss}^{e}}{y_{ss}}\right], \tag{45}$$

where we have imposed $p_{ss}^{I}=1$ and we have used the collateral constraint in the steady state, $R_{ss}^{L}b_{ss}=mp_{ss}^{h}h_{ss}^{e}$. Similarly, the steady-state counterparts of equations (9) and (8) jointly imply

$$\frac{p_{ss}^{h}h_{ss}^{e}}{y_{ss}}=\beta^{e}\left[\left(1-\tau^{e}\right)\nu+\frac{p_{ss}^{h}h_{ss}^{e}}{y_{ss}}\right]+\left(\frac{1}{R_{ss}^{L}}-\beta^{e}\right)m\frac{p_{ss}^{h}h_{ss}^{e}}{y_{ss}},$$

which implies the following steady-state ratio of entrepreneurial real estate wealth over output,

$$\frac{p_{ss}^{h}h_{ss}^{e}}{y_{ss}}=\frac{\beta^{e}\left(1-\tau^{e}\right)\nu}{1-\beta^{e}-m\left(1/R_{ss}^{L}-\beta^{e}\right)}. \tag{46}$$

Using (46) to substitute for $p_{ss}^{h}h_{ss}^{e}/y_{ss}^{s}$ in (45), and imposing the steady-state efficiency requirement that $c_{ss}^{e}/y_{ss}=1-\omega$ (as a result of $c_{ss}=c_{ss}^{e}$ and $\left[1-\omega\right]y_{ss}=\omega c_{ss}+\left[1-\omega\right]c_{ss}^{e}$), we can solve for the tax rate on profits that is consistent with an efficient allocation,

$$\tau^e = 1 - \frac{1-\omega}{(1-\beta^e)\,\nu}\frac{1-\beta^e - m\left(1/R_{ss}^L - \beta^e\right)}{1-m/R_{ss}^L}.$$

Finally, equation (3) implies that, in the steady state,

$$\frac{p_{ss}^h h_{ss}}{c_{ss}} = \frac{\vartheta}{1-\beta+\tau^h}.$$

Combining this with equation (46) and the efficiency requirement $c_{ss} = c_{ss}^e = (1-\omega)\,y_{ss},$ we have that the steady-state distribution of real estate in the decentralized economy is given by

$$\frac{h_{ss}}{h_{ss}^e} = \frac{(1-\omega)\,\vartheta}{\beta^e\,(1-\tau^e)\,\nu}\frac{1-\beta^e - m\left(1/R_{ss}^L - \beta^e\right)}{1-\beta+\tau^h}.$$

The latter coincides with the efficient steady-state distribution, $(1-\omega)\,\vartheta/\,(\beta\nu)$, only if

$$\tau^h = \frac{\beta}{\beta^e}\frac{1-\beta^e - m\left(1/R_{ss}^L - \beta^e\right)}{1-\tau^e} - (1-\beta)\,.$$

APPENDIX B

B.1 Derivation of the quadratic loss function

We start by performing a second order approximation (in logs) of the period utility function around the steady-state,

$$\begin{aligned} U_t &\equiv \omega\left[\log(c_t) + \vartheta_t \log(h_t) - \frac{(l_t^s)^{1+\varphi}}{1+\varphi}\right] + (1-\omega)\log(c_t^e) \\ &= \omega\hat{c}_t + (1-\omega)\,\hat{c}_t^e - \omega\,(l_{ss}^s)^{1+\varphi}\left(\hat{l}_t + \frac{1+\varphi}{2}\hat{l}_t^2\right) + \omega\vartheta\left(\hat{h}_t + z_t^h\hat{h}_t\right) + t.i.p. + O^3, \quad (47) \end{aligned}$$

where hats denote log-deviations from steady state, the subscript ss indicates steady state values, $t.i.p.$ are terms independent of policy and O^3 collects all terms of order third and higher in the size of the shocks.

The aggregate resource constraint in goods markets, $(1-\omega)\, y_t/\Delta_t = \omega c_t + (1-\omega)\, c_t^e$, can be approximated by

$$(1-\omega)\left(\hat{y}_t + \frac{1}{2}\hat{y}_t^2 - \hat{\Delta}_t\right) = \omega \frac{c_{ss}}{y_{ss}}\left(\hat{c}_t + \frac{1}{2}\hat{c}_t^2\right) + (1-\omega)\frac{c_{ss}^e}{y_{ss}}\left(\hat{c}_t^e + \frac{1}{2}\left(\hat{c}_t^e\right)^2\right) + O^3, \qquad (48)$$

where we have used the fact that $\hat{\Delta}_t$ is already a second-order term (see below). Equation (48) implies that

$$\hat{y}_t^2 = \left(\frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\right)^2 \hat{c}_t^2 + \left(\frac{c_{ss}^e}{y_{ss}}\right)^2 \left(\hat{c}_t^e\right)^2 + 2\frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\frac{c_{ss}^e}{y_{ss}}\hat{c}_t\hat{c}_t^e + O^3.$$

Using this to substitute for $\hat{y}_t^2$ in (48) and rearranging terms, we obtain

$$\begin{aligned}\hat{y}_t \;&=\; \frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\hat{c}_t + \frac{c_{ss}^e}{y_{ss}}\hat{c}_t^e + \hat{\Delta}_t + O^3 \\ &\quad + \frac{1}{2}\left[\frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\left(1 - \frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\right)\hat{c}_t^2 + \frac{c_{ss}^e}{y_{ss}}\left(1-\frac{c_{ss}^e}{y_{ss}}\right)\left(\hat{c}_t^e\right)^2 - 2\frac{\omega}{1-\omega}\frac{c_{ss}}{y_{ss}}\frac{c_{ss}^e}{y_{ss}}\hat{c}_t\hat{c}_t^e\right] \qquad (49)\end{aligned}$$

We now make use of our assumption of efficient steady state. This implies $c_{ss} = c_{ss}^e = (1-\omega)\, y_{ss}$. Using this in (49) yields

$$\hat{y}_t = \omega\hat{c}_t + (1-\omega)\,\hat{c}_t^e + \hat{\Delta}_t + \frac{\omega(1-\omega)}{2}\left(\hat{c}_t - \hat{c}_t^e\right)^2 + O^3. \qquad (50)$$

The production function, $y_t = e^{a_t}\left[\omega l_t^s/(1-\omega)\right]^{1-\nu}\left(h_{t-1}^e\right)^{\nu}$, admits the following exact log-linear representation,

$$\hat{y}_t = a_t + (1-\nu)\,\hat{l}_t^s + \nu\hat{h}_{t-1}^e. \qquad (51)$$

Using (50) and (51) to substitute for $\omega \hat{c}_t + (1-\omega)\hat{c}_t^e$ and $\hat{l}_t^s$ respectively in (47), we obtain

$$\begin{aligned} U_t &= \hat{y}_t - \hat{\Delta}_t - \omega\left(l_{ss}^s\right)^{1+\varphi}\left[\frac{\hat{y}_t - \nu\hat{h}_{t-1}^e}{1-\nu} + \frac{1+\varphi}{2}\left(\frac{\hat{y}_t - a_t - \nu\hat{h}_{t-1}^e}{1-\nu}\right)^2\right] \\ &\quad -\frac{\omega(1-\omega)}{2}\left(\hat{c}_t - \hat{c}_t^e\right)^2 + \omega\vartheta\left(\hat{h}_t + z_t^h\hat{h}_t\right) + t.i.p. + O^3. \end{aligned} \tag{52}$$

In an efficient steady state, labor market equilibrium implies $c_{ss}\left(l_{ss}^s\right)^{\varphi} = (1-\nu)\, y_{ss}^s / \left(\frac{\omega}{1-\omega} l_{ss}^s\right)$, which combined with $c_{ss} = (1-\omega)\, y_{ss}$ implies $\omega\left(l_{ss}^s\right)^{1+\varphi} = 1-\nu$. Using this in (52), we have

$$U_t = \nu\hat{h}_{t-1}^e + \omega\vartheta\left(\hat{h}_t + z_t^h\hat{h}_t\right) - \frac{1+\varphi}{2(1-\nu)}\left(\hat{y}_t - \hat{y}_t^*\right)^2 - \frac{\omega(1-\omega)}{2}\left(\hat{c}_t - \hat{c}_t^e\right)^2 - \hat{\Delta}_t + t.i.p. + O^3, \tag{53}$$

where we have used the definition of efficient output (in log-deviations), $\hat{y}_t^* \equiv a_t + \nu\hat{h}_{t-1}^e$. Taking the present discounted sum of (53), we have

$$\begin{aligned} \sum_{t=0}^{\infty}\beta^t U_t &= -\frac{1}{2}\sum_{t=0}^{\infty}\beta^t\left[\frac{1+\varphi}{1-\nu}\left(\hat{y}_t - \hat{y}_t^*\right)^2 + \omega(1-\omega)\left(\hat{c}_t - \hat{c}_t^e\right)^2\right] \\ &\quad + \sum_{t=0}^{\infty}\beta^t\left[\beta\nu\hat{h}_t^e + \omega\vartheta\left(\hat{h}_t + z_t^h\hat{h}_t\right)\right] - \sum_{t=0}^{\infty}\beta^t\hat{\Delta}_t + t.i.p. + O^3, \end{aligned} \tag{54}$$

where we have used the fact that $\hat{h}_{-1}^e$ and $\hat{\Delta}_{-1}$ are independent of policy as of time 0. The equilibrium condition in the real estate market, $\bar{h} = \omega h_t + (1-\omega)\, h_t^e$, can be approximated as follows,

$$\omega h_{ss}\left(\hat{h}_t + \frac{\hat{h}_t^2}{2}\right) + (1-\omega)\, h_{ss}^e\left(\hat{h}_t^e + \frac{\left(\hat{h}_t^e\right)^2}{2}\right) = O^3. \tag{55}$$

The latter equation implies that $\left(\hat{h}_t^e\right)^2 = \left[\omega/(1-\omega)\right]^2\left(h_{ss}/h_{ss}^e\right)^2\hat{h}_t^2 + O^3$. Using this and the efficient distribution of real estate in the steady state, $h_{ss}/h_{ss}^e = (1-\omega)\,\vartheta/(\beta\nu)$, equation (55) becomes

$$\omega\vartheta\hat{h}_t + \beta\nu\hat{h}_t^e = -\frac{\omega\vartheta}{2}\frac{\beta\nu + \omega\vartheta}{\beta\nu}\hat{h}_t^2 + O^3.$$

This implies

$$\sum_{t=0}^{\infty}\beta^t\left[\beta\nu\hat{h}_t^e+\omega\vartheta\left(\hat{h}_t+z_t^h\hat{h}_t\right)\right] = -\frac{\omega\vartheta}{2}\sum_{t=0}^{\infty}\beta^t\left(\frac{\beta\nu+\omega\vartheta}{\beta\nu}\hat{h}_t^2-2z_t^h\hat{h}_t\right)+O^3$$
$$= -\frac{\omega\vartheta}{2}\frac{\beta\nu+\omega\vartheta}{\beta\nu}\sum_{t=0}^{\infty}\beta^t\left(\hat{h}_t-\hat{h}_t^*\right)^2+t.i.p.+O^3, \quad (56)$$

where in the second equality we have used the definition of the efficient level of housing, $\hat{h}_t^*\equiv\left[\beta\nu/\left(\omega\vartheta+\beta\nu\right)\right]z_t^h$.

It is possible to show (see e.g. Woodford, 2003) that

$$\sum_{t=0}^{\infty}\beta^t\hat{\Delta}_t=\frac{\varepsilon}{2}\frac{\theta}{(1-\theta)(1-\beta\theta)}\sum_{t=0}^{\infty}\beta^t\hat{\pi}_t^2+t.i.p.+O^3. \quad (57)$$

Using (56) and (57) in (54), we finally obtain

$$\sum_{t=0}^{\infty}\beta^tU_t=-\frac{1}{2}\sum_{t=0}^{\infty}\beta^tL_t+t.i.p.+O^3, \quad (58)$$

where

$$L_t=\frac{1+\varphi}{1-\nu}\left(\hat{y}_t-\hat{y}_t^*\right)^2+\omega\left(1-\omega\right)\left(\hat{c}_t-\hat{c}_t^e\right)^2+\omega\vartheta\frac{\beta\nu+\omega\vartheta}{\beta\nu}\left(\hat{h}_t-\hat{h}_t^*\right)^2+\frac{\varepsilon\theta}{(1-\theta)(1-\beta\theta)}\hat{\pi}_t^2.$$

QED.

APPENDIX C

C.1 Log-linear equations

All variables in log-deviations from the steady state. The log-linear constraints of the central bank's problem are the following.

1. Household's consumption Euler equation,

$$\hat{c}_t = E_t \hat{c}_{t+1} - E_t \left(\hat{R}_t^D - \hat{\pi}_{t+1} \right).$$

2. Household's demand for housing,

$$\left(1+\tau^h\right)\left(\hat{p}_t^h - \hat{c}_t\right) = \left(1+\tau^h - \beta\right)\left(z_t^h - \hat{h}_t\right) + \beta E_t \left(\hat{p}_{t+1}^h - \hat{c}_{t+1}\right).$$

3. Entrepreneur's borrowing constraint,

$$\hat{b}_t = z_t^m + E_t \hat{p}_{t+1}^h + \hat{h}_t^e - \left(\hat{R}_t^L - E_t \hat{\pi}_{t+1}\right).$$

4. Entrepreneur's consumption Euler equation,

$$\hat{c}_t^e = \beta^e R_{ss}^L E_t \left(\hat{c}_{t+1}^e - \hat{R}_t^L + \hat{\pi}_{t+1}\right) - \left(1 - \beta^e R_{ss}^L\right)\hat{\xi}_t.$$

5. Entrepreneur's demand for real estate,

$$\begin{aligned} \hat{p}_t^h - \hat{c}_t^e \quad = \quad & \beta^e E_t \left\{ \frac{(1-\tau^e)\,\nu}{s_h^e} \left(\hat{y}_{t+1} + \hat{p}_{t+1}^I - \hat{h}_t^e\right) + \hat{p}_{t+1}^h - \left[\frac{(1-\tau^e)\,\nu}{s_h^e} + 1\right] \hat{c}_{t+1}^e \right\} \\ & + m \left(\frac{1}{R_{ss}^L} - \beta^e\right) \left[z_t^m + \hat{\xi}_t + E_t \hat{p}_{t+1}^h - \left(\hat{R}_t^L - E_t \hat{\pi}_{t+1}\right)\right], \end{aligned}$$

where $s_h^e \equiv p_{ss}^h h_{ss}^e / y_{ss}$.

6. Entrepreneur consumption,

$$\hat{c}_t^e = \frac{1-\beta^e}{1-\omega} \left[(1-\tau^e)\,\nu \left(\hat{y}_t + \hat{p}_t^I\right) + s_h^e \left(\hat{p}_t^h + \hat{h}_{t-1}^e\right) - s_h^e m \left(\hat{R}_{t-1}^L + \hat{b}_{t-1} - \hat{\pi}_t\right)\right].$$

7. Bank lending margin,

$$\hat{R}_t^L = \hat{R}_t^D$$

$$+\frac{\beta R_{ss}^L - 1}{\beta R_{ss}^L}\left[\frac{\hat{R}_t^D + \hat{p}_t^h - m\beta E_t\left(\hat{\pi}_{t+1} + \hat{p}_{t+1}^h + z_t^m\right)}{1 - m\beta} - \frac{\eta m\beta E_t\left(\hat{\pi}_{t+1} + \hat{p}_{t+1}^h + z_t^m\right) - \left(\hat{R}_t^D + \hat{p}_t^h\right)}{\eta m\beta - 1}\right].$$

8. New Keynesian Phillips curve,

$$\hat{\pi}_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}\hat{p}_t^I + \beta E_t\hat{\pi}_{t+1}.$$

9. Real marginal costs,

$$\hat{p}_t^I = \hat{c}_t - \hat{y}_t + \frac{1+\varphi}{1-\nu}\left(\hat{y}_t - a_t - \nu\hat{h}_{t-1}^e\right).$$

10. Equilibrium in goods markets,

$$\hat{y}_t = \omega\hat{c}_t + (1-\omega)\,\hat{c}_t^e.$$

11. Equilibrium in the real estate market,

$$\hat{h}_t = -\frac{\beta\nu}{\omega\vartheta}\hat{h}_t^e.$$

References

[1] Aliaga-Díaz, R. and M. Olivero (2010): "Macroeconomic Implications of 'Deep Habits' in Banking", *Journal of Money, Credit and Banking*, 42, 1495-1521.

[2] Andrés, J. and O. Arce (2012): "Banking Competition, Housing Prices and Macroeconomic Stability," *Economic Journal*, 122(565), 1346-1372.

[3] Barth, J. R., G. Caprio Jr. and R. Levine (2004): "Bank regulation and supervision: what works best?", *Journal of Financial Intermediation*, 13(2), 205-248.

[4] Benigno, P. and M. Woodford (2003): "Optimal Monetary and Fiscal Policy: A Linear-Quadratic Approach," *NBER Macroeconomics Annual*, 18, 271-364.

[5] Benigno, P. and M. Woodford (2012): "Linear-Quadratic Approximation of Optimal Policy Problems", *Journal of Economic Theory*, 147(1), 1-42.

[6] Bernanke, B. and M. Gertler (1989), "Agency Costs, Net Worth, and Business Fluctuations", *American Economic Review*, March, Vol. 79(1), pp. 14-31.

[7] Bernanke, B. and M. Gertler (2001), "How Should Central Bankers Respond to Asset Prices?". *American Economic Review Papers and Proceedings*, 91(2), 253-257.

[8] Bils, M., and P. J. Klenow (2004), "Some Evidence on the Importance of Sticky Prices," *Journal of Political Economy*, 112(5), 947-985.

[9] Calvo, G. (1983): "Staggered Prices in a Utility-Maximizing Framework," *Journal of Monetary Economics* 12: 383-398.

[10] Carlstrom C. T. , T. S. Fuerst and M. Paustian (2010), "Optimal Monetary Policy in a Model with Agency Costs", *Journal of Money, Credit and Banking*, 42(s1), 37-70.

[11] Cecchetti, S. G., H. Genberg, and S. Wadhwani (2002), "Asset Prices in a Flexible Inflation Targeting Framework", NBER Working Paper 8970.

[12] Chiappori, P.-A., D. Pérez-Castrillo, and T. Verdier (1995): "Spatial Competition in the Banking System: Localization, Cross Subsidies and the Regulation of Deposits Rates," *European Economic Review*, 39, 889-918.

[13] Christiano, L., Motto R. and Rostagno, M. (2009). 'Financial Factors in Business Cycles', Working paper, Northwestern University.

[14] Claessens, S. (2009): "Competition in Financial Sector: Overview of Competition Policies," *World Bank Research Observer*, Oxford University Press, vol. 24(1), pages 83-118, April.

[15] Claessens, S., and L. Laeven (2004): "What Drives Banking Competition? Some International Evidence," *Journal of Money Credit and Banking*, 36(3), 563-583.

[16] Claessens, S., and L. Laeven (2005): "Financial Dependence, Banking Sector Competition, and Economic Growth," *Journal of the European Economic Association*, 3: 179-207.

[17] Cúrdia, V. and M. Woodford (2009), "Credit Frictions and Optimal Monetary Policy," mimeo.

[18] Cúrdia, V., and M. Woodford (2010). "Credit Spreads and Monetary Policy," *Journal of Money, Credit and Banking*, vol. 42(s1): 3-35.

[19] De Fiore, F., and O. Tristani (2009), "Optimal Monetary Policy in a Model of the Credit Channel", European Central Bank, working paper series no. 1043.

[20] De Fiore, F., P. Teles, and O. Tristani (2011), "Monetary Policy and the Financing of Firms," *American Economic Journal: Macroeconomics*, 3(4), 112-42.

[21] Dick, A. and A. Lehnert (2010): "Personal bankruptcy and credit market competition", *Journal of Finance*, 65(2), 655-686, 04.

[22] Dell'Ariccia, G. (2001): "Asymmetric Information and the Structure of the Banking Industry," *European Economic Review* 45(10): 1957-1980.

[23] Dueker, M, and D. Thornton (1997): "Do Bank Loan Rates Exhibit a Countercyclical Mark-up?". Federal Reserve Bank of St. Louis, No 1997-004.

[24] Freixas, X., and J.-C. Rochet, (1997): *Microeconomics of Banking.* Cambridge: MIT Press.

[25] Gerali, A., Neri S., Sessa L. and Signoretti, F. (2010). "Credit and Banking in a DSGE Model of the Euro Area", *Journal of Money, Credit and Banking*, vol. 42(s1): 107-141.

[26] Guiso, L., P. Sapienza, and. L. Zingales (2007): "The Cost of Banking Regulation," EUI Working Papers ECO 2007/43.

[27] Hülsewig, O., Mayer, E., and Wollmershäuser, T. (2009). "Bank behavior, incomplete interest rate pass-through, and the cost channel of monetary policy transmission," *Economic Modelling*, vol. 26(6): 1310-1327.

[28] Iacoviello, M. (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review* 95, no. 3: 739-764.

[29] Iacoviello, M. and Neri, S. (2010). 'Housing Market Spillovers: Evidence from an Estimated DSGE Model', *American Economic Journal: Macroeconomics*, vol. 2(2), pp. 125−164.

[30] Kimball, M. (1995). "The Quantitative Analytics of the Basic Neomonetarist Model," *Journal of Money, Credit and Banking*, vol. 27(4): 1241-1277.

[31] Kiyotaki, N. and J. H. Moore (1997). "Credit Cycles," *Journal of Political Economy,* 105, 211-248.

[32] Kollmann, R., Z. Enders, and G.J. Müller (2011). "Global Banking and International Business Cycles," *European Economic Review*, 55, 407-426.

[33] Leuvensteijn, M., C. Sørensen, J. Bikker, and A. van Rixtel (2008): "Impact of Bank Competition on the Interest rate Pass-through in the Euro Area," ECB WP 885.

[34] Levin, A. T., J. D. López-Salido, and T. Yun (2007). "Strategic Complementarities and Optimal Monetary Policy," Kiel Working Papers 1355, Kiel Institute for the World Economy.

[35] Mandelman, F. (2011): "Business Cycles and the Role for Imperfect Competition in the Banking System", *International Finance*, 14(1), 103-133.

[36] Maudos, J., and J. Fernández de Guevara (2004): "Factors Explaining the Interest Margin in the Banking Sectors of the European Union," *Journal of Banking and Finance*, 28, 2259-2281.

[37] Monacelli, T. (2007): "Optimal Monetary Policy with Collateralized Household Debt and Borrowing Constraints", in *Asset Prices and Monetary Policy*, J. Campbell (ed.), University of Chicago Press.

[38] Nakamura, E., and J. Steinsson (2008). "Five Facts about Prices: A Reevaluation of Menu Cost Models," *Quarterly Journal of Economics*, 123(4), 1415-1464.

[39] Repullo, R. (2004). 'Capital Requirements, Market Power, and Risk-taking in Banking', *Journal of Financial Intermediation*, 13(2), 156−182.

[40] Rotemberg, J. and M. Woodford (1997): "An Optimization-Based Econometric Model for the Evaluation of Monetary Policy". *NBER Macroeconomics Annual*, 12, 297-346.

[41] Salop, S. (1979): "Monopolistic Competition with Outside Goods," *Bell Journal of Economics* 10: 141-156.

[42] Santos, J.A.C., and A. Winton (2008): "Bank Loans, Bonds, and Information Monopolies across the Business Cycle," *Journal of Finance*, 63(3): 1315-1359.

[43] Saunders, A., and L. Schumacher (2000): "The Determinants of Bank Interest Rate Margins: An International Study," *Journal of International Money and Finance*, 19, 813-832.

[44] Strahan, P.E. (2003): "The Real Effects of U.S. Banking Deregulation," *Federal Reserve Bank of St. Louis Review*, 85, 111-128.

[45] Woodford, M. (2003): *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.

Table 1. Baseline calibration

	Value	Target/Source	Description
β	0.993	$R^D_{ss}/\pi_{ss} = (1.03)^{1/4}$	household discount factor
β^e	0.95	standard	entrepreneur discount factor
ν	0.05	$p^h_{ss}h^e_{ss}/(4y_{ss}) = 0.62$	elasticity of output wrt real estate
ϑ	0.11	$\omega p^h_{ss}h_{ss}/\left[4\left(1-\omega\right)y_{ss}\right] = 1.40$	relative weight on housing utility
n/α	1.58	$4(R^L_{ss} - R^D_{ss}) = 2.5\%$	number of banks/distance cost
ω	0.979	$\tau^e = 0$	household share of population
m	0.85	Iacoviello and Neri (2010)	pledgeability ratio
φ	2	$1/\varphi = 0.5$	(inverse of) labor supply elasticity
ε	6	$\varepsilon/\left(\varepsilon-1\right) = 1.20$	intratemporal elasticity of subst.
θ	0.67	$1/(1-\theta) = 3$ qrts	Calvo parameter
ρ_a	0.93	CSIP-FRBSF TFP series	autocorrelation TFP
σ_a	0.0067	CSIP-FRBSF TFP series	standard deviation TFP shock
ρ_m	0.75	$1/\rho_m = 4$ qrts	autocorrelation pledgeability ratio
σ_m	0.0118	$\sigma_m m = 1$ pp	standard dev. pledgeability ratio shock

Table 2. Correlation between bank lending margins and output

Model	Data range
-0.20	$(-0.31, -0.14)$

Data source: Aliaga-Díaz and Olivero (2010), Kollmann et al. (2011)

Table 3. Standard deviation of stabilization goals and welfare loss, productivity shocks

Policy rule	$4\hat{\pi}_t$	$\hat{y}_t - \hat{y}_t^*$	$\hat{c}_t - \hat{c}_t^e$	$\hat{h}_t - \hat{h}_t^*$	Welfare loss
inflation targeting	0	0.05	7.82	3.17	0.05
output gap targeting	0.57	0	6.56	2.66	0.04
optimal policy	0.54	0.33	2.34	0.95	0.01
simple targeting rule**	0.63	0.21	3.46	1.40	0.02

Note: standard deviations in %, welfare loss as a % of steady-state consumption

** optimal weight: $\zeta = 0.212$

Table 4. Standard deviation of stabilization goals and welfare loss, pledgeability ratio shocks

Policy rule	$4\hat{\pi}_t$	$\hat{y}_t - \hat{y}_t^*$	$\hat{c}_t - \hat{c}_t^e$	$\hat{h}_t - \hat{h}_t^*$	Welfare loss
inflation targeting	0	0.02	2.57	3.96	0.06
output gap targeting	0.37	0	2.44	4.06	0.06
optimal policy	0.42	0.27	5.81	2.60	0.04
simple targeting rule**	0.37	0.13	3.35	3.51	0.05

Note: standard deviations in %, welfare loss as a % of steady-state consumption

** optimal weight: $\zeta = 0.262$

Table 5. Banking competition and welfare loss, productivity shocks

Banking regime	$4\hat{\pi}_t$	$\hat{y}_t - \hat{y}_t^*$	$\hat{c}_t - \hat{c}_t^e$	$\hat{h}_t - \hat{h}_t^*$	Welfare loss
		Inflation targeting			
baseline calibration	0	0.05	7.82	3.17	0.049
perfect competition	0	0.06	9.54	3.84	0.072
		Output gap targeting			
baseline calibration	0.57	0	6.56	2.66	0.042
perfect competition	0.81	0	7.66	3.09	0.061
		Optimal policy			
baseline calibration	0.54	0.33	2.34	0.95	0.014
perfect competition	0.60	0.36	2.19	0.88	0.016
		Simple targeting rule**			
baseline calibration	0.63	0.21	3.46	1.40	0.020
perfect competition	0.74	0.24	3.57	1.44	0.024

Note: standard deviations in %, welfare loss as a % of steady-state consumption

** optimal weights: $\zeta = 0.212$ (baseline) and $\zeta = 0.251$ (perfect competition)

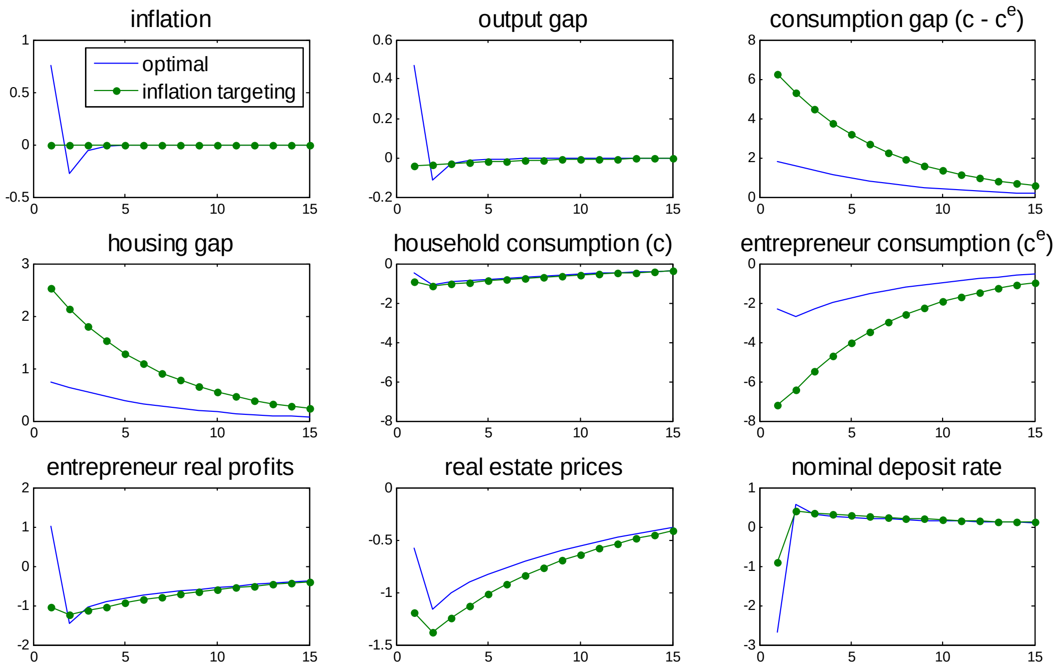
Table 6. Banking competition and welfare loss, pledgeability ratio shocks

Banking regime	$4\hat{\pi}_t$	$\hat{y}_t - \hat{y}_t^*$	$\hat{c}_t - \hat{c}_t^e$	$\hat{h}_t - \hat{h}_t^*$	Welfare loss
			Inflation targeting		
baseline calibration	0	0.02	2.57	3.96	0.058
perfect competition	0	0.02	3.10	3.92	0.058
			Output gap targeting		
baseline calibration	0.37	0	2.44	4.06	0.064
perfect competition	0.49	0	2.83	4.06	0.067
			Optimal policy		
baseline calibration	0.42	0.27	5.81	2.60	0.038
perfect competition	0.33	0.22	6.33	2.84	0.041
			Simple targeting rule**		
baseline calibration	0.37	0.13	3.35	3.51	0.050
perfect competition	0.32	0.12	3.97	3.53	0.051

Note: standard deviations in %, welfare loss as a % of steady-state consumption

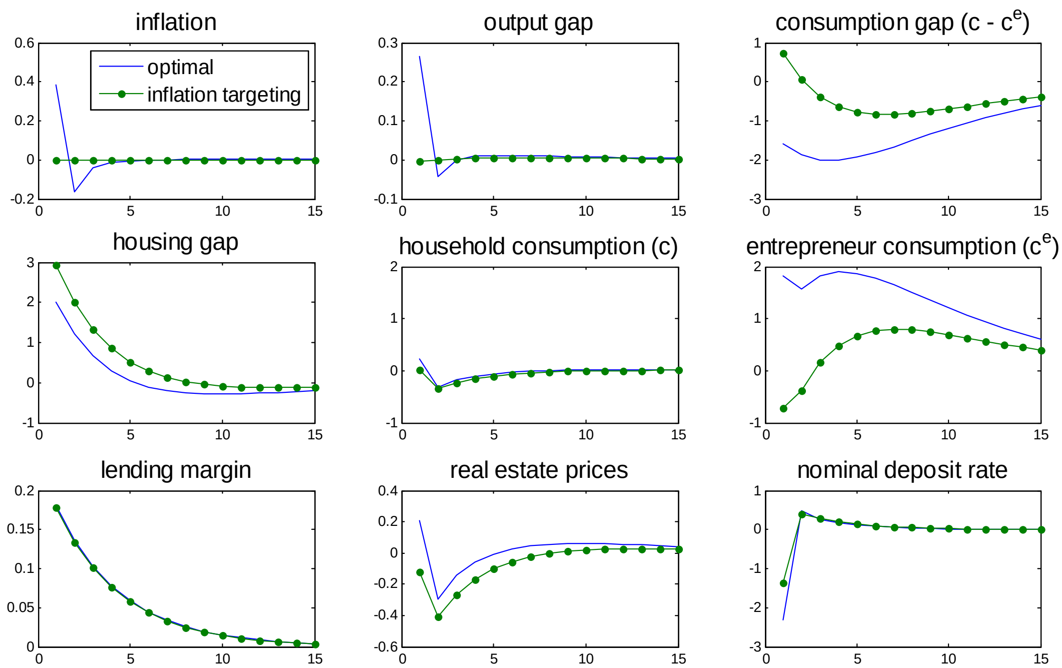
** optimal weights: $\zeta = 0.262$ (baseline) and : $\zeta = 0.226$ (perfect competition)

Figure 1: Impulse-responses to a negative productivity shock



Note: all variables in %; inflation and interest rates in annualized terms

Figure 2: Impulse-responses to a negative shock to the pledgeability ratio ('credit crunch')



Note: all variables in %; inflation, interest rates and lending margins in annualized terms