Banking Competition, Housing Prices and Macroeconomic Stability*
[Forthcoming in *The Economic Journal*]

Javier Andrés[†] Oscar Arce[‡]

March 2012

Abstract

We develop a macroeconomic model with an imperfectly competitive bank-loans market and collateral constraints that tie investors' credit capacity to the value of their real estate holdings. Lending margins are optimally set by banks and have a significant effect on aggregate variables. Over the long run, stronger banking competition increases output by triggering a reallocation of available collateral towards investors. In the short-run output, credit and housing prices, are more responsive on impact to shocks in an environment of highly competitive banks. Also, stronger banking competition implies higher (lower) persistency of credit and output after a monetary (credit-crunch) shock.

JEL numbers: E32, E43, E44, G21.

'[

*Corresponding author: Oscar Arce, CNMV, Research and Statistics Department,Calle Miguel Ángel 11, 28010 Madrid. We are grateful to Larry Christiano, Giancarlo Corsetti, Giovanni Dell'Ariccia, Martin Ellison, Jordi Galí, Matteo Iacoviello, Juan F. Jimeno, Robert Kollman, David López-Salido, Caterina Mendicino, Gabriel Pérez-Quirós, José-Victor Ríos-Rull, Jesús Saurina, Carlos Thomas, Garry Young and seminar participants at the 2nd International Conference on Macroeconomics at Fundación Rafael del Pino (Madrid), Bank of Spain, CCBS/WGEM workshop at Bank of England, Sveriges Riksbank workshop on "Household Indebtness, House Prices and the Economy", EACBN/CREI conference on "Business Cycle Developments, Financial Fragility, Housing and Commodity Prices", European Central Bank workshop on "Monetary policy transmission mechanism in the euro area in its first 10 years" and, especially editor Andy Scott and one anonymous referee for valuable comments. The opinions expressed here are solely those of the authors and do not necessarily reflect the views of the CNMV. Javier Andrés acknowledges financial support by CICYT grants ECO2008-04669 and ECO2011-29050.

[†]Universidad de Valencia and Bank of Spain. E-mail: javier.andres@uv.es

[‡]CNMV (Spanish Securities Market Commission). E-mail: oarce@cnmv.es

The role of financial intermediaries in the monetary transmission mechanism has been largely neglected in the study of macroeconomic fluctuations. Until recently, most dynamic stochastic general equilibrium models (DSGE) that were used to conduct monetary policy analyses incorporated a frictionless financial sector. One key implication of this assumption is that the interest rate set by the central bank coincides with the rate that affects agents' lending and borrowing decisions. However, interest rate spreads are neither zero nor constant in real economies. In fact, spreads are non-negligible and tend to vary significantly over the cycle. To the extent that spreads respond themselves to changes in the monetary policy rate, it is clear that a solid framework for monetary policy analysis must consider the optimal pricing rules followed by financial intermediaries.

Bernanke *et al.* (1999; BGG, henceforth) provide a framework that links financial imperfections, interest rate spreads (the external finance premium) and monetary policy that builds upon the financial accelerator model of Bernanke and Gertler (1989). That theory contends that a positive spread is a natural outcome in an environment featuring principal-agent conflicts between borrowers and lenders.

The framework we develop in this paper shares some features with BGG, chief among them is the role played by the ability of borrowers to supply collateral. However we start from different grounds. We place imperfect competition among banks in the market for loans at the centre of the analysis of endogenous interest rate spreads. As discussed later, imperfect competition among banks has received ample empirical support. In the end, both frictions, imperfect competition and asymmetric information and agency costs in lending relationships, are likely to coexist in reality.

The central question we pose in this paper is the following: How does the degree of banking competition shape the response of the economy to different shocks? To answer it we develop a general equilibrium version of the spatial monopolistic competition model of Salop (1979) in which the demand for loans is modelled explicitly as the outcome of an intertemporal problem of utility maximization.[1] This modelling choice delivers a good compromise between simplicity and economic content. On one end, the model is sufficiently simple to deliver closed-form solutions for the equilibrium lending margins while, on the other, it is rich enough to accommodate a number of complexities that arise from the funding demand side. As regards the latter, we consider an endogenous collateral constraint of the kind analyzed by Kiyotaki and Moore (1997) that links the borrowers' credit capacity to the value of their real estate holdings, in the spirit of Iacoviello (2005). This last assumption is motivated by the fact that real estate is an important collateral asset for firms and a significant determinant of business investment (see e.g. Chaney *et al.* 2010).

In the equilibria we analyze here, (patient) households provide deposits to the banks that use them to make loans to (impatient) entrepreneurs who are subject to collateral constraints. This implies that the demand for funds faced by banks is related not only to the interest rate on loans but also to the expected rate of growth of housing prices and to the tightness of the borrowing constraints, as both determine the amount of collateral pledged by entrepreneurs. The elasticity of the demand for funds at the individual level rises when housing prices are expected to rise and when borrowing constraints are loose, for in either case a small change in the lending rate triggers a large increase in the collateral pledged by borrowers, thus, increasing their demand for funds and inducing lower lending margins. The model also produces a positive relationship between the banks marginal cost, which corresponds to the monetary policy rate, and the lending margin.

All the previous factors together with the intensity of banking competition affect the extensive margin. Stronger competition due to a fall in the monopoly power of banks goes hand in hand with lower margins. Thus, in our model rising real estate prices, loose

[1] The Salop model of monopolistic competition has been extensively used in the literature on banking industrial organization. In this context, this model has been used including, among others, by Chiappori et al. (1995), Freixas and Rochet (1997), Dell'Ariccia (2001) and Repullo (2004).

credit limits and low cost of bank liabilities which, arguably are all natural features of housing booms, tend to depress lending margins and to further drive credit growth. In this way, the model features a monetary policy accelerator, since a shock to the policy rate translates into a more than proportional change in the lending rate.

A first important feature of the model is that stronger competition among banks raises output over the long-run. As banks charge lower margins, the relative user cost of real estate for borrowers vis-à-vis savers falls, since the user cost is positively related to the lending rate for the former and to the deposits rate for the latter. This, in turn, implies a rise in the value of the stock of real estate held by investors. Such a reallocation of the pledgeable asset towards investors raises investment, output and consumption. Thus, stronger banking competition greases the economy's wheels in the long run.

The effects of banking competition on the economy's short-run dynamics are more complex due to the presence of several competing effects. On one hand, lower lending margins lead to higher leverage ratios which tend to exacerbate the short-run response of housing prices, consumption and output. On the other hand, low lending margins facilitate a faster recovery of the investors' net worth and, hence, their borrowing and production capacity in face of an adverse shock. Which of these conflicting forces -*short-run volatility* versus *persistency*- dominates depends crucially on the nature of the shock at work.

In face of a contractionary monetary shock both housing prices and total output exhibit a larger and more persistent fall as the banking sector becomes more competitive. Following the shock, the subsequent negative debt-deflation and collateral (housing price deflation) effects are both amplified in the presence of strong banking competition and high leverage ratios. On the other hand, as competition in the market for loans intensifies, the positive response of lending margins becomes weaker and this mitigates the adverse effects on the previous variables. However, this latter effect is very small and, for reasonable parameterizations of the model, the net worth effect dominates it. Hence, in the face of monetary shocks, stronger banking competition works as an amplification mechanism of net worth effects.

Things are different when the economy faces a temporary tightening of collateral requirements, an issue which is arguably a central feature of the global credit-crunch that followed the collapse of Lehman Brothers in September 2008. In the context of our model, stricter credit rationing leads banks to also pursue aggressive margin increases which, in turn, tend to postpone the economy's recovery for a longer time. Thus, following such a credit-crunch shock, stronger banking competition mitigates the countercyclical response of spreads and works to reduce the total output loss over longer horizons.

Although the model is too stylized to account for some key facts of the recent global financial crisis, it is helpful to shed light on several issues around this episode and the ensuing debate on the potential trade-off between bank competition and stability (see e.g. Berger *et al.* 2008; Beck *et al.* 2010; Vives 2010; Allen *et al.* 2011). In particular, as discussed in Section 1, there is evidence that both in the US and in Europe the level of competition faced by commercial banks is likely to have increased during the years that preceded the crisis. This would have contributed, along the lines of the model of this paper, towards higher leverage on the part of the borrowers. This, in turn, would have acted as an amplification mechanism at the time at which the financial markets turbulences of the summer of 2007 hit most Western economies. Along these lines, stronger banking competition would have contributed towards higher macroeconomic short-run instability. On the other hand, by partly offsetting the latter impact-effect, the model would predict that maintaining a higher level of competition in this sector would facilitate the recovery of credit and activity after an adverse shock, especially if that shock triggers tighter credit constraints.

In the sense just described, the model of this paper helps us identify several channels through which the degree of banking competition affects macroeconomic stability. In Section 1 we frame our paper in the context of the related literature, both empirical and theoretical. Section 2 develops the model. Section 3 contains the analysis of the deterministic steady state of the model. Section 4 discusses fluctuations around the steady-state in response to monetary and financial shocks using a linearized version of the model. Section 5 concludes.

1 Related Literature

In this section we first discuss the connections of this paper with a number of empirical facts highlighted in the literature on banking competition. In particular, we take the most salient empirical regularities in this field as guidance for the analytical exercises performed later. Then, we explain the relationship between the model and the results of this paper with those contained in a number of recent contributions in the field of banking and the macroeconomy.[2]

1.1 *Empirical Facts*

Our paper relates to several branches of the existing empirical literature on banking.[3] First, the basic modelling assumption of monopolistic competition in the banking sector is motivated by ample evidence suggesting that this industry is best characterized by that market structure. The negative relationship between the degree of banking competition and lending margins,[4] which is a central feature of our model, has been documented by

[2] Also, the branch of the literature on banking competition that is focused on regulatory issues has recently enjoyed a renewed interest in the context of the sub-primer crisis of 2007 and its aftermath (see e.g. Vives, 2010) for a recent review). Regulatory issues, however, are beyond the scope of this paper.

[3] Claessens (2009) contains an exhaustive recent survey on this field.

[4] In the empirical literature, the net interest margin is usually measured as the interest income minus the interest expense divided by interest-bearing assets. This measure coincides with the notion of lending margin used in this paper.

a number of recent multi-country studies like those in Barth *et al.* (2003), Claessens and Laeven (2004), Demirguc-Kunt *et al.* (2003), van Leuvensteijn *et al.* (2008).

Of course, monopolistic power is not the only potential source of positive lending spreads, for these are also likely to be affected by the borrowers' risk-profile, the volatility of the interest rates, intermediation costs, regulatory factors, etc. Interestingly, the papers that have decomposed the relative importance of the various factors aforementioned on the lending margins have found evidence in favour of the hypothesis that monopolistic power is a significant determinant of margins. For instance, Saunders and Schumacher (2000) find that pure monopolistic rents accounted for almost 70% of total net margins earned by U.S. commercial banks in 1995. Dick and Lehnert (2007) provide evidence on the importance of the deregulation process in the U.S. in the 1980s, that removed restrictions on branching and lifted barriers on interstate banking, on the interest rate and volume of credit flows through the effects of those regulatory changes on the level of bank competition.[5]

As regards the connection between banking competition and economic growth, Cetorelli and Gambera (2001), Claessens and Laeven (2005), and Strahan (2003), among others, have found evidence that stronger competition exerts a positive effect on long-run growth. Although our model is not adequately equipped to analyze long-run growth dynamics (there is no positive growth in the steady state), it sheds light on a channel through which tighter banking competition may cause a higher level of output over a long horizon, namely through the positive effects of lower interest rate margins on investors' collateral and borrowing capacity.

Switching the focus towards short-run dynamics, several studies have estimated a countercyclical pattern in the interest rate margins that is reminiscent of the existing evidence for business-cycle profile of the external finance premium in the financial ac-

[5] See also Guiso *et al.* (2007) and Maudos and Fernández de Guevara (2004).

celerator literature (see e.g. Levin *et al.*, 2004). Aliaga-Díaz and Olivero (2010) and Duecker and Thornton (1997) both report a robust negative correlation between interest rate spreads up in the U.S. banking industry and an indicator of the business cycle. Also for the U.S., Santos and Winton (2008) find that during recessions, banks rise their interest rates more for bank-dependent borrowers than for those with direct access to bond market financing. Furthermore, they attribute these findings to the role played by information-based monopolistic rents gained by banks rather than to the different risk profile of borrowers with access to public bond markets as opposed to those without such option.[6] The functioning of our model is consistent with countercyclical margins, although the intensity of their response varies considerably depending on the nature of the shocks.

Goodhart *et al.* (2004) exploit data from a sample of OECD countries and find that measures aimed at fostering banking competition tend to increase the sensitivity of bank lending to real estate price movements which, in turn, contributes to strengthening the links between bank credit and business cycles. Interestingly, they point towards the strengthening of the borrowers' net worth channel following financial liberalization as a prime cause of such increased sensitivity. In a similar vein, Adams and Amel (2005) find that in the U.S. the impact of monetary policy on banks loan originations is weaker in less competitive markets. The mechanism of our model that produces a positive relationship between margins, on the one hand, and leverage and short-run volatility, on the other, is consistent with these empirical findings.

1.2 *Banking and the Macroeconomy*

Our paper has also some natural links with several strands of theoretical literature on financial frictions in macroeconomic models. Starting with the hypothesis of imperfect

[6] See also Mandelman (2011) and van Leuvensteijn *et al.* (2008).

banking competition, the closest models to ours are those by Aliaga-Díaz and Olivero (2010), Mandelman (2011) and Stebunovs (2008). In Aliaga-Díaz and Olivero (2010) market power arises from switching costs faced by costumers when moving from one bank to another. Mandelman (2011) models banking competition as an entry game in which potential competitors face fixed settlement costs and incumbents play strategies to deter entry. Stebunovs (2008) also provides a model of spatial monopolistic banking competition with endogenous entry of firms. All these papers find that weaker banking competition causes a larger output response to shocks due to countercyclical lending margins. While our model also features countercyclical lending margins, we emphasize that not only fluctuations in the margin but also its average level (which is a key determinant of the leverage ratio) affect the way the economy responds to shocks. More specifically, the relative strength of these two channels -margins dynamics and leverage- varies with the nature of the shock and hence the relationship between output volatility and banking competition becomes shock-specific too.

Apart from differences in the strategy followed to model banking competition, key to the arguments developed in the present paper is the idea that some agents face borrowing constraints that limit their ability to obtain external finance. In fact, the relationship between the degree of banking competition and the responsiveness of the main macro aggregates in our model hinges crucially on the way in which the two financial frictions - imperfect competition and endogenous borrowing limits- interact with each other. Gertler and Kiyotaki (2010) also combine these two features to study some key aspects of the current crisis such as the disruption in the interbank market and the effect of credit policies. While they focus on the effect of collateral constraints faced by banks within a perfectly competitive financial industry, we look at another supply side characteristic of the banking sector, namely market power, and study its interaction with constraints on the demand side of the loans market.

Huelsewig *et al.* (2006) and Gerali *et al.* (2010) both feature economies with an imperfectly competitive banking sector, in which banks compete à la Dixit-Stiglitz, and examine the macroeconomic consequences of sluggishness in the adjustment of interest rates. We depart from the assumption of interest rate rigidity and rather consider an economy in which lending margins vary endogenously. This strategy allows us to explore in a rather natural way the mutual feedback arising between bank lending margins and the main macroeconomic variables of the model. Such feedback forces turn out to be an important channel through which bank competition shapes the economy's response to different shocks by triggering, muting or exacerbating them.

Goodfriend and McCallum (2007), Christiano *et al.* (2009), Canzoneri *et al.* (2008) and Cúrdia and Woodford (2009) also provide recent analyses on the role of financial intermediaries in general equilibrium monetary models although none of them consider imperfect banking competition. Rather, some of these papers look at the implications of exogenous margins whereas others focus their attention in the way different loan-producing banking technologies influence the equilibrium determination of interest rates and whether they amplify or attenuate the effects of macroeconomic shocks. As we are mainly interested in isolating the macroeconomic effects of imperfect banking competition, in our baseline model we instead consider a simple technology for loan production.

2 The Model

The economy consists of continuum of households with measure 1 and a continuum of entrepreneurs of mass 1 producing a homogenous consumption good, a continuum of retailers of mass 1 that differentiate the output of the entrepreneurs, a fixed number $n > 2$ of banks and a central bank in charge of monetary policy. Households and entrepreneurs obtain utility from consumption of a composite good. Also, the flow of services produced by their real estate stocks delivers utility directly to households, while entrepreneurs employ real estate as a production factor. The stock of real estate $\overline{H}$, is fixed in the aggregate and can be allocated indistinctly and frictionlessly in the household sector (residential use) or in the production sector (commercial use).[7]

Households and entrepreneurs participate in the credit market either lending or borrowing funds. As in Iacoviello (2005), we assume that the entrepreneurs are less patient so that they discount future utility more heavily than the households. This assumption implies that in the steady state equilibrium households optimally choose to lend while entrepreneurs borrow.[8] Only bank-intermediated credit is available so that the households supply funds (henceforth, deposits) to the banking sector and the latter make loans to the entrepreneurs. We assume that competition in the loans market is imperfect so that each bank enjoys some monopolistic power whereas the market for deposits is perfectly competitive. Also, we assume a cash-less economy and abstract from any role of money in the economy beyond that of serving as numeraire.

In order to model imperfect competition in the loans market we assume that entrepreneurs are distributed uniformly on a circumference of unit length. Individual locations vary each period according to an *i.i.d.* stochastic process. Changing individual locations in that way rules out the possibility that banks learn about lenders position which, in turn, simplifies the analysis by removing dynamic strategic interactions among banks, as those studied by Dell'Ariccia (2001). Banks are located symmetrically on this circumference. Their position is time-invariant. An entrepreneur asking for credit has to travel

[7] The assumption of a fixed stock of real estate units is made for simplicity. An earlier draft of the paper featuring a rental market and an endogenous flow of real estate services is available upon request. Also, a preliminary version of the model featuring depreciation of the real estate stock and a construction sector, along the lines of Iacoviello and Neri (2010), produced qualitatively similar results to those reported here. Key to this is the fact that the rate of depreciation of real estate, which matches the flow of new units in the steady state, is typically low in real economies. For instance, Davis and Heathcote (2005) estimate that housing in the US depreciates at a modest 1.6 per cent per year.

[8] An appendix containing an extension of the model in which a fraction of (impatient) households also borrow from banks is available upon request. That appendix also includes some empirical results of the kind reported later in the extended model. The qualitative results of the paper are not altered by that extension.

to a bank incurring a utility cost which is proportional to the distance between his and the bank's location.[9] Given this cost, entrepreneurs optimally choose every period their lending bank to maximize the discounted present value of their lifetime utility. Banks set profit-maximizing lending rates taking into account that a higher rate raises unit margins at the cost of reducing the individual demand for funds (intensive margin) and its market share (extensive margin). With this spatial environment in mind we next describe the objectives and constraints faced by each type of agent.

2.1 *Households*

Let C_t, H_t, and L_t represent, respectively, consumption, housing services and hours worked for a household who has a subjective discount factor $\beta \in (0,1)$ and seeks to maximize

$$U_0 = E_0 \sum_{t=0}^{\infty} (\beta)^t \left(\log C_t - L_t + \vartheta \log H_t \right), \tag{1}$$

subject to the sequence of budget constraints

$$C_t + I_t + \frac{\phi I_t^2}{2K_{t-1}} + P_t^h (H_t - H_{t-1}) + D_t = W_t L_t + P_t^k K_{t-1} + \int_0^1 \Gamma_{jt} dj + \sum_{i=1}^{n} \Omega_t^i + \frac{R_{t-1}^d D_{t-1}}{\pi_t}, \tag{2}$$

and the capital accumulation equation

$$K_t = I_t + (1 - \delta) K_{t-1}. \tag{3}$$

At the beginning of period t the household receives labour income $W_t L_t$, where W_t is the real wage, and income from renting his capital holdings, K_{t-1}, to entrepreneurs at a real

[9] This utility cost is a pragmatic modelling device aimed at capturing the sources of monopolistic power by banks over and above those strictly related to literal transportation cost. But even the literal interpretation of geographical distance between lenders and borrowers as an explanatory variable for pricing and availability of credit has received some attention in the empirical literature (see e.g. Petersen and Rajan, 2002; Degryse and Ongena, 2005). Indeed, Petersen and Rajan (1995) use borrower-bank distance as a proxy for monopolistic banking power.

rental price P_t^k. Γ_{jt} and Ω_t^i are dividends from ownership of the j_{th} retail firm and the i_{th} bank, respectively. D_{t-1} is the real value of nominally risk-free one-period bank deposits carried over from $t-1$, that pay a nominal gross rate R_{t-1}^d at the beginning of t, and π_t is the gross inflation rate. I_t represents capital investments and the term $\phi(I_t^2/2K_{t-1})$ captures capital adjustment costs with a non-negative constant ϕ. H_t stands for the stock of houses owned by the household and P_t^h is the real unit housing price in terms of consumption goods. We assume that households derive utility from housing services that are proportional to their housing holdings. Real estate does not depreciate while capital depreciates at a rate δ.

The first order conditions for consumption (4), labour supply (5), owner-occupied real estate demand (6), deposits (7) and capital supply (9) are

$$\frac{1}{C_t} = \lambda_t, \tag{4}$$

$$\lambda_t W_t = 1, \tag{5}$$

$$\lambda_t P_t^h = \frac{\vartheta}{H_t} + \beta E_t \left(\lambda_{t+1} P_{t+1}^h \right), \tag{6}$$

$$\lambda_t = \beta E_t \left(\lambda_{t+1} R_t^d / \pi_{t+1} \right), \tag{7}$$

$$Q_t = 1 + \phi I_t / K_{t-1} \tag{8}$$

$$\left(Q_t - P_{t+1}^k \right) \lambda_t = \beta E_t \left\{ \lambda_{t+1} \left[\frac{\phi}{2} \left(\frac{I_{t+1}}{K_t} \right)^2 + (1-\delta) Q_{t+1} \right] \right\}, \tag{9}$$

where λ_t is the Lagrange multiplier on the flow of funds constraint (2). The shadow value of installed capital, Q_t, is the familiar Tobin's Q. We define the housing *user cost* for a household, denoted by ϖ_t, as the marginal rate of substitution between consumption of goods and housing services. Combining (4) and (6), we can express the user cost as,

$$\varpi_t \equiv \frac{\vartheta C_t}{H_t} = P_t^h - \beta E_t \left(P_{t+1}^h \frac{C_t}{C_{t+1}} \right). \tag{10}$$

2.2 *Production*

2.2.1 *Entrepreneurs*

The representative entrepreneur operates in a perfectly competitive environment and produces an intermediate good, Y_t, that is sold to a final-goods sector which is introduced later. The production function is

$$Y_t = A_t \left(K_t^e\right)^{\mu} \left(L_t^e\right)^{(1-\mu-\nu)} \left(H_{t-1}^e\right)^{\nu}, \tag{11}$$

where A_t is an exogenous productivity index, K_t^e is capital, L_t^e is labour and H_t^e is real estate. As for the objective function, we assume that an entrepreneur located at point $k \in (0, 1]$ seeks to maximize the following utility function,

$$U_0^e = E_0 \sum_{t=0}^{\infty} \left(\beta^e\right)^t \left(\log C_t^e - \alpha d_t^{k,i}\right), \tag{12}$$

where C_t^e, $d_t^{k,i}$ and α denote consumption, the distance between entrepreneur k and bank i, and the utility loss per distance unit, respectively. Entrepreneurs are assumed to be more impatient than savers, so that $\beta^e < \beta$. The entrepreneur faces the following flow of funds constraint

$$C_t^e + P_t^h(H_t^e - H_{t-1}^e) + R_{t-1}^e B_{t-1}^e/\pi_t = B_t^e + Y_t/X_t - W_t L_t^e - P_t^k K_t^e, \tag{13}$$

where X_t denotes the markup of final over intermediate goods charged by retailers and a borrowing constraint of the form,

$$B_t^e \leq m_t E_t P_{t+1}^h \frac{\pi_{t+1}}{R_t^e} H_t^e, \tag{14}$$

where m_t (< 1) is the loan-to-value ratio. B_t^e is the real value of a nominal one-period bank loan taken at t, and R_t^e is the gross nominal interest rate on such loan, payable at the beginning of $t+1$. That is, at time t entrepreneurs can only borrow up to a fraction m_t of the discounted next-period resale value of their time t stock of real estate.

The dual role of commercial real estate as a production input and a pledgeable asset has been explicitly acknowledged before in the context of a macrofinancial model by e.g. Iacoviello (2005), Aoki *et al.* (2009) and Liu *et al.* (2011). On the empirical front, Chaney *et al.* (2010) estimate over the period 1993-2007 an elasticity of corporate investment with respect to the value of corporate collateral of 6% for the typical U.S. public firm. They argue that a rise in collateral increases debt capacity and, hence, fuels investment, finding an elasticity of debt with respect to collateral of 4%. These authors show that in 1993, 58% of U.S. public firms owned some real estate whose market value accounted for near one fifth of the company's total market value. Similar effects of changes in the value of real estate collateral on corporate investment in the U.S. have been recently reported by Liu *et al.* (2011) while Gan (2007) offers evidence on the significance of this channel in Japan in the 1990s.

The first order conditions of the representative entrepreneur for consumption (15), capital demand (16), labour demand (17), debt (18), and housing demand (19) are,

$$\frac{1}{C_t^e} = \lambda_t^e, \tag{15}$$

$$P_t^k = \frac{\mu Y_t / X_t}{K_t^e}, \tag{16}$$

$$W_t = \frac{(1-\mu-\nu)\, Y_t / X_t}{L_t^e}, \tag{17}$$

$$\lambda_t^e = \beta^e E_t \left(\lambda_{t+1}^e \frac{R_t^e}{\pi_{t+1}} \right) + \xi_t^e, \tag{18}$$

$$\lambda_t^e P_t^h = \beta^e E_t \left[\lambda_{t+1}^e \left(P_{t+1}^h + \frac{\nu Y_{t+1}/X_{t+1}}{H_t^e} \right) \right] + \xi_t^e m_t E_t P_{t+1}^h \frac{\pi_{t+1}}{R_t^e}. \tag{19}$$

We will look at equilibria in which R_t^e is low enough so that (14) binds and the multiplier ξ_t^e, is positive. Now, the user cost for an entrepreneur, ϖ_t^e, is given by the ratio between the marginal utility of consumption to the expected marginal product of housing properly discounted, i.e.

$$\varpi_t^e = E_t \left(\frac{\beta^e \lambda_{t+1}^e}{\lambda_t^e} \right) \frac{\nu Y_{t+1}}{X_{t+1} H_t^e},$$

which using (15) and (19) can be written as

$$\varpi_t^e = P_t^h - E_t \left[\beta^e \left(\frac{C_t^e}{C_{t+1}^e} \right) + \xi_t^e m_t C_t^e \frac{\pi_{t+1}}{R_t^e} \right] P_{t+1}^h, \tag{20}$$

which has a similar interpretation as the households user cost except for the fact that ϖ_t^e features an additional term that captures the value of an additional unit of housing as collateral.

2.2.2 *Final goods producers*

Aggregate final output, Y_t^f, is a composite of different varieties produced by monopolistically competitive retail firms with elasticity of substitution in consumers preferences equal to ε. A retail firm producing variety j buys the output of competitive intermediate firms at a real price X_t^{-1} and converts it one-to-one into a variety, Y_{jt}^f, that is sold in the market at a price P_{jt}. The demand for variety j is given by $Y_{jt}^f = (P_{jt}/P_t)^{-\varepsilon} Y_t^f$, where the aggregate price is defined by $P_t = \left[\int_0^1 (P_{jt})^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}$ and $Y_t^f = \left[\int_0^1 \left(Y_{jt}^f \right)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}$.

Prices are sticky in the retail sector. Following Calvo (1983), each period a random fraction of firms adjust prices. We denote by $\widetilde{P}_{j,t}$ the optimal price of the representative firm changing prices at t and by $1-\theta$ the probability that a firm adjusts prices. Also we assume that those firms that do not set their prices optimally at t follow a simple indexation rule to steady-state inflation of the form $P_{j,t} = \pi P_{j,t-1}$. Then, $\widetilde{P}_{j,t}$ maximizes the expected present discounted value of future dividends subject to the demand function

$$\widetilde{p}_{jt} = \left(\frac{\varepsilon}{\varepsilon - 1}\right) \frac{E_t \sum_{\widetilde{k}=0}^{\infty} (\beta\theta)^{\widetilde{k}} \left(\frac{C_t}{C_{t+\widetilde{k}}}\right) mc_{j,t,t+\widetilde{k}} Y^f_{j,t+\widetilde{k}} \prod_{i=1}^{\widetilde{k}} \pi_{t+i}}{E_t \sum_{\widetilde{k}=0}^{\infty} (\beta\theta)^{\widetilde{k}} \left(\frac{C_t}{C_{t+\widetilde{k}}}\right) Y^f_{j,t+\widetilde{k}} \prod_{i=1}^{\widetilde{k}} (\pi)^{\widetilde{k}-1}},$$

where $mc_{j,t,t+\widetilde{k}}$, and $P_{j,t+\widetilde{k}}$ are the firm's marginal cost and the aggregate price, respectively and $\widetilde{p}_{jt} = \frac{\widetilde{P}_{jt}}{P_t}$. The aggregate price level satisfies,

$$1 = \left[\theta \left(\frac{\pi}{\pi_t}\right)^{1-\varepsilon} + (1-\theta)\widetilde{p}_t^{(1-\varepsilon)}\right]^{\frac{1}{1-\varepsilon}}.$$

Since retailers do not use other inputs in production, the expected marginal cost of the optimizing firm at $t + \widetilde{k}$ equals the inverse of the markup, X_t, i.e.$mc_{j,t,t+\widetilde{k}} = mc_{t+\widetilde{k}} = 1/X_{t+\widetilde{k}}$. Thus, the profits of the firms in this sector are $\Gamma_{jt} = \frac{X_{jt}-1}{X_{jt}} Y^f_{jt}$. Finally, in the neighbourhood of a zero inflation steady-state we approximate aggregate Y_t^f by Y_t.

2.3 *Banks*

Bank i chooses the interest rate on loans to entrepreneurs $R_t^{i,e}$, and the volume of deposits D_t^i, in order to maximize

$$E_0 \sum_{t=0}^{\infty} \prod_{s=0}^{t} \left(\beta \frac{C_{s-1}}{C_s}\right) \Omega_t^i, \tag{21}$$

where Ω_t^i stands for the bank's dividends, subject to the set of flow of funds constraints

$$\Omega_t^i + B_t^i + R_{t-1}^d D_{t-1}^i / \pi_t = R_{t-1}^{i,e} B_{t-1}^i / \pi_t + D_t^i, \tag{22}$$

and the balance-sheet identity, $D_t^i = B_t^i$.[10] Each bank takes all prices, the interest rate R_t^d (which is set by the central bank), the interest charged on loans made by its competitors and the entrepreneurs demand for funds functions as given and beyond the effect of its own actions.

In the Appendix, we show that the solution to this optimization problem in a symmetric equilibrium in which all banks set the same lending rate, R^e, implies the following expression for the interest rate margin:

$$R_t^e - R_t^d = \frac{1 - m_t E_t \left(\pi_{t+1}^h \pi_{t+1} / R_t^d\right)}{\eta m_t E_t \left(\pi_{t+1}^h \pi_{t+1} / R_t^d\right) - 1} R_t^d, \tag{23}$$

where $\eta \equiv 1 + \frac{n}{\alpha} \frac{\beta^e}{1-\beta^e}$ and $\pi_{t+1}^h \equiv P_{t+1}^h / P_t^h$. The (nominal) margin depends negatively on the expected rate of capital gains from housing investments, the loan-to-value ratio, and the number of banks. On the other hand, margins depend positively on the deposit rate and the utility cost.

The intuition behind (23) is the following. Changes in the aforementioned variables affect the semi-elasticity of the demand for loans with respect to the interest rate which, as in any standard model of imperfect competition, is negatively related to the margin charged by a monopolistic firm.[11] Specifically, according to (14), a rise in $E_t \left(\pi_{t+1}^h \pi_{t+1}\right)$ and $m_t \pi_{t+1}^h$ and a fall in R_t^d increase the value of the collateral pledged by a borrower which, in turn, raises the demand for loans along with the total cost of servicing the debt in the future. This makes borrowers more choosy in the search for the lowest rate in the market and *caeteris paribus* eager to pay the utility cost of searching at longer distances.

[10] This is a very stylized representation of a bank's balance-sheets along which we are abstracting, among other things, from reserve requirements and intermediation costs. In the working paper version we augment the model with intermediation costs and study their implications (http://iei.uv.es/javierandres/Research/andres_arce.pdf). We find that although both changes in operating costs and in the degree of monopoly power in the banking industry affect the size of the spread between lending and borrowing rates, only the latter have a direct effect on the cyclical response of the spread and hence of other macroeconomic variables.

[11] This is a reflection of the result that links negatively the *elasticity* of the demand faced by a monopolist and its *markup*, which in this case is given by $\left(R_t^e - R_t^d\right) / R_t^d$.

This adds downward pressure to the margins charged by banks.

More formally, we notice that the borrowing constraint (14) constitutes the main channel through which changes in R_t^e affect the demand for loans. Specifically, a fall in R_t^e tends to raise the demand for loans by a constrained borrower, given $E_t P_{t+1}^h \pi_{t+1} H_t^e$ and m_t. Moreover, from (14) we see that for a level of real estate investment, $P_t^h H_t^e$, entrepreneurial debt reacts more strongly to changes in R_t^e when expected capital gains from housing investments, $E_t\left(\pi_{t+1}^h \pi_{t+1}\right)$, are high. This reflects that high expected capital gains tend to amplify the effect of a change in R_t^e on the volume of collateral pledged by the entrepreneur, and hence, the response of his demand for loans. In formal terms, the latter implies a higher semi-elasticity of the demand for loans with respect to R_t^e and, thus a lower spread. According to the same argument, we also learn that higher values of m_t tend to reduce the spread.

As regards the effect of R_t^d on the margin, we first notice that R_t^e and R_t^d are positively linked, as expected. That is, a fall in the marginal cost, R_t^d, causes a fall in the price, R_t^e. Further, a reduction in R_t^e unleashes a positive convex effect on the demand for funds, B_t^e, as can be readily seen from (14). Intuitively, this non-linear relationship implies that when interest rate is already low, an additional fall in R_t^e gives rise to a relatively large increase in B_t^e, i.e. the semi-elasticity of B_t^e with respect to R_t^e rises as R_t^d falls and, hence, R_t^e falls, thus triggering a reduction of the margin. Finally, the qualitative effects of n and α on the margin are as expected: more banks and lower distance costs reduce margins.

Equation (23) shows in rather transparent manner how the model links collateral constraints with an imperfectly competitive banking sector to produce an endogenous interest rate spread. This mechanism shares an important feature with the central proposition of BGG in which due to principal-agent conflicts the external finance premium paid by a borrower depends inversely on the soundness of the borrower's financial position, measured in terms of factors akin to the borrowers' capacity to offer collateral, such as net worth, liquidity, cash flows, etc. In our set up, a negative relationship between the interest rate margin and the borrowers' capacity to pledge collateral, as captured by the term $m_t E_t \left(\pi_{t+1}^h \pi_{t+1} / R_t^d\right)$ in (23), obtains as well. In contrast to the BGG framework, however, the channel we study here emphasizes the idea that the degree of competition among lenders also shapes the function that links a borrower's capacity to pledge collateral and the incentives faced by the lender when setting its lending rate. As such, we think of the mechanism explored here as working parallel and, potentially, amplifying or mitigating the one highlighted in BGG.

2.4 *Monetary Policy*

We assume that the central bank sets the interest rate R_t^{cb} according to a Taylor rule of the form:

$$R_t^{cb} = \rho_r R_{t-1}^{cb} + (1 - \rho_r) \left(\frac{\pi}{\beta^s} + \rho_\pi (\pi_t - \pi) \right) + \epsilon_t^R, \tag{24}$$

that represents a smoothed response of the interest rate to deviations of current inflation from its steady-state target, π. The term ϵ_t^R follows an autoregressive process, $\epsilon_t^R = \varsigma^R \epsilon_{t-1}^R + u_t^R$,where u_t^R is a white noise shock process with zero mean and and variance σ_R^2. Assuming that R_t^{cb} would be the rate prevailing in an (unmodeled) interbank market, it follows that non-arbitrage requires that $R_t^{cb} = R_t^d$, i.e. the marginal cost of external funding for banks is the same regardless of the funding source (deposits or interbank market).

2.5 *Equilibrium*

Given a sequence of shocks, we define a symmetric equilibrium in which all banks set the same interest rates ($R_t^{i,e} = R_t^e$, for all $i = 1, ..., n$), maintain the same volume of deposits and loans ($D_t^i = D_t^B$, $B_t^i = B_t^B$, for all $i = 1, ..., n$) and, hence, dividends ($\Omega_t^i = \Omega_t$), as an allocation $\{C_t, C_t^e, H_t, H_t^e, L_t, L_t^e, K_t, K_t^e, I_t, D_t, D_t^B, B_t^e, B_t^B, \Omega_t, \Gamma_t\}_{t=0}^{\infty}$ and a vector of prices $\{P_t, P_t^h, Q_t, \widetilde{P}_t, W_t, X_t, P_t^k, R_t^d, R_t^e, R_t^{cb}\}_{t=0}^{\infty}$, such that the households, the entrepreneurs and the banks solve their respective maximization problem and all markets clear: (*goods*) $Y_t = C_t + C_t^e + I_t + \frac{\phi(I_t)^2}{2K_{t-1}}$, (*housing*) $\overline{H} = H_t + H_t^e$, (*capital*) $K_{t-1} = K_t^e$, (*labour*) $L_t = L_t^e$, (*deposits*) $D_t = nD_t^B$, and (*loans*) $B_t^e = nB_t^B$.

3 Steady State Analysis

In this section we examine the long-run implications of changes in the degree of banking competition. To this aim, we first study the determinants of the steady-state lending margins and then, through some numerical exercises, we analyze how banking competition influences some variables of interest.

3.1 *Steady State Margin*

In the steady state the households subjective discount factor determines the real interest rate paid on deposits through the Euler equation (7), such that $r^d = 1/\beta$, where $r^d \equiv R^d/\pi$. (We drop the time subscript to denote a variable in the steady state.) Then, by combining the steady state version of (7) with that of (18) we can express the multiplier associated with the borrowing constraint as $\xi^e = \left(1 - \frac{\beta^e}{\beta}\frac{r^e}{r^d}\right)\lambda^e$, where $r^e \equiv R^e/\pi$. In the special case in which $r^d = r^e$ (i.e. zero real lending margins), the assumption that savers are more patient ensures that ξ^e is positive, which implies that impatient entrepreneurs are financially constrained. Furthermore, if an interest rate differential arises in the steady-state equilibrium, then the value of the multiplier associated to the collateral constraint is lower than in the zero-margin case, since the willingness to borrow falls. As long as the corresponding lending markup r^e/r^d, is bounded above by β/β^e, entrepreneurs will optimally exhaust their borrowing limits in a steady state. We henceforth restrict our analysis to steady states in which this bound is respected.[12]

Using (23), we obtain the following expression for the lending margin,

$$r^e - r^d = \frac{r^d - m}{\eta m - r^d} r^d. \tag{25}$$

This expression reflects the role of the different model components on the margin. In particular, we find that higher steady-state deposit rates r^d, which in the current context are to be understood as a lower discount factor for savers β, go hand in hand with higher margins. Stricter collateral requirements, as captured by lower m, also contribute to raise lending margins. This latter feature of the model reflects the idea that collateral constraints not only limit the *amount* of credit but may also influence its *price*. Finally, as expected, the margin is positively associated with stronger banking monopolistic power, as captured by low values of η.

3.2 *Calibration*

To evaluate numerically the main properties of the model in the steady state we next calibrate its parameters to a quarterly time period. Except for the parameters that govern the bank lending margins, for the remaining we follow a calibration strategy similar to the one pursued by Iacoviello (2005).

The households discount factor β, is set in our central scenario at 0.9926, which produces an annual real interest rate on deposits of 3%. We then set $\beta^e = 0.97$, which is within the range of the normal bands used in the previous literature.[13] We also set

[12] In the dynamic stochastic analysis of the next section we exploit a continuity argument and consider disturbances that are small enough so that the borrowing constraint also binds even when the economy temporarily departs from its steady state.

[13] The degree of impatience implicit here is higher than the one calibrated by Krusell and Smith (1998) and Campbell and Hercowitz (2009), who set $\beta^e = 0.985$. Since in our set up there is a positive lending margin, we choose a lower β^e to ensure that in the vicinity of the steady state the borrowing constraint

$m = 0.85$, which is in line with recent estimations for the U.S.[14] We set the ratio α/n equal to 1.1 in order to produce a real annual lending margin of 250 basis points.[15] This is roughly the mean value of the interval considered by Christiano *et al.* (2009) who present some previous estimates for the U.S. economy.

As regards the parameters governing the distribution of the stock of real estate between the entrepreneurs and households sectors, we set $\vartheta = 0.1$ and $\nu = 0.05$, which together imply, first, that 20% of the stock is owned by the entrepreneurs and, second, that the value of the stock of real estate used as a production factor is around 65% of annual output. These values are in line with those reported by Iacoviello (2005). The remaining parameters are more standard and we select values for them that are within the range usually considered in the literature. Specifically, μ, ε, θ, π, ρ_r, ρ_π and ϕ equal 0.35, 8, 0.75, 1.005, 0.7, 1.3, and 2, respectively.

3.3 *Long Run Effects of Imperfect Banking Competition*

The panels in Figure 1 represent the steady state value of several magnitudes along different levels of the annualized lending margin measured in real terms. The latter ranges from zero, which corresponds to a perfectly competitive banking sector (i.e. $\alpha/n = 0$) to 400 basis points, which obtains by setting $\alpha/n = 1.76$. All variables are normalized to take a value of 100 in the benchmark case described above (i.e. $\alpha/n = 1.1$).

Figure 1.1 shows that the steady state level of output is positively related to the degree of banking competition. In fact, investment and consumption of both households and entrepreneurs (Figures 1.2-1.4) all rise as α/n and, hence, lending margins fall. In order to get intuition into the mechanism behind this result, it is helpful to examine

is always binding even when we consider high margins.

[14] Iacoviello (2005) estimates this parameter at 89% and Iacoviello and Neri (2010) find a value of 85%.

[15] We herein refer to the ratio α/n rather than to α and n separately because, in a symmetric equilibrium, these two variables always enter in the solution of the model in the form of this ratio.

how competition among banks affects the distribution of the stock of real estate between households and entrepreneurs, which crucially hinges on how the user cost for an entrepreneur relative to that of a household varies with α/n. Using (10) and (20) and substituting out for ξ^e, we can write the relative user cost for an entrepreneur vis-à-vis a household as,

$$\frac{\varpi^e}{\varpi} = \frac{1 - \beta^e - \left(\frac{1}{r^e} - \frac{\beta^e}{\beta}\frac{1}{r^d}\right) m}{1 - \beta}. \tag{26}$$

The relative user cost of housing as expressed in (26) is an increasing function of α/n (Figure 1.6). This is an intuitive result. As α/n goes down, the interest rate paid by the entrepreneurs falls for any given a rate on deposits, r^d. Since the latter, which is the relevant intertemporal price for the households user cost, is unaffected by the fall in α/n, using housing services becomes relatively less expensive for entrepreneurs, thus raising their demand, H^e (see Figure 1.5). The rise in the use of housing services in the production function (11), in turn, increases output. The latter pushes up wages and entrepreneurial net worth which trigger a rise in households and entrepreneurs consumption, respectively.

4 Dynamic Analysis

In this section we use a log-linearized version if the model to analyze the dynamics of its main variables in response to several transitory shocks. The presence of collateral constraints and monopoly power in banking may induce very different responses of these variables as compared with models without these frictions. The role of housing as a pledgeable asset in a context with collateral constraints has been analyzed in Aoki *et al.* (2004), Iacoviello (2005) and Calza *et al.* (2010) and Iacoviello and Neri (2010), among others. Our focus here is on the way in which short-run dynamics are affected by the presence of monopoly power in the banking industry. To this aim we analyze a number of response functions after two types of $AR(1)$ shocks: i) a monetary policy shock affecting the Taylor rule (with autoregressive coefficient $\rho_r = 0.1$), and ii) a shock to the pledgeability ratio (m_t) with respect to its steady-state value (the autoregressive coefficient is set at $\rho_m = 0.95$).[16] We refer to this last perturbation as a credit-crunch shock, in that its direct effect consists of a reduction in the banks' willingness to lend, given everything else.

4.1 *Monetary Policy Shocks*

Herein we focus on the effects of an unanticipated temporary monetary shock, implemented as a positive innovation ϵ_t^R in (24), that raises the nominal rate R_t^d. Figure 2.1 shows the accumulated response of output under the benchmark calibration with long-run annual real lending margins of 250 b.p., and under a perfectly competitive banking sector, i.e. $\alpha/n = 0$ and a zero margin. This Figure shows that weaker banking competition tends to induce a milder and less persistent response of output. Specifically, the accumulated output loss in the economy with perfectly competitive banks is 27% higher than in the benchmark case. In order to get the intuition on these numerical findings, we next focus on three important channels through which monetary shocks affect this economy: sticky goods-prices, endogenous lending margins and net worth effects.

Price rigidity. The presence of sticky prices has the usual effect in this model. The interest rate innovation causes an upward reaction of the real interest rate that diminishes consumption, via intertemporal substitution, and investment spending. The inspection of Figure 2.2 suggests that price rigidity is unlikely to account for the sizeable differences in the output responses. In fact, the dynamics of inflation across banking structures are remarkably similar and this implies that the sacrifice ratio over a sufficiently long period, in terms of output loss relative to inflation, is also significantly higher in the economy with a more competitive banking industry.

[16] In the working paper version (http://iei.uv.es/javierandres/Research/andres_arce.pdf) we show that the main results of the paper are robust to alternative values of these $AR(1)$ coefficients.

Endogenous lending margins. The contribution of price inertia to the dynamics of output via higher real interest rates is reinforced by the countercyclical response of real lending margins in the economy with banking monopolistic power (see Figure 2.3). The following expression is the log-linearized version of the margin equation (23), in which both sides have been deflated by expected inflation in order to represent real margins and interest rates,

$$\widehat{(r^e - r^d)}_t = c_1 \widehat{r}_t^d - c_2 \widehat{\pi}_{t+1}^h, \tag{27}$$

where a hatted variable denotes deviations of that variable with respect to its steady state value. r_t^e and r_t^d are the *ex ante* real interest on loans and deposits, respectively, i.e. $r_t^e = R^e/\pi_{t+1}$ and $r_t^d = R^d/\pi_{t+1}$. The constant multipliers are $c_1 \equiv \left[\eta m/r^d + r^d/(r^e\text{-}r^d)\right] / \left(\eta m/r^d\text{-}1\right)$ and $c_2 \equiv \left[\eta m/r^d + m/(r^e\text{-}r^d)\right] / \left(\eta m/r^d\text{-}1\right)$. Thus, from (27) we see that the positive impact of the monetary shock on the real lending margin is the net result of two opposite effects. On the one hand, the initial increase in the real marginal cost faced by banks ($\widehat{r}_t^d > 0$), gives rise to an increase in the real lending rate ($\widehat{r}_t^e > 0$), that makes the individual demand for funds less sensitive with respect to $\widehat{r}_t^e$. On the other hand, positive house price inflation following the shock, ($\widehat{\pi}_{t+1}^h > 0$; see Figure 2.4), unchains the opposite effect. Intuitively, as the house price recovers towards its steady state value, a unit of internal funds invested in real estate allows an entrepreneur to rise more debt since the resale value of housing is growing. This, in turn, raises both the leverage ratio $B_t^e/P_t^h H_t^e$, and the sensitiveness of the individual demand for bank loans. This latter effect dampens the upwards response of the margin.

Taking the response of lending margins in isolation, one would expect that stronger banking competition would help moderate output fluctuations following monetary shocks. Under imperfect competition, lending margins react countercyclically, thus amplifying the effects of the original disturbance. Hence, along this countercyclical response of margins, our model is akin to the financial accelerator mechanism in BGG. However, our economy also incorporates borrowing limits and nominal debt. Both elements, as explained below, interact in the presence of a monetary shock to reduce, or even undo, the previous stabilizing role of stronger banking competition that obtains through a reduction in the countercyclical pattern of lending margins.

Collateral and net worth effects. The differences in the accumulated output response for the two levels of banking competition in Figure 2.1 are mainly due to the strong influence of interest rate margins on the behaviour of constrained entrepreneurs. In fact, the downwards adjustment in the consumption of savers is in line with what one would expect in a standard Ricardian environment free of financial frictions (see Figure 2.5). Such response is small, for the only channel through which movements in the interest rate affect consumption of households in this economy is the intertemporal allocation of wealth. The usual substitution and income effects arising from changes in the deposit real interest rate operate in different directions, yet the reduction in other sources of income associated with the fall in the level of activity generates a negative income effect that leads to a small negative net response of consumption.

This mild reaction in the consumption of households contrasts with that of entrepreneurs (Figure 2.6). The unexpected rise in the interest rate erodes their net worth, thus reducing their consumption. Unlike in the case of households, entrepreneurs consumption is very sensitive to the degree of competition in the banking sector. In particular, the corresponding impact response of entrepreneurs consumption is 20% higher under perfect banking competition than in the benchmark case.

To gain some further insights into this last mechanism, it is helpful to analyze the impact response of the entrepreneurs demand for goods. As shown in Appendix, C_t^e can be expressed as a constant fraction $1-\beta^e$ of the entrepreneur's net worth, where the latter is defined as the total value of the beginning-of-period real estate holdings, $P_t^h H_{t-1}^e$, net of maturing debts, $R_{t-1}^e B_{t-1}^e/\pi_t$, plus the output share accruing to the entrepreneur's stock of real estate, $\nu Y_t/X_t$, i.e.,

$$NW_t^e = P_t^h H_{t-1}^e - \frac{R_{t-1}^e}{\pi_t} B_{t-1}^e + \nu Y_t/X_t, \tag{28}$$

where we use NW_t^e to denote net worth. Now, imposing that the borrowing constraint (14) binds, we can write (28) at the time of the shock (say, $t = 1$) as

$$NW_1^e = \left(1 - m\frac{\pi}{\pi_1}\right) P_1^h H^e + \nu Y_1/X_1. \tag{29}$$

Log-linearizing (29) around the steady state gives the following expression for the relative deviation of net worth on impact,

$$\widehat{NW^e}_1 = \beta^e \frac{1}{1 - \frac{m}{r^e}} \left[\widehat{P}_1^h + m\widehat{\pi}_1 + \nu\frac{Y}{X}\left(\widehat{Y}_1 - \widehat{X}_1\right)\right]. \tag{30}$$

Using (14) evaluated at the steady state, the term m/r^e can be expressed as the leverage ratio of the economy: $B^e/P^h H^e$. Hence, according to (25), an increase in competition reduces r^e, thus increasing the leverage ratio. Higher leverage, in turn, amplifies the magnitude of changes in the price of real estate, the real value of maturing debts, the size of the debt-deflation effect and the marginal productivity of entrepreneurial real estate, all of which take on negative values after the shock. In this context, stronger banking competition tends to amplify the original negative effect on debtors' net worth. As this happens, their ability to obtain external funding in the current period falls (see Figure 2.7) even though stronger competition keeps margins lower as discussed above. Then, lower access to credit unchains a negative effect on entrepreneurs demand for real estate that puts extra downward pressure on prices and, hence, on their net wealth, reducing also their ability to obtain external funding and curtailing the demand for consumption and capital, with the latter driving down capital investment. These net worth and collateral effects, which quantitatively dominate the lending margin effect, explain the correlation of strong banking competition, with large falls in housing prices, aggregate consumption, capital investment and output.[17]

It must be noted that the responses of output and other variables across values of α/n, which are not so much different on impact, get amplified as time passes. This points to an important feature of our model that stems from the fact that entrepreneurs have only limited access to consumption smoothing due to collateral constraints. Differences in banking competition generate substantial variations in the steady-state level of leverage in the model that have a small impact on the short run multipliers. However, as time goes by, leveraged entrepreneurs have to give up consumption and real estate purchases for longer periods in order to restore their net worth positions thus adding to the accumulated output loss.

4.2 *A Credit-crunch Shock*

We next analyze the effects of an exogenous fall in the pledgeability ratio, m_t, that given everything else, reduces the borrowers credit capacity. In contrast to the case of a monetary shock, now the differential impact response of output differs from the long-run one. Whereas output falls (slightly) more on impact in the competitive case it also recovers faster. Figure 3.1 shows the accumulated output loss over our benchmark 40-period horizon that is significantly larger in the benchmark economy with imperfect banking competition. In particular, the output loss in this case is 28% higher than under the perfect competition.

An immediate consequence from this shock is a fall in the housing price due to the

[17] In the working paper version of this paper, we also study technology shocks. Qualitatively, the results are similar to those reported here for the monetary shock. However, differences in the responses of most variables across the two banking structures are milder because net worth effects are weaker under a technology shock. This is due to the fact that such shocks induce responses in goods and housing inflation of opposite sign, which tends to smooth the final effect of the shock on the entrepreneurs' net worth.

tightening of the borrowing constraint (14). This, in turn, triggers a negative effect on entrepreneurs' net worth, which further depresses housing prices. Thus, on impact, this shock unchains a propagation mechanism that is qualitatively similar to the one discussed before in the context of a monetary shock. But now the impact response of entrepreneurial consumption is almost identical in the two cases under study. This is due to the fact that the lending margin in the benchmark case now rises by a much larger amount since, according to (23), the margin is negatively related to m_t. Formally, the log-linearized expression for the real margin (27), now becomes

$$(\widehat{r^e - r^d})_t = c_1 \widehat{r}_t^d - c_2 \left(\widehat{\pi}_{t+1}^h + \widehat{m}_t \right).$$

This last equation shows that the shock to m_t produces a first-order effect on the lending margin in the benchmark case with imperfect banking competition, as illustrated in Figure 3.3, that is absent after the monetary shock. The strong response of the margin means that the real interest rate on loans rises far more in this case than under a perfectly competitive banking sector. In turn, a higher interest on loans is tantamount to a further tightening of the borrowing constraint since the expected resale value of the entrepreneur's housing stock during the following period is more heavily discounted, thus, reducing the leverage ratio. The latter triggers a fall in housing demand that further depresses housing prices and entrepreneurs' net worth (see Figures 3.4 and 3.7 for the response of housing prices and debt, respectively).

In the benchmark case the persistent positive deviation of the lending margin with respect to its steady state value tends to slow down the recovery of housing prices, entrepreneurs' net worth and their debt capacity, all of which remain well below their stationary levels for a long time. This explains why, in contrast to the monetary shocks analyzed before, the accumulated output loss over a sufficiently long horizon is higher when banks enjoy monopolistic power, as shown in Figure 3.1.

This last exercise helps us to understand the potential role of a secular rise in the level of competition among banks, as recently documented in several jurisdictions, including the U.S. and the European Union, during the various phases of the recent financial crisis. As competition heightens and lending margins fall, borrower's leverage rises, making credit and output more sensitive in face of a tightening in collateral requirements. In this sense, the aforementioned trend in banking competition could have contributed to render the economy's impact-response more intense after the several financial shocks that virtually collapsed some of the key wholesale funding markets starting from the summer of 2007. Yet, the fact that stronger competition, by keeping spreads low, favors a faster recovery of credit and output, suggests that the involved authorities should try to maintain strong competition among banks along the recovery phase.

4.3 *Spreads, Competition and Collateral Constraints*

Lending margins may fall over time for reasons other than the intensification of banking competition. Within the logic of the model, according to (23), the degree of tightness of the collateral constraint, m, is also an important determinant of margins beside their monopolistic power, as proxied by α/n. This raises the natural question of whether the underlying cause of low spreads (and high leverage ratios), i.e. a rise in m or a fall in α/n , has distinctive consequences in terms of the dynamic response of the main variables. To shed light on this issue we carry out an additional experiment. We compare the responses of output to a monetary and a credit crunch-shock for two levels of the spreads, denoted by *high* and *low* (each corresponding with a margin of 250 *p.b.*and 85 *p.b.* respectively), under two alternative assumptions concerning the underlying cause of a low lending margin: 1) an increase in m (a *financial deepening* mechanism) and 2) a fall in α/n (a *competition* mechanism). To perform this exercise, we consider the two values for m in line with those reported by Iacoviello and Neri (2010): $m_L = 0.76$ and

$m_H = 0.91$.

1. *Financial deepening.* We set $m = m_L$ and choose α/n such that the annual interest rate margin equals 250 *b.p.* as in our benchmark. We then compare this scenario with one in which we keep α/n constant and set $m = m_H$, which reduces the spread to 85 *b.p.* The accumulated output responses in these two scenarios are depicted in Figures 4.1 (monetary shock) and 4.3 (credit-crunch shock).

2. *Competition.* We here compare our baseline scenario with one in which, keeping m constant, α/n is set to deliver a margin of 85 *b.p.*, i.e. similar to the high competition scenario featured above. The output responses are plotted in Figures 4.2 and 4.4 for the monetary and credit-crunch shock, respectively.

Regarding the monetary shock, the comparison between Figures 4.1 and 4.2 reveals that, for a given fall in the margin, the increase in m and the reduction in α/n have the same qualitative effect on the output response. In both cases the economy with higher leverage reacts more strongly than in the benchmark. In particular, the quantitative effect of the increase in m is stronger for two reasons. First, changes in m have a direct effect on constrained borrowers' demand, and, second, the countercyclical response of the spread is weak in response to a monetary shock, a discussed before.

The pattern, however, is very different when the economy is hit by a credit crunch-shock. In this case, the economy with a low spread reacts more strongly than in the benchmark when the reduction in the spread is caused by an increase in m (Figure 4.3) whereas the opposite follows when low margins are the result of a fall in α/n (Figure 4.4). Again, the countercyclical behaviour of the spread is key to understand this asymmetric pattern. Whereas lower leverage in the benchmark makes the economy more stable in the presence of shocks, higher spreads work in the opposite direction. The latter channel, which is stronger after a credit crunch shock is mildly affected by a reduction of α/n

whereas it is sharply weakened when m increases.

All in all, these results highlight that the dynamic response of the economy critically depends on the ultimate cause of the spread reduction. Specifically, the above simulations confirm the distinctive importance of the mechanism analyzed in this paper, in the sense that variations in the level of bank competition and in the collateral requirements do trigger different effects in terms of the output response, especially in face of credit-crunch shocks.

5 Conclusions

We develop a dynamic general equilibrium model with an imperfectly competitive bank-loans market and collateral constraints that tie investors' credit capacity to the value of their real estate holdings. Banks set optimal lending rates taking into account the effects of their price policies on their market share and on the volume of funds demanded by each borrower.

We find that both fluctuations in the lending margin as well as its average value may exert a significant effect on aggregate variables. Over the long run, fostering banking competition increases total consumption, investment and output by raising the collateral in hands of investors. However, the effects of banking competition on the short-run economy's response to exogenous perturbations are more complex. Enhanced banking competition lowers the margin between lending and the borrowing rates and this gives rise to two competing effects. On the one hand, lower *lending margins* imply higher *leverage ratios* which tend to exacerbate the short-run response of housing prices, consumption and output, through the familiar net worth acceleration mechanism induced by endogenous borrowing constraints. On the other hand, lower *lending margins* promote a faster recovery of the borrowers' net worth and, hence, their borrowing and production capacity in face of an adverse shock. Which of the previous conflicting forces dominates depends crucially on the nature of the shock hitting the economy.

In face of a contractionary monetary shock output exhibits a larger and more persistent fall as banking competition heightens. After the shock, both the negative debt-deflation and collateral (housing price deflation) effects get amplified in the presence of low lending margins and high leverage ratios. However, as banking competition intensifies, the positive response of lending margins following the shock becomes weaker, which mitigates the downwards response of housing prices, debt and output. This latter effect, however, is found to be very small in the case of a monetary shock and insufficient to compensate the previous negative net worth effect.

However, the previous conclusion does not hold when we study the effects of credit-crunch shocks that reduce the degree of pledgeability of collateralizable assets, as was arguably the case in the initial phases of the recent global financial crisis. In this case, we find that stricter credit rationing leads banks to pursue aggressive margin increases which, in turn, tend to postpone the economy's recovery for a longer time. Hence, in this case the model predicts that stronger banking competition would work to reduce the total output loss over longer horizons by accelerating the recovery.

Hence, although the model developed here is too stylized it helps us identify several channels through which the degree of banking competition affects the transmission of shocks to the wide economy and, hence, its overall stability. Specifically, a central finding of the paper is that the relative importance of these channels depends on the nature of the shocks hitting the economy and on the time horizon considered.

Universidad de Valencia and Banco de España
Comisión Nacional del Mercado de Valores (CNMV)
Submitted: 26 July 2010
Accepted: 1 March 2012

References

[1] Adams, R. M. and Amel, D. F. (2005). 'The Effects of Local Banking Market Structure on the Bank-Lending Channel of Monetary Policy', *Finance and Economics Discussion Series* 2005-16, Board of Governors of the Federal Reserve System.

[2] Aliaga-Díaz, R. and Olivero, M. (2010). 'Macroeconomic Implications of 'Deep Habits' in Banking', *Journal of Money, Credit and Banking,* vol. 42(8), pp. 1495−1521.

[3] Allen, F., Carletti, E. and Marquez, R. (2011). 'Credit Market Competition and Capital Regulation', *Review of Financial Studies*, vol. 24(4), pp. 983−1018.

[4] Aoki, K., Proudman, J. and Vlieghe, G. (2004). 'House prices, consumption, and monetary policy: A financial accelerator approach', *Journal of Financial Intermediation,* vol. 13(4), pp. 414−435.

[5] Aoki, K., Benigno, G. and Kiyotaki, N. (2009). 'Capital Flows and Asset Prices', NBER Chapters, in: NBER International Seminar on Macroeconomics 200, pp. 175−216.

[6] Barth, J. R., Caprio, G. Jr. and Levine, R. (2004). 'Bank regulation and supervision: What works best?', *Journal of Financial Intermediation*, vol. 13(2), pp. 205−248.

[7] Beck, T., De Jonghe, O. and Schepens, G. (2010). 'Bank competition and stability: Reconciling conflicting empirical evidence', Working Paper, Tilburg University.

[8] Berger, A.N., Klapper, L.F. and Ariss, R.T. (2008). 'Bank Competition and Financial Stability', *Journal of Financial Services Research*, vol. 35(2), pp. 99−118.

[9] Bernanke, B. and Gertler, M. (1989). 'Agency Costs, Net Worth, and Business Fluctuations', *The American Economic Review*, vol. 79(1), pp. 14−31.

[10] Bernanke, B., Gertler, M. and Gilchrist, S. (1999). 'The Financial Accelerator in a Quantitative Business Cycle Framework', in (J.B. Taylor and M. Woodford, eds.), *Handbook of Macroeconomics*, vol. 1C, Amsterdam: Elsevier Science, North−Holland.

[11] Calvo, G. (1983). 'Staggered Prices in a Utility−Maximizing Framework', *Journal of Monetary Economics,* vol. 12(3), pp. 383−398.

[12] Calza, A., Monacelli, T. and Stracca, L. (2010). 'Housing Finance and Monetary Policy," *Journal of the European Economic Association* (forthcoming).

[13] Campbell, J. R. and Hercowitz, Z. (2009): 'Welfare Implications of the Transition to High Household Debt', *Journal of Monetary Economics*, vol. 56(1), pp. 1−16.

[14] Canzoneri, M., Cumby, R., Diba, B. and López-Salido, D. (2008). 'Monetary Aggregates and Liquidity in a Neo−Wicksellian Framework', *Journal of Money, Credit and Banking*, vol. 40(8), pp. 1667−1698.

[15] Cetorelli, N. and Gambera, M. (2001). 'Banking Market Structure, Financial Dependence and Growth: International Evidence from Industry Data', *Journal of Finance*, vol. 56(2), pp. 617−648.

[16] Chaney, T., Sraer, D. and Thesmar, D. (2010). 'The Collateral Channel: How Real Estate Shocks Affect Corporate Investment', NBER Working Paper 16060.

[17] Chiappori, P.-A., Pérez-Castrillo, D. and Verdier, T. (1995). 'Spatial Competition in the Banking System: Localization, Cross Subsidies and the Regulation of Deposits Rates', *European Economic Review*, vol. 39(5), pp. 889−918.

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

[19] Claessens, S. (2009). 'Competition in Financial Sector: Overview of Competition Policies', *World Bank Research Observer*, vol. 24(1), pp. 83−118, April.

[20] Claessens, S. and Laeven, L. (2004). 'What Drives Banking Competition? Some International Evidence', *Journal of Money Credit and Banking*, vol. 36(3), pp. 563−583.

[21] Claessens, S. and Laeven, L. (2005). 'Financial Dependence, Banking Sector Competition, and Economic Growth', *Journal of the European Economic Association*, vol. 3(1), pp. 179−207.

[22] Curdia, V. and Woodford, M. (2009). 'Credit Frictions and Optimal Monetary Policy', Working Paper, Columbia University.

[23] Davis, M. and Heathcote, J. (2005). 'Housing and the Business Cycle', *International Economic Review,* vol. 46(3), pp. 751−784.

[24] Dell'Ariccia, G. (2001). 'Asymmetric Information and the Structure of the Banking Industry', *European Economic Review,* vol. 45(10), pp. 1957−1980.

[25] Degryse, H. and Ongena, S. (2005). 'Distance, Lending Relationships, and Competition', *Journal of Finance*, vol. 60(1), pp. 231−266.

[26] Demirguc-Kunt, A., Laeven, L. and Levine, R. (2003). 'The Impact of Bank Regulations, Concentration, and Institutions on Bank Margins', Policy Research Working Paper no. 3030, World Bank.

[27] Dick, A. and Lehnert, A. (2010). 'Personal bankruptcy and credit market competition', *Journal of Finance*, 65(2), pp. 655−686, 04.

[28] Dueker, M. and Thornton, D. (1997). 'Do Bank Loan Rates Exhibit a Countercyclical Mark-up?', Working Paper 1997−004, Federal Reserve Bank of St. Louis.

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

[30] Gan, J. (2007). 'Collateral, Debt Capacity, and Corporate Investment: Evidence from a Natural Experiment', *Journal of Financial Economics*, vol. 85(3), pp. 709−734.

[31] Gerali, A., Neri S., Sessa L. and Signoretti, F. (2010). 'Credit and Banking in a DSGE Model', *Journal of Money, Credit and Banking*, vol. 42(s1), pp. 107−141.

[32] Gertler, M. and Kiyotaki, N. (2010). 'Financial Intermediation and Credit Policy in Business Cycle Analysis', *Handbook of Monetary Economics*, vol. 3, pp. 547−599.

[33] Goodfriend, M. and McCallum, B. (2007). 'Banking and interest rates in monetary policy analysis: A quantitative exploration', *Journal of Monetary Economics,* vol. 54(5), pp. 1480–1507.

[34] Goodhart, C., Hofmann, B. and Segoviano, M. (2004). 'Bank Regulation and Macroeconomic Fluctuations', *Oxford Review of Economic Policy*, vol .20(4), pp. 591−615.

[35] Guiso, L., Sapienza P. and Zingales, L. (2007). 'The Cost of Banking Regulation', Working Paper ECO 2007/43, European University Institute

[36] Huelsewig, O., Mayer, E. and Wollmershaeuser, T. (2006). 'Bank Behavior and the Cost Channel of Monetary Transmission', Working Papers no. 1813, CESIFO

[37] Iacoviello, M. (2005). 'House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle', *The American Economic Review,* vol. 95(3), pp. 739−764.

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

[39] Kiyotaki, N. and Moore, J. H. (1997). 'Credit Cycles', *Journal of Political Economy,* vol. 105(2), pp. 211−248.

[40] Krusell, P. and Smith, A. A. (1998). 'Income and Wealth Heterogeneity in the Macroeconomy', *Journal of Political Economy*, vol. 106(5), pp. 867−896.

[41] Leuvensteijn, M., Sørensen, C., Bikker, J. and van Rixtel, A. (2008). 'Impact of Bank Competition on the Interest rate Pass-through in the Euro Area', Working Paper 885, European Central Bank.

[42] Levin, A.T., Natalucci, F.M. and Zakrajsek, E. (2004). 'The Magnitude and Cyclical Behaviour of Financial Markets Frictions', Finance and Economics Discussion Series 2004−70, Board of Governors of the Federal Reserve System.

[43] Liu, Z., Wang, P. and Zha, T. (2011). 'Land-price Dynamics and Macroeconomic Fluctuations', Working Paper 17045, NBER.

[44] Mandelman, F. (2011). 'Business Cycles: A Role for Imperfect Competition in the Banking System", *International Finance*, forthcoming.

[45] Maudos, J. and Fernández de Guevara, J. (2004). 'Factors Explaining the Interest Margin in the Banking Sectors of the European Union', *Journal of Banking and Finance,* vol. 28(9), pp. 2259−2281.

[46] Northcott, C.A. (2004). 'Competition in Banking: A Review of the Literature', Working Papers 2004−24, Bank of Canada.

[47] Petersen, M.A. and Rajan, R. (1995). 'The Effect of Credit Market Competition on Lending Relationships', *Quarterly Journal of Economics*, vol. 110(2), pp. 407−443.

[48] Petersen, M.A. and Rajan, R. (2002). 'Does Distance Still Matter? The Information Revolution in Small Business Lending', *Journal of Finance*, vol. 57(6), pp. 2533−2570.

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

[50] Salop, S. (1979). 'Monopolistic Competition with Outside Goods', *Bell Journal of Economics, vol.* 10(1), pp. 141−156.

[51] Santos, J.A.C. and A. Winton (2008). 'Bank Loans, Bonds, and Information Monopolies across the Business Cycle', *Journal of Finance*, vol. 63(3), pp. 1315−1359.

[52] Saunders, A. and Schumacher, L. (2000). 'The Determinants of Bank Interest Rate Margins, An International Study', *Journal of International Money and Finance,* vol. 19(6), pp. 813—832.

[53] Stebunovs, V. (2008). 'Finance as a Barrier to Entry: U.S. Bank Deregulation and the Business Cycle', Working Paper, Board of the Governors of the Federal Reserve System.

[54] Strahan, P.E. (2003). 'The Real Effects of U.S. Banking Deregulation', Federal Reserve Bank of St. Louis Review, July/August, 85, pp. 111−128.

[55] Vives, X. (2010). 'Competition and Stability in Banking', Working Paper no. 3050, CESifo.

6 Appendix. Derivation of lending margins

In this appendix we provide the formal proof of the derivation of expression (23) containing the optimal interest rate margin in a symmetric equilibrium.

Bank i maximizes (21) subject to the sequence of flow of funds constraints (22) and the balance-sheet identity, $D_t^i = B_t^i$. The first order condition of this maximization problem with respect to $R_t^{i,e}$ is given by

$$R_t^{i,e} - R_t^d = -\frac{\partial B_t^i}{\partial R_t^{i,e}} \frac{1}{B_t^i}. \tag{31}$$

That is, the optimal lending margin equals the semi-elasticity of B_t^i with respect to $R_t^{i,e}$.

For the sake of the exposition of the derivations provided below, it is convenient to express its total demand for loans faced by bank i in terms of an *intensive* and an *extensive* margin as follows,

$$B_t^i = B_t^{i,e} \widetilde{b}_t^i, \tag{32}$$

where, $B_t^{i,e}$ represents the individual demand for funds by the representative entrepreneur faced by bank i at time t (i.e. the intensive margin), and $\widetilde{b}_t^i$ denotes the measure of entrepreneurs that borrow from that bank (i.e. the extensive margin). Then using this decomposition, (31) can be rewritten as

$$R_t^{i,e} = R_t^d + \frac{1}{\Lambda_t^i + \widetilde{\Lambda}_t^i}, \tag{33}$$

where, $\Lambda_t^i \equiv -\frac{\partial B_t^{i,e}}{\partial R_t^{i,e}} \frac{1}{B_t^{i,e}}$ represents the semi-elasticity of the entrepreneurial debt intensive margin, respectively, while $\widetilde{\Lambda}_t^i \equiv -\frac{\partial \widetilde{b}_t^i}{\partial R_t^{i,e}} \frac{1}{\widetilde{b}_t^i}$ denotes the semi-elasticity of the extensive margin. We next derive the analytical expressions for Λ_t^i and $\widetilde{\Lambda}_t^i$. In so doing we follow several steps.

Step 1. Obtaining an analytical expression for the individual demand for funds function, $B_t^{i,e}$.

We start by showing that the familiar result that under logarithmic utility and a Cobb-Douglas function an entrepreneur saves a fraction β^e of his net worth and consumes the remaining fraction, $1-\beta^e$, holds in our set-up. To this aim, we first combine (15), (18) and (19) and rearrange terms to arrive at the following equality,

$$\frac{P_t^h - m_t E_t\left(P_{t+1}^h \pi_{t+1}/R_t^e\right)}{C_t^e} = \beta^e E_t\left\{\frac{1}{C_{t+1}^e}\left[P_{t+1}^h + \frac{\nu Y_{t+1}/X_{t+1}}{H_t^e} - \frac{m_t}{\pi_{t+1}} E_t\left(P_{t+1}^h \pi_{t+1}\right)\right]\right\}. \tag{34}$$

Next, by multiplying both sides of (34) by H_t^e and using the expression of the net worth (28) together with the flow of funds constraint (13) and the borrowing constraint (14) holding as an equality, we can rewrite (34) as

$$\frac{NW_t^e - C_t^e}{C_t^e} = \beta^e E_t\left(\frac{NW_{t+1}^e}{C_{t+1}^e}\right). \tag{35}$$

Thus,

$$C_t^e = \left(1-\beta^e\right) NW_t^e \tag{36}$$

is a solution to (35). Then, using (13) and (28), we can write net savings as the unconsumed fraction of the net worth, i.e.

$$P_t^h H_t^e - B_t^e = \beta^e NW_t^e. \tag{37}$$

Then, combining (37) with the borrowing constraint (14) holding as an equality, we can write the demand for funds of an entrepreneur who travels to bank i at time t, denoted by $B_t^{i,e}$ as

$$B_t^{i,e} = \frac{\beta^e NW_t^e}{P_t^h\left[m_t E_t\left(P_{t+1}^h \pi_{t+1}\right)/R_t^{i,e}\right]^{-1} - 1}. \tag{38}$$

(Note that we are using the superscript i on $R_t^{i,e}$ in (38) whereas we write R_{t-1}^e in (28). We follow this notational convention to emphasize that the entrepreneur's banking choice at $t-1$ is irrelevant for the current one. Furthermore, R_{t-1}^e is taken as an element of a past symmetric equilibrium and, hence, it is common for all banks.). From (38), we learn that the demand for funds by an entrepreneur borrowing from bank i depends positively on NW_t^e, m_t, and $E_t \pi_{t+1}^h$, where $\pi_{t+1}^h \equiv P_{t+1}^h / P_t^h$, and negatively on the expected real interest rate $E_t(R_t^{i,e}/\pi_{t+1})$.

Step 2. Obtaining an analytical expression for the semi-elasticity of the intensive margin, Λ_t^i.

Equation (38) gives us an expression for the intensive margin of the demand faced by bank i. We then exploit it to arrive at the following closed-form solution for Λ_t^i,

$$\Lambda_t^i = \left[R_t^{i,e} - m_t E_t \left(\pi_{t+1}^h \pi_{t+1} \right) \right]^{-1}, \tag{39}$$

in which we have exploited the fact that NW_t^e does not depend on $R_t^{i,e}$ (see the definition of NW_t^e in (28)).

Step 3. Obtaining an analytical expression for the semi-elasticity of the extensive margin, $\widetilde{\Lambda}_t$.

We proceed by first identifying the entrepreneur k located between banks i and $i-1$ who is indifferent between the loan rates offered by both banks (henceforth, the "pivotal entrepreneur"). We do this by equalizing the pivotal entrepreneur's total discounted utility values (i.e. the time t version of (12)) that would obtain conditional on borrowing at time t from bank i as opposed to bank $i+1$. To clear the desk, it is helpful to note that current consumption, C_t^e, according to (28) and (36), is independent of the entrepreneur's current banking choice. Also, since each borrower decides optimally his lending bank period by period and without any history-given constraint, we learn that the utility-cost term $d_s^{i,k}$ for $s > t$, is independent of the current banking choice, as well. Hence, the pivotal entrepreneur is implicitly identified through the following equality,

$$E_t \left[\sum_{s=t+1}^{\infty} (\beta^e)^{s-t} \log C_s^{i,e} \right] - \alpha d_t^{i,k} = E_t \left[\sum_{s=t+1}^{\infty} (\beta^e)^{s-t} \log C_s^{i+1,e} \right] - \alpha d_t^{i+1,k}, \tag{40}$$

where $C_s^{i,e}$ and $C_s^{i+1,e}$ are interpreted as the optimal level of consumption conditional on the entrepreneur having obtained a loan at time t from bank i or bank $i+1$, respectively. An important feature of this problem is that the current banking choice displays persistent effects on consumption at *all* future dates. To see this, we combine (28) and (37) with (14) holding as an equality and express entrepreneurial net worth at $t+1$ as a function of its own lagged value,

$$NW_{t+1}^{i,e} = \beta^e \frac{\nu Y_{t+1}/\left(X_{t+1}H_t^e\right) + P_{t+1}^h - m_t E_t \left(P_{t+1}^h \pi_{t+1}\right)/\pi_{t+1}}{P_t^h - m_t E_t \left(P_{t+1}^h \pi_{t+1}\right)/R_t^{i,e}} NW_t^e. \tag{41}$$

Importantly, the ratio $Y_{t+1}/\left(X_{t+1}H_t^e\right)$ is independent of the lending rate, $R_t^{i,e}$. This is due to the fact that the markets for capital and labour are both competitive, which together with a Cobb-Douglas technology imply that the optimal output-housing ratio can be expressed as a function of the wage and the rental price of capital. Formally, combining (11), (16) and (17), we learn that,

$$\frac{Y_{t+1}/X_{t+1}}{H_t} = \left[\frac{A_t}{X_{t+1}}\left(\frac{1-\mu-\nu}{W_{t+1}}\right)^{1-\mu-\nu}\left(\frac{\mu}{P_{t+1}^k}\right)^{\mu}\right]^{1/\nu}. \tag{42}$$

Hence, the only channel through which $R_t^{i,e}$ affects $NW_{t+1}^{i,e}$ is through the direct effect of $R_t^{i,e}$ on the (constrained) amount of external funding that the entrepreneur borrows at t. The following expression extends (41) to future dates,

$$NW_{t+s+1}^{i,e} = \beta^e \frac{\nu Y_{t+s+1}/\left(X_{t+s+1}H_{t+s}^e\right) + P_{t+s+1}^h - m_t E_{t+s}\left(P_{t+s+1}^h \pi_{t+s+1}\right)/\pi_{t+s+1}}{P_{t+s}^h - m_t E_{t+s}\left(P_{t+s+1}^h \pi_{t+s+1}\right)/R_{t+s}^e} NW_{t+s}^{i,e}, \tag{43}$$

which is valid for $s \geq 1$. (Following the same argument as before, we are using the superscript i on $NW_{t+s}^{i,e}$ for $s \geq 1$, in expressions (41) and (43) to emphasize that the net worth at future dates depends on the time t banking choice via $R_t^{i,e}$, while such distinction is irrelevant for NW_t^e). Then , given that the distance between two consecutive banks, say i and $i+1$, is $1/n$ (recall that there are n banks distributed uniformly on a circumference of unit length), we can write the distance between entrepreneur k and bank i as $d_t^{i+1,k} = 1/n - d_t^{i,k}$. Recalling that the utility cost of travelling to a bank is simply equal to the distance (by assumption), we next use the consumption function (36) together with the recursive representation of the net worth in (43), to express (40) as

$$\frac{\beta^e}{1-\beta^e} E_t \left(\log NW_{t+1}^{i,e} - \log NW_{t+1}^{i+1,e}\right) = \alpha \left(2d_t^{i,k} - 1/n\right). \tag{44}$$

The intuition behind this equality is the following. By lowering its lending rate, bank i tends to attract entrepreneurs that are further away from its own position (i.e. higher $d_t^{i,k}$), since a lower $R_t^{i,e}$ increases net worth at $t+1$, which, in turn, allows for higher consumption not only at $t+1$ but also in the future. We then apply the same reasoning to identify the pivotal entrepreneur between banks i and $i-1$, denoted by k'. In particular, we now exploit the fact that there is a continuum of entrepreneurs of mass 1 distributed uniformly around the unit circle (i.e. 'distance' and 'mass of entrepreneurs' coincide in this environment) to write the bank i's market share (extensive margin) as $\widetilde{b}_t^i = d_t^{i,k} + d_t^{i,k'}$, or using (44), as

$$\widetilde{b}_t^i = 1/n + \left[\frac{1}{2\alpha} \frac{\beta^e}{1-\beta^e} E_t \left(2 \log NW_{t+1}^{i,e} \text{-} \log NW_{t+1}^{i+1,e} \text{-} \log NW_{t+1}^{i-1,e}\right)\right]. \tag{45}$$

This last expression makes clear that the extensive margin depends negatively on the number of competing banks. The second term in the right hand side of (45) reflects the fact that an increase in $R_t^{i,e}$ reduces the utility surplus that entrepreneurs obtain from borrowing from bank i as compared with borrowing from either alternative, $i-1$ or $i+1$. That surplus is comprised of the discounted value stream of utility gains from $t+1$ on. Also the sensitiveness of the market share to variations in the surplus falls as α increases. If the utility cost of moving to other bank increases, then the incentive to do so will be reduced. Then, using the expression for $NW_{t+1}^{i,e}$ in (41) to obtain $\frac{\partial \widetilde{b}_t^i}{\partial R_t^{i,e}}$, and then imposing symmetry, we obtain the semi-elasticity of the market share,

$$\widetilde{\Lambda}_t = \frac{n}{\alpha} \frac{\beta^e}{1-\beta^e} \left\{ \left[\frac{R_t^e}{m_t E_t \left(\pi_{t+1}^h \pi_{t+1}\right)} - 1 \right] R_t^e \right\}^{-1}. \tag{46}$$

where we have used the fact that in a symmetric equilibrium the market share of each bank is simply $1/n$. Equation (46), when combined with (39), can also be expressed as

$$\widetilde{\Lambda}_t = \frac{n}{\alpha}\left[\frac{\beta^e}{1-\beta^e} m_t \frac{E_t\left(\pi^h_{t+1}\pi_{t+1}\right)}{R^e_t}\right]\Lambda_t. \tag{47}$$

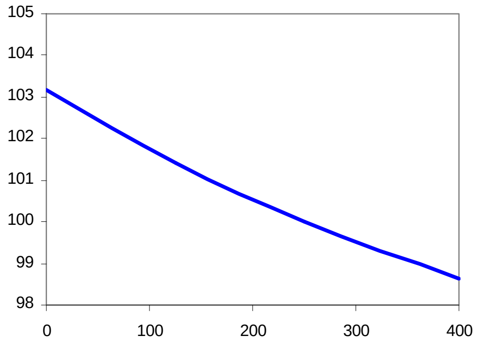
This last expression is intuitive in light of the previous discussion around its intensive margin counterpart, Λ_t. As the time t volume of collateral varies strongly with the lending rate, i.e. Λ^i_t is high, so does the time $t+1$ net worth and, hence, consumption at that date. In short, a large value of Λ^i_t, given everything else, implies that a small increase in bank i's lending rate causes a large outflow of potential borrowers and vice versa. Furthermore, the fact that innovations in the net worth at $t+1$ unchain persistent wealth effects implies that a given degree of sensitiveness of the intensive margin gets amplified over the extensive margin, as formally captured by the term in brackets in the right side of (47). The effect of the term n/α (which can be thought as of representing the "effective degree of bank competition") on $\widetilde{\Lambda}^e_t$ is straightforward. High values of n/α imply a low degree of local monopoly power which, in turn, translates into higher sensitivity of the market share with respect to the lending rate.

Step 4. Obtaining the expression for the interest rate margin.

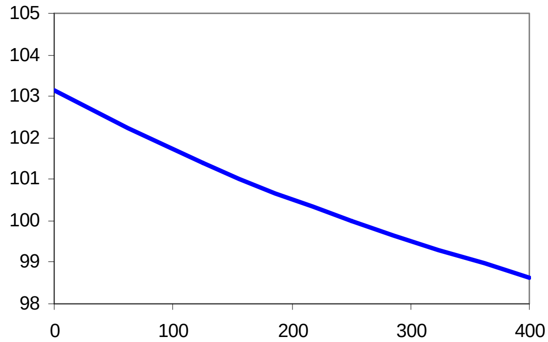
By combining (33), (39) and (46) we get equation (23) in the main text.

Fig. 1. Steady State levels for different degrees of banking competition.

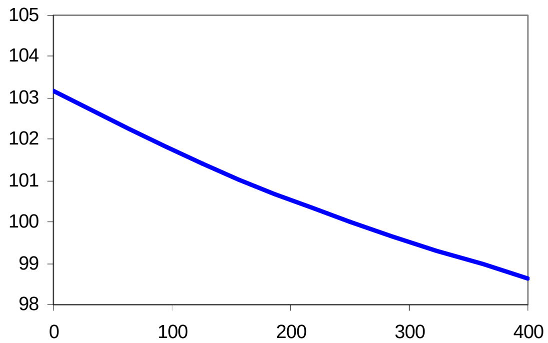
1.1 Output



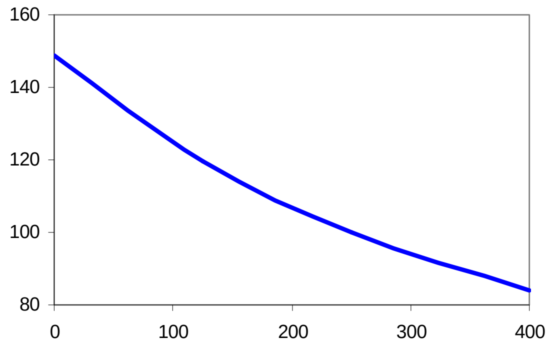
1.2. Investment



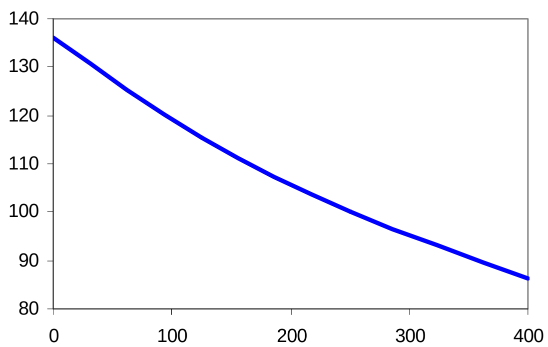
1.3. Households Consumption



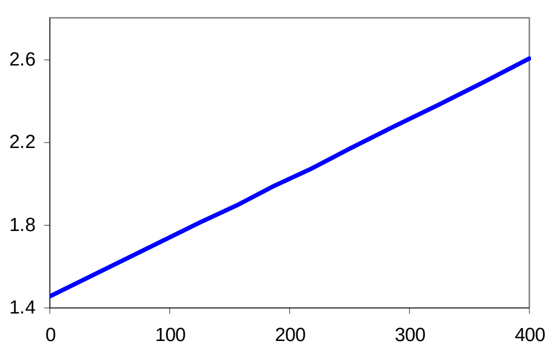
1.4. Entrepreneurs Consumption



1.5. Entrepreneurs Housing



1.6. Relative User Cost



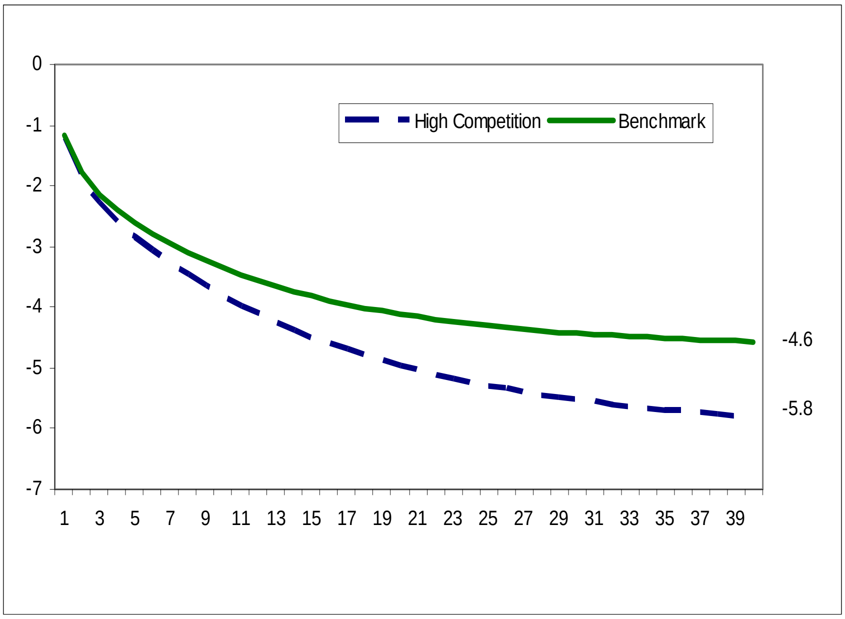
Horizontal axis: real lending margin (basis points, annual);

Vertical axis: Figs. 1.1-1.5, normalized levels (benchmark with 250 basis point = 100);

Vertical axis: Fig. 1.6, value of the relative user cost

Fig. 2. Impulse responses. Monetary shock.

2.1. Output accumulated

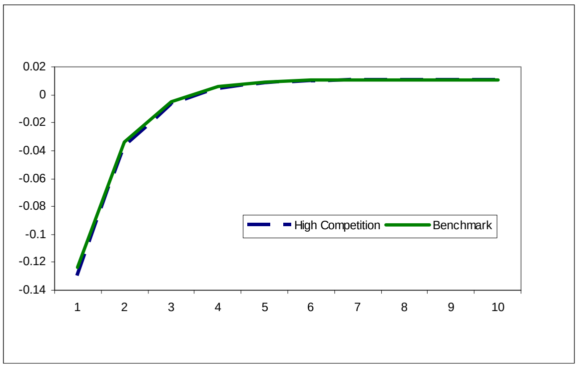


Horizontal axis: quarters after the shock.

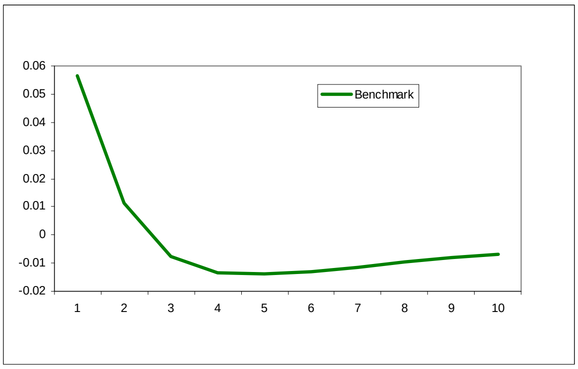
Vertical axis: Acc. deviation from the steady state in percentage points

Fig. 2 cont'd. Impulse responses. Monetary shock.

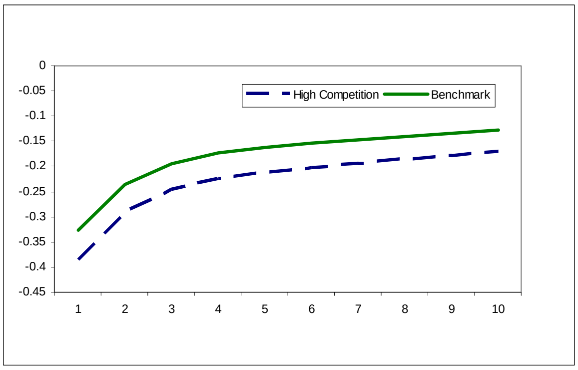
2.2. Inflation



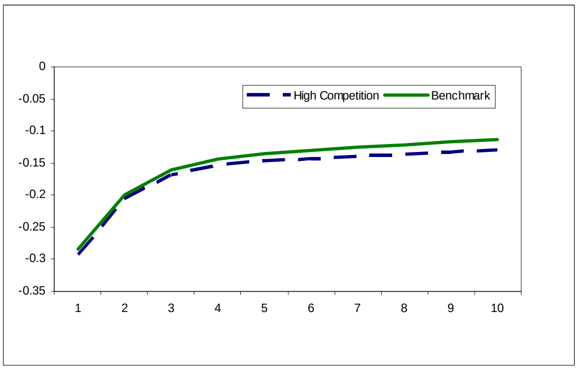
2.3. Real Margin



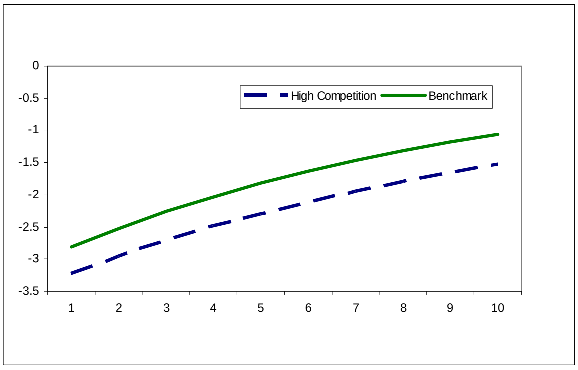
2.4. House Price



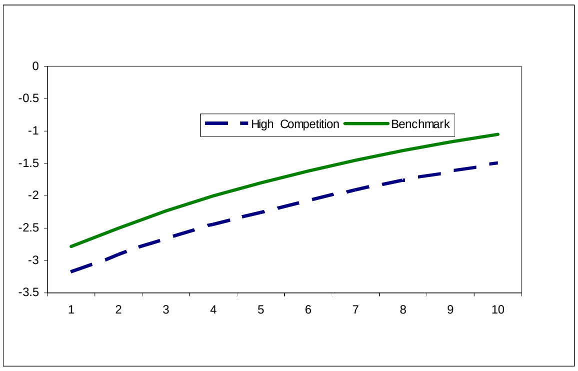
2.5. Households Consumption



2.6. Entrepreneurs Consumption



2.7. Debt

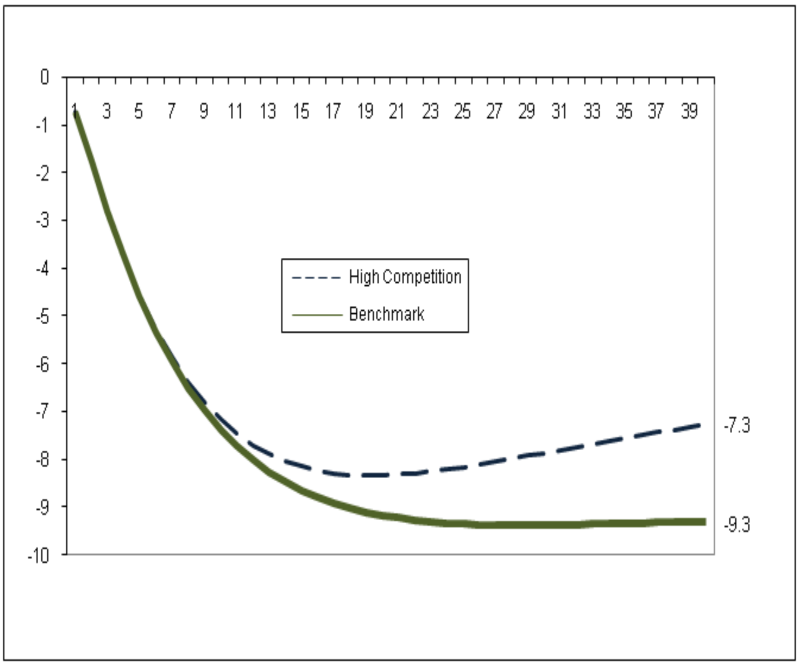


Horizontal axis: quarters after the shock.

Vertical axis: Deviation from the steady state value in percentage points

Fig. 3. Impulse responses. Credit-crunch shock.

3.1. Output accumulated

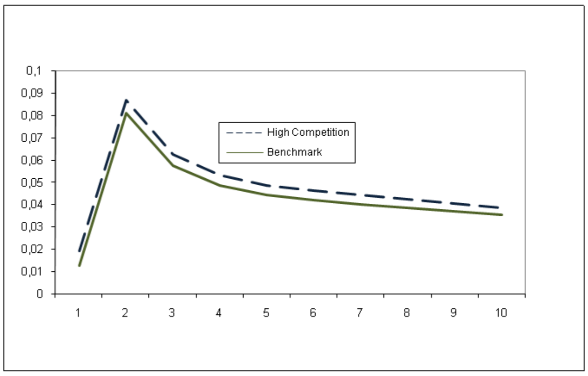


Horizontal axis: quarters after the shock.

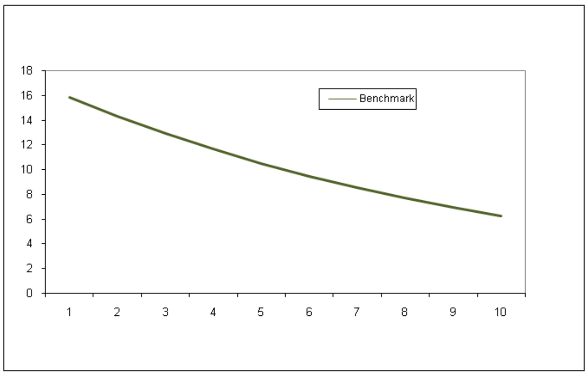
Vertical axis: Acc. deviation from the steady state in percentage points

Fig. 3 cont'd. Impulse responses. Credit-crunch shock

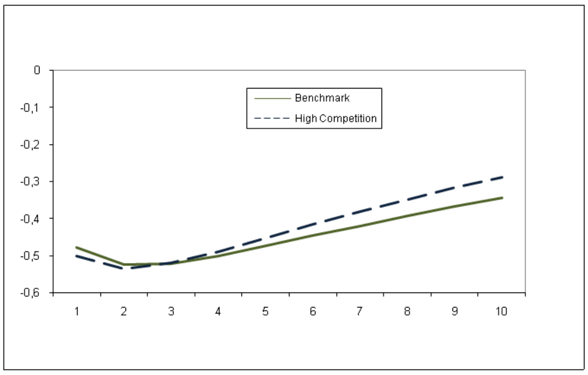
3.2. Inflation



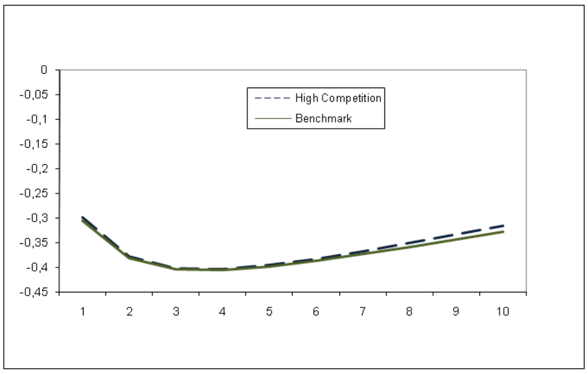
3.3. Real Margin



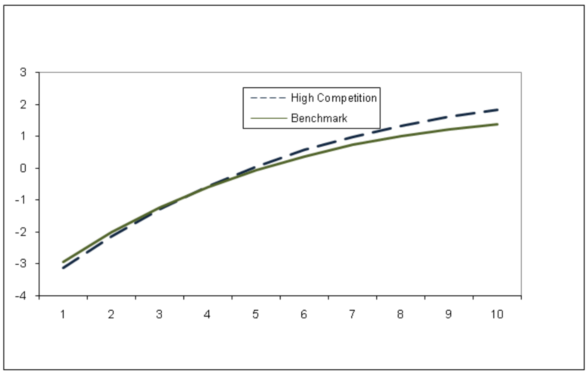
3.4. House Price



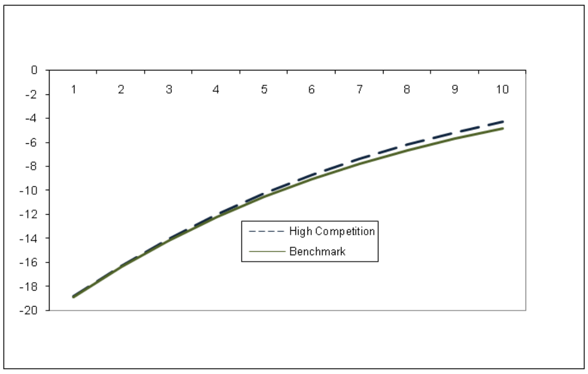
3.5. Households Consumption



3.6. Entrepreneurs Consumption



3.7. Debt



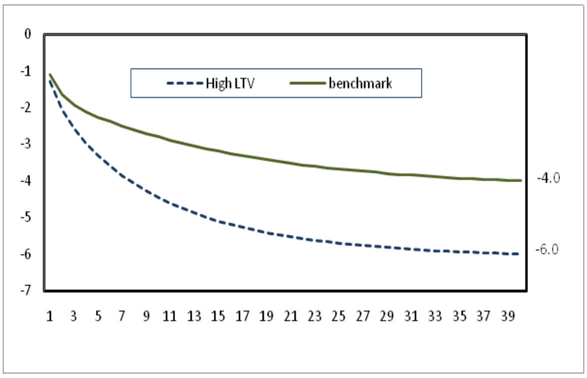
Horizontal axis: quarters after the shock.

Vertical axis: Deviation from the steady state value in percentage points

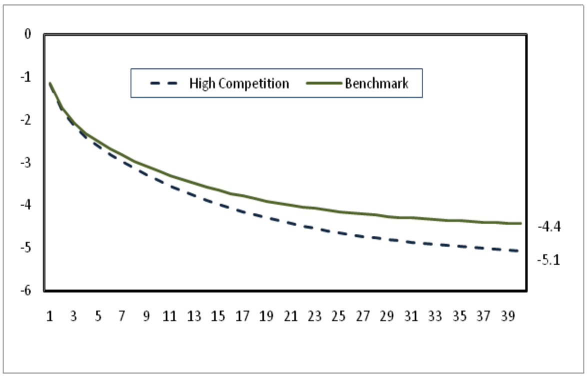
Fig. 4. Competition versus loan-to-value ratios

Monetary Shock

4.1. Output accumulated: higher m

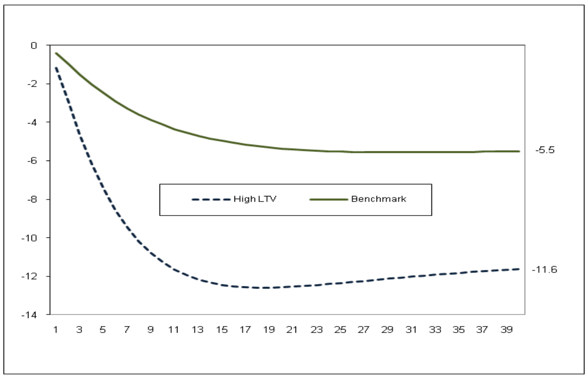


4.2. Output accumulated: lower α/n

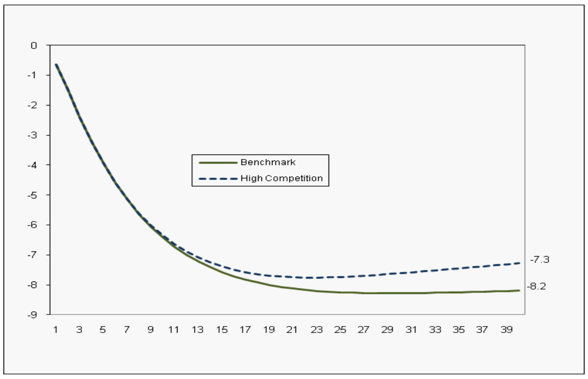


Credit-crunch Shock

4.3. Output accumulated: higher m



4.4. Output accumulated: lower α/n



Horizontal axis: quarters after the shock.

Vertical axis: Accumulated deviation from the steady state value in percentage points