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Abstract

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 customer. Lending margins have a significant effect on aggregate variables. Over the long run, fostering banking competition increases total consumption and output by triggering a reallocation of available collateral towards investors. However, as regards the short-run dynamics, we find that most macroeconomic variables are more responsive to exogenous shocks in an environment of highly competitive banks. Key to this last result is the reaction of housing prices and their effect on borrowers' net worth. The response of housing prices is more pronounced when competition among banks is stronger, thus making borrowers' net worth more vulnerable to adverse shocks and, specially, to monetary contractions. Thus, regarding changes in the degree of banking competition, the model generates a trade-off between the long run level of economic activity and its stability at the business cycle frequency.

Keywords: Banking competition, collateral constraints, housing prices.

JEL numbers: E32, E43, E44, G21.

1 Introduction

The role of financial intermediaries in the monetary transmission mechanism has been largely neglected in the study of macroeconomic fluctuations. Most dynamic stochastic general equilibrium models (DSGE) that are used to conduct monetary policy analyses incorporate 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, differentials between lending and borrowing rates are non-negligible and tend to vary significantly over the cycle, specially at times of financial stress. Furthermore, to the extent that such differentials respond themselves to changes in the monetary policy rate, amplifying or dampening the effects of the initial monetary impulse, it becomes clear that a solid framework for monetary policy analysis must include a sound analysis of the optimal pricing rules followed by financial intermediaries.

Bernanke, Gertler and Gilchrist (1999; BGG, henceforth) provide a comprehensive framework that links financial imperfections, interest rate spreads and monetary policy that builds upon the financial accelerator model of Bernanke and Gertler (1989). That theory contends that a positive spread, which they call *external finance premium* and define as the gap between the cost of external funding and the opportunity cost of internal funds, is a natural outcome in an environment featuring principal-agent conflicts between borrowers and lenders. Such external premium depends inversely on the strength of the borrower's financial position, understood in terms of factors akin to the borrowers capacity to offer collateral (net worth, cash flows,...). BGG show that under reasonable parametrizations. of a DSGE model, this financial friction may significantly amplify the effects of real and monetary shocks to the economy.

The theory 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, yet we start from different grounds. We place imperfect competition among banks in the market for loans at the center of the analysis of endogenous interest rate spreads, which we henceforth refer to as *lending margins*. We think of this departure from the standard Walrasian model of non-intermmediated credit market as a natural route to explain, at least partially, the existence of interest rates spreads. In so doing, we see the mechanism studied here as an alternative to the one emphasized by BGG. Clearly, in reality, both underlying frictions, imperfect competition among banks and asymmetric information and agency costs in lending relationships, are likely to coexist. In short, the central question we pose in this paper is the following: *How does the degree of banking competition shapes the response of the economy to different shocks?*

To answer the previous question we develop a general equilibrium version of the spatial monopolistic competition model of Salop (1979) in which the borrowers' demand for external funding is modelled explicitly as the outcome of an intertemporal problem of utility maximization.[1] Overall, the modelling strategy in this paper can be summarized as follows: we pose a banking structure that is compatible with banks charging a positive lending margin and study the economic factors that determine the degree of elasticity of the demand for loans faced by banks and, hence, the behavior of margins. The merit of using a general equilibrium model is that it allows us to pose the reverse question, i.e. how lending margins, in turn, affect aggregate prices and allocations.

As the source of monopolistic power we assume that borrowers suffer a utility cost when traveling to a bank.[2] Given this cost, borrowers optimally choose period by period their lending bank as well as the amount of borrowing to maximize the discounted present value of their lifetime utility. Banks set profit-maximizing lending rates taking into account that a higher lending rate raises unit margins at the cost of reducing the individual demand for funds (*intensive margin*) and its market share (*extensive margin*). This modelling choice delivers a good compromise between simplicity and economic content. On one end, the model is sufficiently simple so as 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 economy with a real estate asset (housing, for short) and endogenous collateral constraints of the kind analyzed by Kiyotaki and Moore (1997) that link the credit capacity of borrowers to the value of their real estate holdings, in the spirit of Iacoviello (2005). Beside collateral constraints, the economy is subject to two standard nominal frictions: nominal (non-indexed) debt and goods-price rigidity. Asset prices (interest rates and the price of housing) are flexible and the total stock of housing is fixed.

In the equilibria we analyze here, (patient) households provide deposits to the banks that use them to make loans to (impatient) entrepreneurs who find optimal to exhaust their collateral constraints.[3] Hence, it follows 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 affect also the amount of collateral pledged by debtors. Both, housing price inflation and maximum leverage ratios, are major determinants of

[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 and Repullo (2004).

[2] Of course, 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) and Degryse and Ongena (2005)). Indeed, Petersen and Rajan (1995) use borrower-bank distance as a proxy for monopolistic banking power.

[3] In a previous version (available upon request), we provide an extended model that also includes a group of impatient households that are also financially constrained. The main results presented here are unchanged.

the elasticity of the demand for funds at the individual level with respect to the loans interest rate and, thus, of the lending margins. In particular, such elasticity increases whenever 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 amount of collateral in hands of the borrowers, thus, raising 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. Thus, the model generates a monetary policy accelerator, since a shock to the policy rate translates into a more than proportional change in the lending rate.

As regards the behavior of the extensive margin, we find that stronger banking competition, say, due to an increase in the number of banks or a fall in transportation costs, goes hand in hand with lower margins. In addition to this intuitive result, we show that the previous determinants of the elasticity of the intensive margin (i.e. housing price inflation, leverage and cost of funds faced by banks) play a similar role with respect to the extensive margin. For instance, when housing price inflation is expected to be high, a marginal increase in the lending rate by a given bank causes a large outflow of borrowers from that bank towards its competitors. Thus, in our model rising housing prices, loose 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 impulse credit growth.

In order to analyze the macroeconomic effects of imperfect banking competition we first study the steady state properties of the model. The main result here is that stronger competition among banks stimulates consumption, investment and, hence, total output over the long-run. As banks charge lower margins, the relative user cost of housing for debtors vis-à-vis savers falls, since the user cost is positively related to the lending rate for the former and to the deposits rate to the latter. This, in turn, implies a reallocation of the available stock of housing from savers to debtors who also value houses for their services as collateral. Such reallocation of the pledgeable asset towards debtors rises overall investment, output and consumption. Thus, stronger banking competition "greases the economy's wheels" in the long run.

Yet, the fact that lower lending margins are associated with higher leverage ratios for borrowers bears some risks in the short-run in the form of increased output and consumption volatility. For instance, following an adverse monetary shock both housing prices and total output fall more as the banking sector becomes more competitive. On the one hand, stronger banking competition implies a weaker positive response of lending margins, which tends to mitigate the adverse effects on housing prices, consumption and output. On the other, lower lending rates are consistent with higher leverage in the first place. Thus, when the shock hits the economy, the subsequent negative debt-deflation, and collateral (housing price deflation) effects both get amplified in the presence of a larger stock of outstanding debt relative to internal funds for debtors. For reasonable parametrizations. of the model, the latter (negative) borrowers net-worth effects overcome the former (positive) lending margin effect. As regards the magnitude of the net effect, we find that the accumulated output loss following an unexpected rise in the policy rate after 40 quarters is around 27 per cent (40) larger in an economy with a fully competitive banking sector than in economy with steady state lending margins of 250 basis points per annum (400 basis points).[4] Hence, stronger banking competition works as a powerful amplification mechanism of net-worth effects.

Our paper is related to several strands of literature on financial frictions and the macroeconomy. Regarding the central hypothesis of imperfect banking competition, the closest models to ours are those by Aliaga-Díaz and Olivero (2006), Mandelman (2006) and Stebunovs (2008). In Aliaga-Díaz and Olivero market power arises from switching costs faced by costumers when trying to move from one bank to another. Mandelman models banking competition as an entry game in which potential competitors face fixed settlement costs and incumbents play strategies aimed at deterring entry. Stebunovs (2008) also provides a model of spatial monopolistic banking competition with endogenous entry of firms, in which new entrants borrow from banks to finance some start-up costs. He finds that stronger monopoly power in the banking industry increases the financial burden faced by borrowers, thus reducing the number of firms in the market and the aggregate level of output. In these circumstances a positive technology shock has a proportionally higher effect on total production than in a perfectly competitive banking environment.

Apart from differences in the strategy followed to model banking competition with respect to the one pursued here, the above papers study non-monetary economies in which banking monopolistic power is the only financial friction. In contrast, key to the arguments developed in the present paper is the idea that investing agents also face borrowing constraints that limit their ability to obtain external finance, linking such constraints to the value of their pledgeable assets. In fact, the positive 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. Importantly, the aforementioned models find that weaker banking competition is associated with a larger output response to productivity shocks due to countercyclical lending margins. While our model also features countercyclical lending margins, we emphasize that the main channel through which margins affect our economy is related to the strength of the net worth effects rather than intertemporal substitution effects.

[4] These differences are smaller in the case of a technology shock since in that case the prices of maturing debts and housing run in opposite directions, so that the overall effect on the borrowers' net worth is weaker.

Huelsewig *et al.* (2006) and Gerali *et al.* (2008) both provide economies featuring an imperfectly competitive banking sector, in which banks compete à la Dixit-Stiglitz, and examine the macroeconomic consequences of sluggishness in banks interest rates. Here we are rather interested in exploring the determinants of the elasticity of the demand for funds and, hence, of bank lending margins, and the links between these and some macroeconomic variables. In so doing, we find natural to assume fully flexible interest rates.

Goodfriend and McCallum (2007), Christiano *et al.* (2007) and Canzoneri *et al.* (2008) also provide recent analyses on the role of banks in general equilibrium monetary models although none of them consider imperfect banking competition. Rather, the interest in these papers is to analyze how different banking technologies to produce loans out of labor, capital, etc., influence the equilibrium determination of the different interest rates and how such technology tends to either amplify or attenuate the effects of macroeconomic shocks. In contrast, we are mainly interested in isolating the macroeconomic effects of imperfect banking competition and, to this aim, we instead consider a very simple technology for loan production.

On the empirical front, Goodhart, Hofmann and Segoviano (2004) using a sample of OECD countries, find that measures taken towards fostering banking competition were associated with an increased sensitivity of bank lending to real estate price movements, thus strengthening the links between bank credit and business cycles. Interestingly, they point towards the strengthened of the borrowers' net worth channel following financial liberalization as a prime cause of such increased sensitivity, thus, in line with the results of our model. Likewise, 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 paper is organized as follows. Section 2 introduces the model. Section 3 is devoted to derive the analytical solution of the profit maximization problem solved by the banks. Section 4 contains the analysis of the deterministic steady state of the model. Section 5 discusses fluctuations around the steady-state in response to monetary and technology shocks using a linearized version of the model. Section 6 concludes.

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, who provide work effort to produce goods, and entrepreneurs obtain utility from consumption of a composite good. Also, the flow of services produced by their housing stocks delivers utility directly to households, while entrepreneurs employ housing services as a production factor. The total housing stock $\overline{H}$, is fixed.

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.[5] This assumption will give rise to a sharp qualitative steady state equilibrium effect, namely, that the households optimally choose to lend while the entrepreneurs borrow. 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. Throughout the paper, we maintain the assumption 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 use a version of Salop's (1979) circular-city model. Specifically, 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. Whenever an entrepreneur asks for credit he has to travel to a bank incurring a utility cost which is proportional to the distance between his and the bank's location. With this spatial environment in mind we next describe the objectives and constraints faced by each type of agent.[6]

2.1 Households

Let C_t, H_t, and L_t represent 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

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

[5] A similar assumption is made by Campbell and Hercowitz (2006).

[6] The reasons for choosing Salop's approach to imperfect competition, instead of the more popular Dixit-Stiglitz differentiated product framework, are twofold. First, loans are far more homogenous products than those composing the consumption basket; and second, we are interested on exploring endogenous variations of the elasticity of the demand for loans as well as lending margin fluctuations that are not necessarily associated to sticky rates.

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 labor income $W_t L_t$, where W_t is the real wage, and income from renting his capital holdings, K_t, to entrepreneurs at a real rental price Q_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 $t-1$, which 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 and occupied by the household and P_t^h is the unit housing price in terms of consumption goods. Implicit in the layout of the problem is the assumption that the flow of housing services that produce utility to the home-owner is equal to the housing stock. Houses do not depreciate while capital depreciates at a rate δ.

The first order conditions for consumption (4), labor supply (5), owner-occupied housing demand (6), deposits (7) and capital supply (8) are

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

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

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

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

$$\left(P_t^k - Q_t^k \right) \lambda_t = \beta E_t \left\{ \lambda_{t+1} \left[\frac{\phi}{2} \left(\frac{I_{t+1}}{K_t} \right)^2 + (1-\delta) P_{t+1}^k \right] \right\}, \tag{8}$$

where λ_t is the Lagrange multiplier on the flow of funds constraint (2). The shadow value of installed capital, P_t^k, is the Tobin's Q, and satisfies $P_t^k = 1 + \phi I_t / K_{t-1}$.

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 therefore express the user cost as,

$$\varpi_t \equiv \frac{\vartheta C_t}{H_t} = P_t^h - \beta E_t \left(P_{t+1}^h \frac{C_t}{C_{t+1}} \right). \tag{9}$$

Thus, the user cost is positively related to the current price P_t^h and negatively related to the expected resale price P_{t+1}^h. It is also positively related to expected consumption growth, as this term captures the utility cost of an extra housing unit due to deferred consumption.

2.2 Production

2.2.1 Entrepreneurs

The representative entrepreneur produces an intermediate good in an amount Y_t using the following constant returns-to-scale technology,

$$Y_t = A_t \left(K_t^e\right)^{\mu} \left(L_t^e\right)^{(1-\mu-\nu)} \left(H_{t-1}^e\right)^{\nu}, \tag{10}$$

where A_t is an exogenous productivity index, K_t^e is capital, L_t^e is labor and H_t^e is real estate. Entrepreneurs are assumed to be more impatient than savers, so that their subjective discount factor β^e satisfies $\beta^e < \beta$.

As for the objective function, we assume that an entrepreneur located at point $k \in (0, 1]$ seeks to maximize the following utility function,

$$U_0^e = E_0 \sum_{t=0}^{\infty} \left(\beta^e\right)^t \left[\log C_t^e - \alpha^e d_t^{k,i}\right], \tag{11}$$

where C_t^e, $d_t^{k,i}$ and α^e denote consumption, the distance between the entrepreneur k and bank i, and the utility loss per distance unit, respectively. The entrepreneur faces the following flow of funds constraint

$$C_t^e + P_t^h (H_t^e - H_{t-1}^e) + R_{t-1}^e B_{t-1}^e / \pi_t = B_t^e + Y_t / X_t - W_t L_t^e - Q_t^k K_t^e, \tag{12}$$

and the borrowing limit,

$$B_t^e \leq m^e E_t P_{t+1}^h \frac{\pi_{t+1}}{R_t^e} H_t^e, \tag{13}$$

where $m^e < 1$. 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 $t + 1$. X_t denotes the markup of final over intermediate goods charged by retailers.

The first order conditions of the representative entrepreneur for consumption (14), capital demand (15), labor demand (16), debt (17), and housing demand (18) are,

$$\frac{1}{C_t^e} = \lambda_t^e, \tag{14}$$

$$Q_t^k = \frac{\mu Y_t / X_t}{K_t^e}, \tag{15}$$

$$W_t = \frac{(1-\mu-\nu)\, Y_t/X_t}{L_t^e}, \quad (16)$$

$$\lambda_t^e = \beta^e E_t \left(\lambda_{t+1}^e \frac{R_t^e}{\pi_{t+1}} \right) + \xi_t^e, \quad (17)$$

$$\lambda_t^e P_t^h = \beta^e E_t \left\{ \lambda_{t+1}^e \left(P_{t+1}^h + \frac{\nu Y_{t+1}/X_{t+1}}{H_t^e} \right) \right\} + \xi_t^e m^e E_t P_{t+1}^h \frac{\pi_{t+1}}{R_t^e}. \quad (18)$$

We will look at equilibria in which R_t^e is low enough so that (13) binds and its corresponding multiplier ξ_t^e, is positive. Now, the user cost for an entrepreneur, ϖ_t^e, is given by the ratio of 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 (14) and (18) can be written as

$$\varpi_t^e = P_t^h - E_t \left(\beta^e \left(\frac{C_t^e}{C_{t+1}^e} \right) + \xi_t^e m^e C_t^e \frac{\pi_{t+1}}{R_t^e} \right) P_{t+1}^h, \quad (19)$$

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. This last term is $\xi_t^e m^e C_t^e E_t \left(\pi_{t+1} P_{t+1}^h \right) / R_t^e$.

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 the consumers preferences ε. A retail firm producing variety j buys the output of competitive wholesale firms and converts it into a variety Y_{jt} that is sold in the market at a price P_{jt}. The demand for variety j is given by $Y_{jt} = (P_{jt}/P_t)^{-\varepsilon} Y_t^f$, where the aggregate price is defined by $P_t = \left[\int_0^1 (P_{jt})^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}$.

Prices are sticky in the retail sector. Following Calvo (1983), each period a random fraction of firms adjust prices. Let $\widetilde{P}_{j,t}$ be the optimal price of the representative firm changing prices at t and $1-\theta$ 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 $P_{j,t} = \pi P_{j,t-1}$. The optimal price maximizes the expected present discounted value of future dividends subject to the demand function

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

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

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

We assume that retail firms are owned by savers. Then, the relevant discount rate in pricing $\zeta_{j,t,t+\widetilde{k}}$ can be expressed as $E_t \zeta_{j,t,t+1} = \beta^s E_t \lambda_{t+1}^s / \lambda_t^s$. Finally, 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 $\Gamma_{jt} = \frac{X_{jt}-1}{X_{jt}} Y_{jt}$. Finally note that aggregate output can be expressed either as the CES aggregator over Y_{jt} $(\forall j)$ or as the sum of total production by competitive intermediate firms. Thus in aggregate we write $Y_t^f = Y_t$.

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

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

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

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

and the balance-sheet identity, $D_t^i = B_t^i$.[7] Each bank takes all prices, including 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. In order to solve for the optimal loan interest rate rules followed by bank i, it is convenient to express its total demand for loans in terms of an *intensive* and an *extensive* margin as follows,

$$B_t^i \equiv b_t^i \widetilde{b}_t^i,$$

where, b_t^i 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).

The first order conditions of this profit maximization problem can then be written in compact

[7] This is a very stylized representation of a banks balance-sheets along which we are abstracting, among other things, from reserve requirements.

form as,

$$R_t^{i,e} = R_t^d + \frac{1}{\Lambda_t^i + \widetilde{\Lambda}_t^i}, \tag{20}$$

where, $\Lambda_t^i \equiv \frac{\partial b_t^i}{\partial R_t^{i,e}} \frac{1}{b_t^i}$ 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.

2.4 Monetary policy

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

$$R_t^d = \rho_r R_{t-1}^d + (1 - \rho_r) \left(\frac{\pi}{\beta^s} + \rho_\pi (\pi_t - \pi) \right) + \epsilon_t^R, \tag{21}$$

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 is an innovation to monetary policy.

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, I_t, K_t^e, D_t, D_t^B, B_t^e, B_t^B, Ω_t, $\Gamma_t\}_{t=0}^\infty$ and a vector of prices $\{P_t$, P_t^h, P_t^k, $\widetilde{P}_t$, W_t, X_t, Q_t^k, R_t^d, $R_t^e\}_{t=0}^\infty$, such that the households and the entrepreneurs 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*) $K_t = K_t^e$, (*labor*) $L_t = L_t^e$, (*deposits*) $D_t = nD_t^B$, and (*loans*) $B_t^e = nB_t^B$.

3 Equilibrium lending margins

In this section we study the determinants of the equilibrium lending margin, $R_t^e - R_t^d$. To this aim we derive the analytical expressions for the semi-elasticities appearing in the first order condition of the banks' problem, (20). In order to obtain an expression for the lending rate, we first derive a closed form solution for the individual demand for funds function, B_t^e. In so doing we exploit the familiar result that under logarithmic utility an entrepreneur saves a fraction β^e of his net worth and consumes the remaining fraction, $1 - \beta^e$. An entrepreneur's net worth can be written as

$$NW_t^e = P_t^h H_{t-1}^e + \nu Y_t / X_t - \frac{R_{t-1}^e}{\pi_t} B_{t-1}^e. \tag{22}$$

That is, the net worth is composed of the total value of the beginning-of-period real estate holdings, $P_t^h H_{t-1}^e$, plus the output share accruing to the entrepreneur's stock of real estate, $\nu Y_t/X_t$, net of maturing debts, $R_{t-1}^e B_{t-1}^e/\pi_t$. Now, using the constraint (12), we obtain the following expressions for the entrepreneur's time t total net investment,

$$P_t^h H_t^e - B_t^e = \beta^e NW_t^e, \tag{23}$$

and consumption,

$$C_t^e = (1-\beta^e)\, NW_t^e. \tag{24}$$

Then, combing (23) with the borrowing constraint (13) holding as an equality, we can write the demand for funds of an entrepreneur who travels to bank i at time t as

$$B_t^e = \frac{\beta^e NW_t^e}{P_t^h \left[m^e E_t\left(P_{t+1}^h \pi_{t+1}\right)/R_t^{i,e}\right]^{-1} - 1}. \tag{25}$$

(Note that we are using the superscript i on $R_t^{i,e}$ in (25) whereas we write R_{t-1}^e in (22). 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 (25), we learn that the demand for funds by an entrepreneur borrowing from bank i depends positively on his net worth, NW_t^e, the loan-to-value ratio, m^e, and the expected housing inflation rate $E_t\pi_{t+1}^h$, with $\pi_{t+1}^h \equiv P_{t+1}^h/P_t^h$, and negatively on the real interest rate $E_t(R_t^{i,e}/\pi_{t+1})$. As expected, neither the number of banks, n, nor the utility cost, $\alpha^e d_{j,t}^{ki}$, have a *direct* effect on the intensive margin (although there is an *indirect* effect through $R_t^{i,e}$ as shown below).

The previous expression (25) allows us to arrive at the following closed-form solution for the semi-elasticity of bank i's intensive margin,

$$\Lambda_t^i = \left\{R_t^{i,e} - m^e E_t\left(\pi_{t+1}^h \pi_{t+1}\right)\right\}^{-1}. \tag{26}$$

From (26) we see that entrepreneurial debt is more sensitive to changes in the nominal lending rate when expected capital gains from housing investments, in nominal terms, $E_t\left(\pi_{t+1}^h\pi_{t+1}\right)$, are high. This reflects the fact that high expected capital gains tend to amplify the effect of a change in $R_t^{i,e}$ on the amount of pledgeable collateral in hands of entrepreneurs, and hence, the response of their demand for funding. Also, higher values of m^e tend to raise Λ_t^i when there is a positive expected nominal whereas decrease Λ_t^i when $E_t\left(\pi_{t+1}^h\pi_{t+1}\right) < 0$.

We next focus on the extensive margin of the demand for funds faced by bank i. 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 (11)) 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 (22) and (24), is independent of the entrepreneur's current banking choice. Also, as each borrower decides optimally his lending bank period by period and without any history-given constraint, we learn that the utility-cost terms $d_s^{k,i}$ for $s > t$, are independent of the current banking choice, as well. Hence, the pivotal entrepreneur is implicitly identified through the following equality,

$$E_t \left\{ \sum_{s=t+1}^{\infty} (\beta^e)^{s-t} \log C_s^{e,i} \right\} - \alpha^e d_t^{k,i} = E_t \left\{ \sum_{s=t+1}^{\infty} (\beta^e)^{s-t} \log C_s^{e,i+1} \right\} - \alpha^e d_t^{k,i+1}, \quad (27)$$

where $C_s^{e,i}$ and $C_s^{e,i+1}$ 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 (22) and (23) with (13) holding as an equality and express entrepreneurial net worth at $t+1$ as a function of its own lagged value,

$$NW_{t+1}^{e,i} = \beta^e \frac{\nu Y_{t+1}/\left(X_{t+1} H_t^e\right) + P_{t+1}^h - m^e E_t\left(P_{t+1}^h \pi_{t+1}\right)/\pi_{t+1}}{P_t^h - m^e E_t\left(P_{t+1}^h \pi_{t+1}\right)/R_t^{i,e}} NW_t^e. \quad (28)$$

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 labor 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 (10), (15) and (16), we learn that,

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

Hence, the only channel through which $R_t^{i,e}$ affects $NW_{t+1}^{e,i}$ 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 (28) to future dates,

$$NW_{t+s+1}^{e,i} = \beta^e \frac{\nu Y_{t+s+1}/\left(X_{t+s+1} H_{t+s}^e\right) + P_{t+s+1}^h - m^e E_{t+s}\left(P_{t+s+1}^h \pi_{t+s+1}\right)/\pi_{t+s+1}}{P_{t+s}^h - m^e E_{t+s}\left(P_{t+s+1}^h \pi_{t+s+1}\right)/R_{t+s}^e} NW_{t+s}^{e,i}, \quad (29)$$

which is valid for $s \geq 1$. (Following the same argument as before, we are using the superscript i on $NW_{t+s}^{e,i}$ for $s \geq 1$, in expressions (28) and (29) to emphasize that the net worth at future dates depends on the time t banking choice via $R_t^{e,i}$, while such distinction is irrelevant for NW_t^e).

Then , given that $d_t^{k,i+1} = 1/n - d_t^{k,i}$, we next use the consumption function (24) together with the recursive representation of the net worth in (29), to express (27) as

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

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 $d_t^{k,i}$), 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', to write the market share (extensive margin) of bank i as $\widetilde{b}_t^i = d_t^{k,i} + d_t^{k',i}$, or

$$\widetilde{b}_t^i = 1/n + \left[\frac{1}{2\alpha^e} \frac{\beta^e}{1-\beta^e} E_t \left(2 \log NW_{t+1}^{e,i} \text{-} \log NW_{t+1}^{e,i+1} \text{-} \log NW_{t+1}^{e,i-1} \right) \right]. \tag{30}$$

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 (30) reflects the fact that an increase in $R_t^{i,e}$ reduces the utility surplus that entrepreneurs obtain from borrowing at bank i as compared with borrowing at 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^e increases; if the utility cost of moving to other bank increases, then the incentive to do so will be reduced.

Finally, using the expression for $NW_{t+1}^{e,i}$ in (28) 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,

$$\widetilde{\Lambda}_t = \frac{n}{\alpha^e} \frac{\beta^e}{1-\beta^e} \left\{ \left(\frac{R_t^e}{m^e E_t \left(\pi_{t+1}^h \pi_{t+1} \right)} - 1 \right) R_t^e \right\}^{-1}, \tag{31}$$

where we have used the fact that in a symmetric equilibrium the market share of each bank is simply $1/n$. Equation (31), when combined with (26), can also be expressed as

$$\widetilde{\Lambda}_t = \frac{n}{\alpha^e} \left\{ \frac{\beta^e}{1-\beta^e} m^e \frac{E_t \left(\pi_{t+1}^h \pi_{t+1} \right)}{R_t^e} \right\} \Lambda_t. \tag{32}$$

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_t^i is high, so does time $t+1$ net worth and, hence, consumption at that date. In short, a large value of Λ_t^i, 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 wealth effects over the entire time horizon 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 (32). Finally, the effect of the term n/α^e (which can be thought as of representing the "effective degree of bank competition") on $\widetilde{\Lambda}_t^e$ is straightforward. High values of n/α^e 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.

We are now in a position to obtain the following expression for the symmetric equilibrium lending margin, $R_t^e - R_t^d$, by combining (20), (26) and (31),

$$R_t^e - R_t^d = \frac{1 - m^e E_t\left(\pi_{t+1}^h \pi_{t+1}/R_t^d\right)}{\eta^e m^e E_t\left(\pi_{t+1}^h \pi_{t+1}/R_t^d\right) - 1} R_t^d, \tag{33}$$

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

Equation (33) shows in rather transparent manner how the model links collateral constraints with an imperfectly competitive banking sector to produce an endogenous external finance premium. This mechanism shares an important feature with the central proposition of BGG which contends that, in a context with 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 external finance premium and the borrowers capacity to pledge collateral, as captured by the term $m^e E_t\left(\pi_{t+1}^h \pi_{t+1}/R_t^d\right)$ in (33), obtains, as well. In contrast to the BGG framework, however, the channel we study in this paper emphasizes the idea that the degree of competition among lenders 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 the one highlighted in BGG.

4 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, with the help of some numerical exercises, we analyze how the degree of banking competition influences some variables of interest.

4.1 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 (17) we can express the multiplier associated with the borrowing constraints 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 than the other agents in the economy 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.[8]

Using (33), we obtain the following expression for the lending margin,

$$r^e - r^d = \frac{r^d - m^e}{\eta^e m^e - r^d} r^d. \tag{34}$$

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^e, also contribute to rise 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 larger banking monopolistic power, as captured by low values of η^e.

4.2 Calibration

To evaluate numerically the main properties of the model in the steady state we next assign values to the parameters. We start with those governing the bank lending margins. The savers subjective discount factor β, is set in our central scenario at 0.9926, which produces an annual real interest rate on deposits of 3 per cent. We then chose a discount factor for impatient entrepreneurs $\beta^e = 0.97$, which is within the range of the normal bands used in the previous

[8] In the dynamic stochastic analysis of 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.

literature (see Iacoviello (2005) and the references therein).[9] We also set $m^e = 0.85$, which is in line with recent estimations for the U.S.[10] We normalize the number of banks at 10 and set $\alpha^e = 11$ that yields a real annual lending margin of 250 basis points. This is roughly the mean value of the interval considered by Christiano *et al.* (2007) who present some previous estimates for the U.S. economy.

As regards the parameters governing the distribution of the housing stock between the entrepreneurs and households sectors, we set $\vartheta = 0.1$ and $\nu = 0.05$, which together imply, first, that 20 per cent of the housing 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 per cent 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. Thus, μ, ε, θ, π, ρ_r, ρ_π and ψ equal 0.35, 8, 0.75, 1.005, 0.7, 1.3, and 2, respectively.

4.3 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. $\alpha^e = 0$) to 400 basis points, which obtains by setting $\alpha^e = 17.6$. All variables are normalized to take a value of 100 in the benchmark case described above (i.e. $\alpha^e = 11$).

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^e and, hence, lending margins fall. The sensitiveness of the long-run level of entrepreneurial consumption with respect to the lending margin is naturally higher than the one corresponding to households. Thus, putting things together, the model predicts that stronger banking competition "greases the economy's wheels" in the long run.

In order to get intuition into the mechanism behind the above result, it is helpful to examine how competition among banks affects the distribution of the housing stock between households and entrepreneurs. To this aim we next analyze how the user cost for an entrepreneur relative to that of a household varies with α^e. Using (9) and (19) and substituting out for ξ^e, we can

[9] The degree of impatience implicit here is higher than the one calibrated by Krusell and Smith (1998) and Campbell and Hercowitz (2006a, 2006b), 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 is always binding even when we consider unrealistically high margins.

[10] Cambell and Hercowitz (2006b) calculate that the average equity share of new home owners in the U.S. for the last decade has been around 17.5%., which is consistent with a loan-to-value ratio of 82.5%. Likewise, Iacoviello (2005) obtains an estimation of the loan-to-value for U.S. entrepreneurial debt at 89%.

write the relative user cost for an entrepreneur vis-à-vis a household as,

$$\frac{\varpi^e}{\varpi} = \frac{1-\beta^e - \left(\frac{1}{r^e} - \frac{\beta^e}{\beta}\frac{1}{r^d}\right)m^e}{1-\beta}. \tag{35}$$

The relative user cost of housing as expressed in (35) is an increasing function of α^e (figure 1.6). This is an intuitive result. As α^e 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^e, 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 (10), in turn, increases output. The latter pushes up wages and entrepreneurial net worth which trigger a rise in households and entrepreneurs consumption, respectively.

5 Dynamic analysis

In this section we analyze the dynamics of a number of variables at the business cycle frequency in response to 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, Proudman and Vlieghe (2004), Iacoviello (2005) and Calza, Monacelli and Stracca (2007), among others. Our main focus here is on the way in which short-run dynamics are affected by the presence of monopoly power in the banking industry.

Lending rates turn out to be key components of the transmission mechanism of shocks. As discussed before, weaker competition in the banking sector raises lending rates in the steady state, reducing consumption expenditure of savers and more so that of borrowers due to a reallocation of available collateral from the latter to the former. The responses of the main aggregate variables to various shocks will not be independent to the structure of this industry either. In what follows we illustrate this by analyzing the response function of some aggregate variables after two types of $AR(1)$ shocks: monetary policy ($\rho_r = 0.1$) and technology ($\rho_r = 0.9$) shocks.

5.1 Monetary policy shocks and banking competition

Herein we focus on the effects of an unanticipated temporary monetary shock, implemented as a positive innovation ϵ_t^R in the monetary policy rule (21), that raises the nominal rate R_t^d. Figure 2 compares the accumulated response of output corresponding to the benchmark calibration with long-run annual real lending margins of 250 b.p., with two other economies, one featuring a perfectly competitive banking sector, i.e. $\alpha^e = 0$ and a zero margin, and another with high banking monopolistic power ($\alpha^e = 17.6$) in which the lending margin reaches 400 b.p. This figure shows that weaker competition in the banking industry 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 per cent (40) higher than in the benchmark (low competition) case.

For illustrative purposes, it is worth noticing that the previous relative output losses across different levels of banking competition are even of higher order of magnitude than those reported by Iacoviello (2005) when comparing the output loss in his benchmark economy with debt deflation and collateral effects against (i) an economy with no debt deflation and collateral effects (lost output over 40 quarters is16 per cent higher than in the benchmark) and (ii) an economy with neither debt deflation nor collateral effects (33 per cent higher than in the benchmark). The fact that fostering banking competition produces an impact on the volatility of output seemingly comparable to that stemming from looser borrowing constraints suggests that strong banking competition might be a potentially powerful destabilizing channel in economies in which productive agents face endogenous credit limits.

In order to get intuition on the previous numerical findings, we next focus on three important channels through which monetary shocks affect the variables of this economy: sticky prices in the manufacturing sector, endogenous lending margins and net worth effects.

Price rigidity. The presence of nominal rigidities 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. From causal inspection of figure 3.1, it is clear that price rigidity is unlikely to account for the sizeable differences in the output response. In fact the dynamics of inflation across banking structures are remarkably similar and that implies that the sacrifice ratio, in terms of output loss relative to inflation, is also significantly higher in the economy with a more competitive banking industry.

Endogenous lending margins. The contribution of rigid prices to the dynamics of output via higher real interest rates is reinforced by the countercyclical response of real lending margins in the economies with banking monopolistic power (see figure 3.2). The following expression is the log-linearized version of the margin equation (33), in which both sides have been deflated by expected inflation in order to deal with real margins and interest rates,

$$\widehat{(r^e - r^d)}_t = c_1 \widehat{r}_t^d - c_2 \widehat{\pi}_{t+1}^h, \tag{36}$$

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 multipliers are $c_1 \equiv \left[\eta^e m^e/r^d + r^d/(r^e - r^d)\right] / \left(\eta^e m^e/r^d - 1\right)$ and $c_2 \equiv \left[\eta^e m^e/r^d + m^e/(r^e - r^d)\right] / \left(\eta^e m^e/r^d - 1\right)$. Thus, from (36) 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 $\widehat{r}_t^e$, i.e. both intensive- and extensive-margin semielasticities fall. On the other hand, positive house price inflation following the shock, ($\widehat{\pi}_{t+1}^h > 0$; see figure 3.3), unchains the opposite effect. Intuitively, as the house price recovers towards its steady state value, a unit of internal funds invested in housing 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. Thus, this latter effect partially dampens the upwards response of the margin.

Taking the response of lending margins in isolation, one would conclude that stronger banking competition helps to dampen output fluctuations following monetary shocks. Since the interest rate faced by investing agents rises more than one-to-one respect to the policy rate, weaker banking competition leads to an amplification of the effects of original disturbance. The effect of banking competition operating through the lending margin 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 to 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 various levels of banking competition in figure 2 are mainly due to the strong influence of interest rate margins on the behavior 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 3.5). In short, 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.

The previous mild reaction in the consumption of households contrasts with that corresponding to entrepreneurs (figure 3.6). The unexpected rise in the interest rate erodes their net worth, thus reducing their consumption. Hence, both the substitution and the wealth effects operate in the same direction. 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 per cent higher under perfect banking competition than in the low competition environment. This naturally follows from the fact that stronger competition among banks drives lending rates down which raises leverage ratios. To gain some further insights into this latter mechanism, it is helpful to analyze the impact response of entrepreneurs net worth at the time of the shock ($t = 1$). To this aim, we combine (13), holding as an equality, and (22), to express the entrepreneurial net worth at $t = 1$ as

$$NW_1^e = \left(1 - m\frac{\pi}{\pi_1}\right) P_1^h H^e + \nu Y_1 / X_1. \tag{37}$$

Log-linearizing (37) around the steady state gives the following expression for the relative deviation of net worth on impact,

$$\widehat{NW^e}_1 = \beta^e \frac{r^e}{r^e - m^e} \left[\widehat{P}_1^h + m^e \widehat{\pi}_1 + \nu \frac{Y}{X} \left(\widehat{Y}_1 - \widehat{X}_1 \right) \right]. \tag{38}$$

The term, $r^e/(r^e - m^e)$ in the above expression corresponds to the steady state ratio of housing investments over net worth, i.e. $P^h H^e / NW^e$, which can also be expressed as an increasing function of the leverage ratio, $B^e/P^h H^e$, as $1/\left(1 - B^e/P^h H^e\right)$. Clearly, the leverage ratio is negatively related to r^e and, hence, according to (34), it increases with the degree of baking competition. Higher leverage ratios, in turn, amplify the magnitude of changes in the house price, the real value of maturing debts, debt-deflation and the marginal productivity of entrepreneurial real estate, all of which are negative. In this context, stronger banking competition tends to amplify the original negative effect on debtors net worth. As this happens, their ability to demand funds in the current period falls even though stronger banking competition keeps margins lower as discussed above. Then, lower access to credit unchains a negative effect on debtors demand for housing that puts extra downward pressure on housing prices (figure 3.3) and, hence, on debtors net wealth, reducing their ability to obtain external funding (see figure 3.4) and curtailing their demand for consumption and capital, with the latter driving down capital investment. These net worth and collateral effects, which quantitatively dominate the margin effect, lie behind the positive association between higher competition and larger falls in housing prices, aggregate consumption, capital investment and output.

In order to provide a general view of the mechanisms described above, we find particularly useful to think about our model as one "nesting" two of the most prominent macroeconomic theories of financial imperfections. On one end, stronger banking competition triggers a stabilization effect in the form of a less pronounced countercyclical response of lending margins. Along this dimension, our model has an implication that resembles the central one in the financial accelerator framework of BGG, namely, that by alleviating the underlying friction (asymmetric information between borrowers and lenders in BGG and banking monopolistic power here) the economy becomes less sensitive to monetary shocks. On the other, lower lending margins associated with stronger competition go hand in hand with higher debtors' leverage, which in a context of binding endogenous collateral constraints works as an amplification mechanism of exogenous disturbances, as emphasized by Kiyotaki and Moore (1997). The numerical exercises presented here suggest that the incidence of banking competition on the intensity of the financial friction that applies directly to the *volume* of credit is of greater magnitude that the one affecting the *price* of such credit.

So far, we have focused on the effects of changing levels of banking competition on the lending margin and net worth channels. The model also provides clear answers regarding the incidence of the second friction (collateral constraints) on those channels. First, we learn from (38) that higher m^e implies a larger multiplier effect of changes in inflation, house and productivity on entrepreneurs net worth, a result which is in line with findings in Iacoviello (2005) and Calza, Monacelli and Stracca (2007). Furthermore, the marginal effect of an increase in m^e on the multiplier in (38) is amplified by a higher degree of banking competition, i.e. a lower r^e.[11]

In contrast, the incidence of m^e on the response of the lending margin exhibits a negative sign, that is, a higher m^e reduces the rise in the real margin following the shock, thus contributing to stabilize output. Formally, this latter mechanism works mainly through an increase in the multiplier on the capital gains term in (36), c_2, that more than compensates a parallel rise in c_1. In words, as m^e takes on higher values, debtors are able to capitalize a greater fraction of the positive house price inflation during the recovery phase following the shock (recall that $\widehat{\pi}_{t+1}^h > 0$), which allows them to increase their leverage. As this happens, the demand for funds becomes more sensitive to variations in the lending rate, thus putting some downward pressure on the lending margin.

We are now in a position to place these findings in the context of some previous results in the literature. Goodfriend and McCallum (2007) and Christiano et al. (2007) also provide recent analyses on the role of banks in general equilibrium monetary models although neither consider imperfect banking competition. In the model by Goodfriend and McCallum banks employ a technology for producing loans that combines labor, physical capital and collateral. Relative to the benchmark without a banking sector, they find that banks may either amplify or dampen shocks since their model features both an accelerator and an attenuator effect. Focusing, for instance, on an expansionary monetary shock, the former effect induces a larger response of the supply of loans (relative to the benchmark) together with a fall in the lending premium, as a consequence of the rise in the value of banks' collateral. The attenuator effect, however, results from the fact that a higher demand for loans can only be met by rising employment in the

[11] Of course, changes in m^e also affect the endogenous variables in (38). However, the dominant effect comes from the influence of m^e on the multiplier, $r^e/(r^e - m^e)$.

banking sector. This last effect, triggers an increase in the marginal cost of banks that tends to rise the external finance premium, thus counteracting the previous expansionary effect. For reasonable calibrations, either effect may dominate. Likewise, Christiano et al. (2007) introduce a production function for banking transaction services that also makes use of labor, physical capital and excess reserves. They find that, relative to an economy without such a banking sector, output responds more strongly following a monetary shock.

5.2 Technology shocks

Figure 4 depicts the 40-period accumulated output response following a positive technology shock. The response is stronger in the economy in which market competition is more intense. Yet, differences in the output response are of a much smaller magnitude in this case. The response under a perfectly competitive banking sector is 7 per cent higher than in the benchmark case and 10.5 per cent higher than in the model in which banking competition is lowest. The reason for this milder incidence of the banking structure comes from the presence of two opposite effects of banking competition on the borrowers' net worth. Following a positive technology shock the rise in the housing price increases the value of collateral in hands of entrepreneurs. But this shock has a deflationary effect on impact that raises the interest payments on outstanding debt; this negative effect on the net worth is increasing in the amount of accumulated debt that is higher in economies with low interest rate margins (see (38)). Hence, more competitive banking industries induce stronger responses of both the value of housing and interest rate payments. Although the first effect dominates, the sensitivity of net worth, and hence consumption, is much lower than in the case of a monetary shock.

As with the monetary shock, the role played by the net worth effect on the response of aggregate output is reflected on the unequal reaction of consumption across agents. Whereas the impact response of households consumption (figure 5.5) is 0.61 per cent of its steady state value in the benchmark, the increase of entrepreneurs' consumption is comparatively larger (around 4 per cent in the benchmark; see figure 5.6). The increase in households consumption is entirely due to the improvement in the efficiency in the economy that increases output, real wages and the value of housing and productive capital. Entrepreneurs, on the other hand, have another important determinant of consumption, namely the value of the collateral that determines the borrowing limit. The increase in housing prices raises their wealth and, hence, their ability to pledge collateral thus pushing up both current consumption and debt. Also, the unequal response of output across different degrees of banking competition is entirely explained by the differences obtained in consumption spending by constrained agents ($3.7-4.6$ depending on the degree of banking competition), while the reaction of households consumption is virtually unaffected by the degree of competition in the banking industry ($0.61-0.62$).

The reduction in volatility of macroeconomic variables associated with high market power in the banking industry is in stark contrast with the implication of most previous models that incorporate a banking sector. Aliaga-Díaz and Olivero (2006), Stebunovs (2008) and Mandelman (2006) all develop models with imperfect banking competition and find that higher monopolistic power is associated with a larger output response to productivity shocks. In Aliaga-Díaz and Olivero market power arises from switching costs faced by costumers when trying to move from one bank to another. Such a "lock-in effect" implies that current low rates serve to attract new consumers but also reduce the future profits that a bank obtains from each locked-in customer. Following an expansionary shock, the importance of future market share relative to current profits increases, which motivates a countercyclical lending margin. Relative to an economy with a perfectly competitive banking industry, countercyclical margins unambiguously render the economy more volatile. Mandelman (2006) models banking competition as an entry game in which potential competitors face fixed settlement costs and incumbents play strategies aimed at deterring entry. After a positive productivity shock the aggregate demand for loans expands, thus increasing the number of potential entrants in the industry which leads incumbents to lower their rates. In so doing, banks set countercyclical lending margins which contribute to augment the effect of technology shocks on output. Finally, competition à la Salop in Stebunovs (2008) has a similar effect since the deregulation in the banking industry reduces the lending margin and makes it possible for more firms to enter the market. Higher output and more firms in the steady-state make the competitive economy less responsive to exogenous technology shocks, and then more stable over the business cycle.

Our model shares with these the fact the more competitive banking industries are associated with higher output in the steady-state as well as the countercyclical response of lending margins (figure 5.2). However, as in the case of monetary shocks, the presence of collateral constraints that are alleviated by positive technology shocks, in particular through the rise in the housing price (figure 5.3) that fuels credit (figure 5.4), dominates, making the output response stronger under perfect competition in banking. The latter additional channel, which is missing in the papers above, lies at the core of the positive link between banking competition and output response.[12]

[12] In this sense, our results are consistent with the hypothesis put forward by Goodhart, Hofmann and Segoviano (2004, p.602): "In models with credit-constrained borrowers, a positive productivity shock gives rise to a boom–bust cycle in lending, economic activity, and asset prices. A positive productivity shock leads to an increase in the value of collateralizable assets. As the borrowing capacity of entrepreneurs depends on the value of their collateralizable assets, this gives rise to higher lending, which in turn further fuels economic activity and asset prices, which again increases borrowing capacity, and so on."

6 Conclusions

In this paper we develop a dynamic general equilibrium model with an imperfectly competitive banking sector and collateral constraints that tie agents' credit capacity to the value of their real estate holdings. Banks enjoy monopolistic power in the loans market and set optimal lending rates taking into account the effects of their price policies on the market share and on the amount of funds demanded by each customer. Lending margins have a significant effect on aggregate variables. Over the long run, fostering banking competition increases total consumption and output by triggering a reallocation of available collateral towards debtors. However, as regards the short-run dynamics, we find that most macroeconomic variables are more responsive to exogenous shocks in an environment of highly competitive banks. Key to this last result are the reaction of housing prices and the overall volume of outstanding debt. The response of housing prices is more pronounced when competition among banks is stronger and so is the amount of collateral and outstanding debt, making borrowers' net worth more sensitive to shocks and, specially, to monetary ones. Thus, regarding changes in the degree of banking competition, the model generates a trade-off between the long run level of economic activity and its stability at the business cycle frequency.

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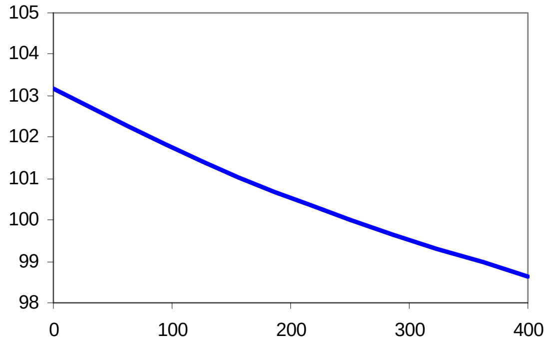
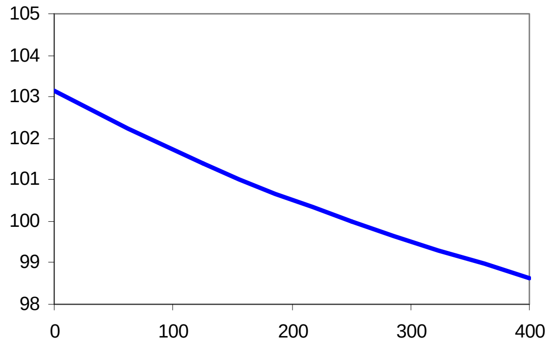
Figure 1.Steady State levels for different degrees of banking competition.

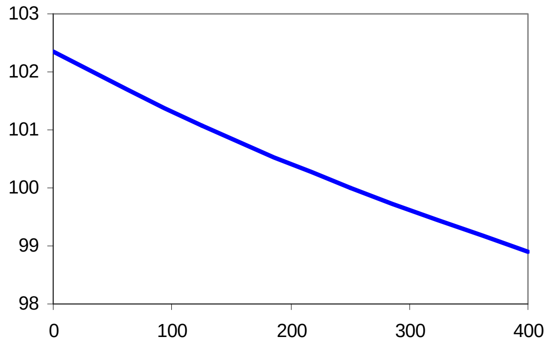
1.1 Output



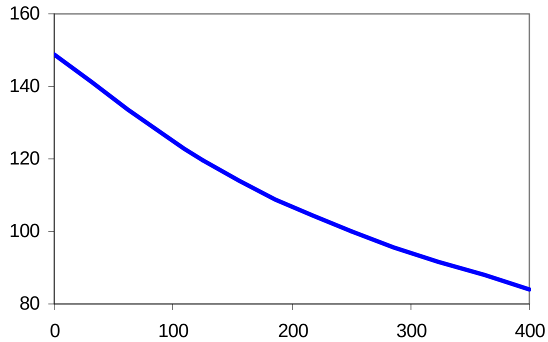
1.2. Investment



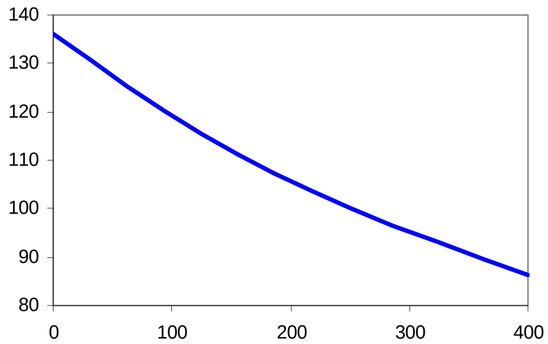
1.3. Households Consumption



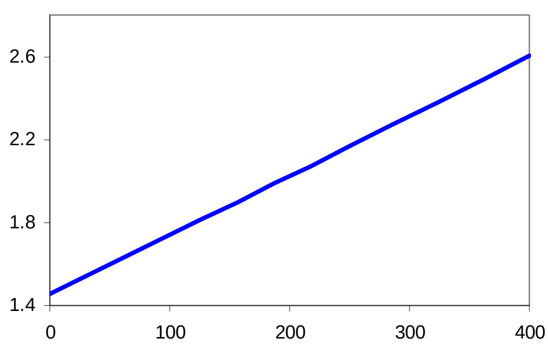
1.4. Entrepreneurs Consumption



1.5.Entrepreneurs Housing

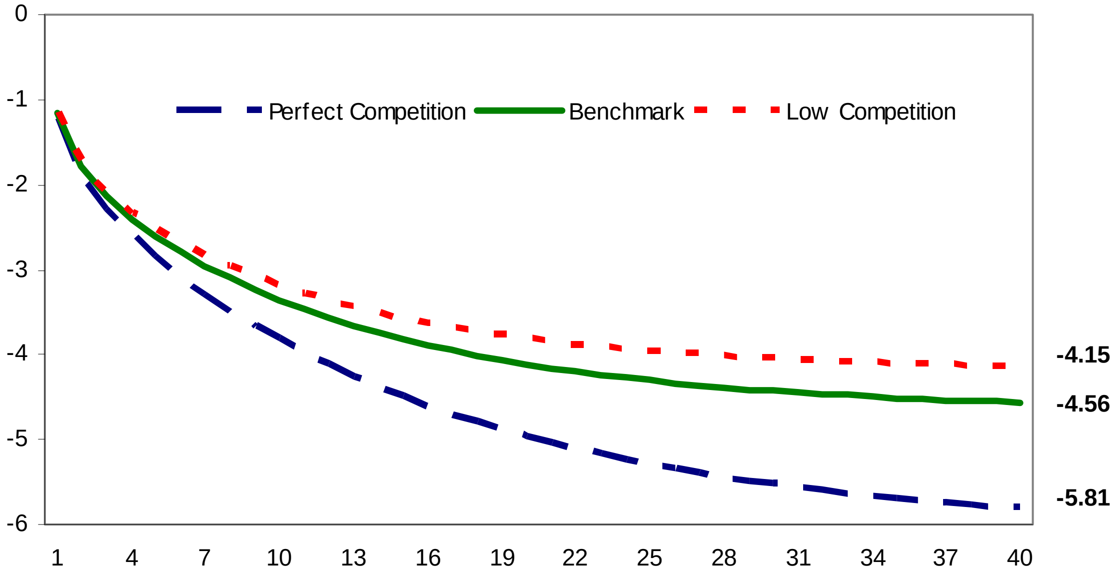


1.6.Relative User Cost



Horizontal axis: real lending margin (basis points, annual); .vertical axis:
for figures 1.1-1.5, normalized levels (benchmark with 250 basis point = 100);
for figure 1.6, value of the realtive user cost

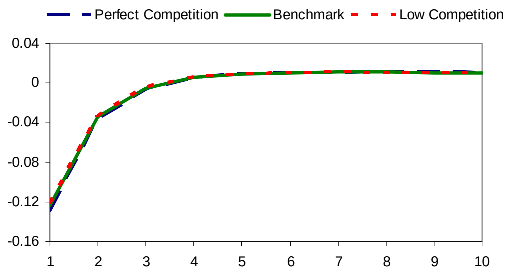
Figure 2. Monetary shock: Accumulated output response



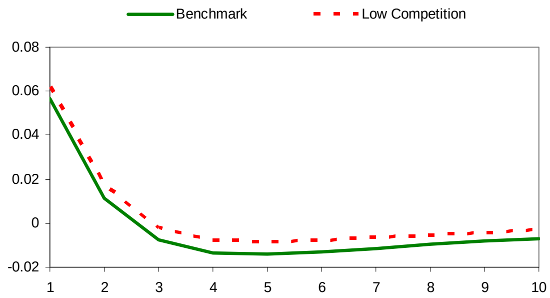
Horizontal axis: quarters after the shock; vertical axis:
accumulated deviation from the steady state value in percentage points

Figure 3. Monetary shock: Impulse responses.

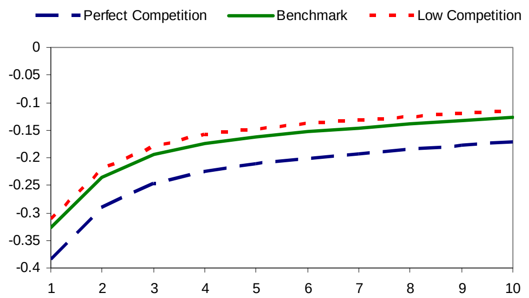
3.1 Inflation



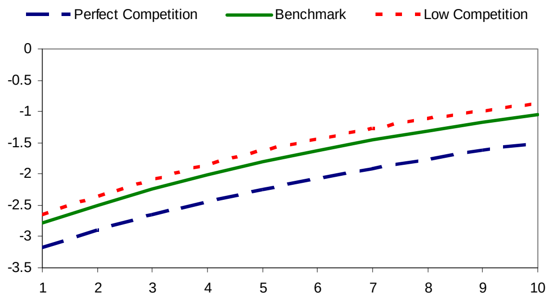
3.2 Real lending margin



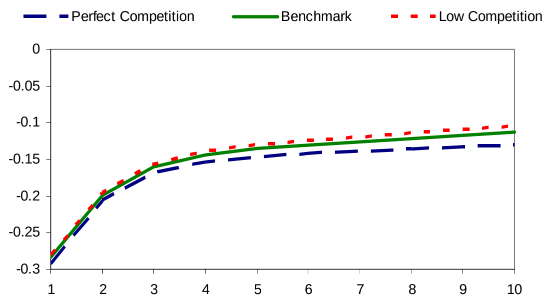
3.3. Housing price



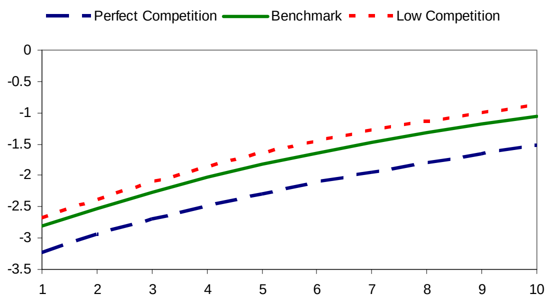
3.4. Entrepreneurs debt



3.5. Households consumption

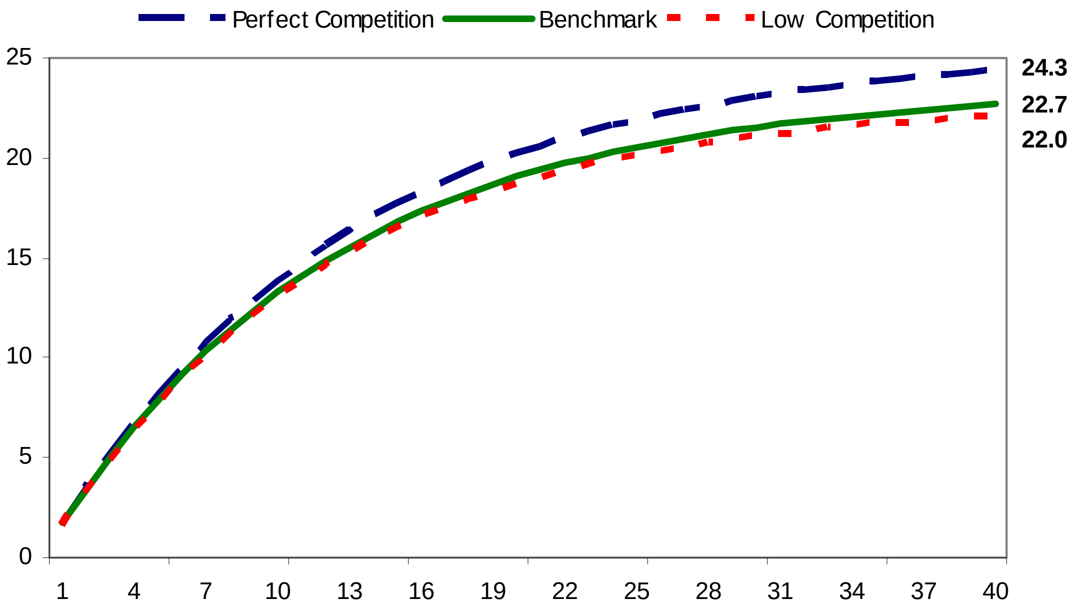


3.6. Entrepreneurs consumption



Horizontal axis: quarters after the shock; vertical axis: deviation from the steady state value in percentage points

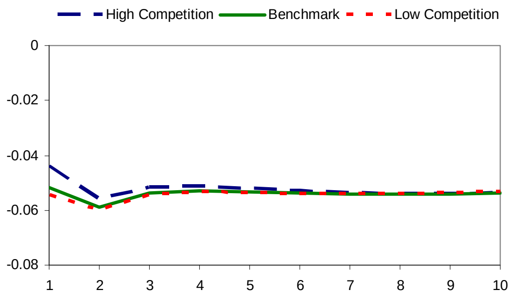
Figure 4. Technology shock: Accumulated output response



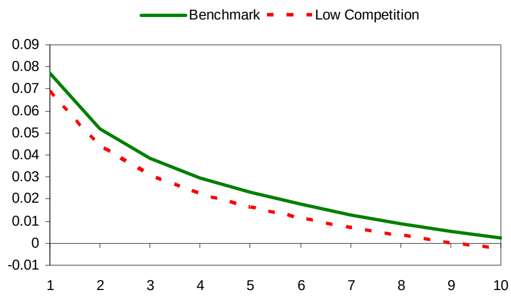
Horizontal axis: quarters after the shock; vertical axis:
accumulated deviation from the steady state value in percentage points

Figure 5. Technology shock: Impulse responses.

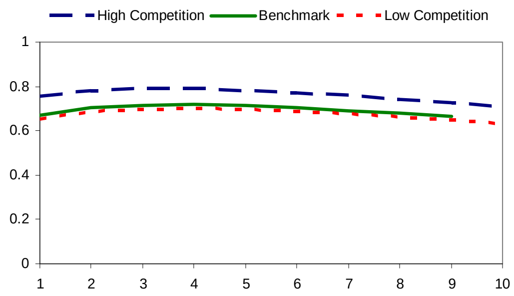
5.1 Inflation



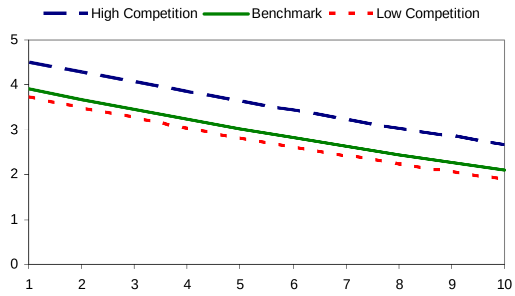
5.2 Real lending margin



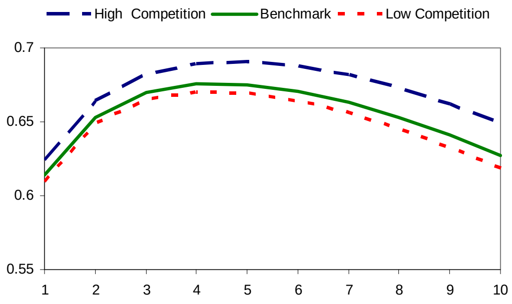
5.3. Housing price



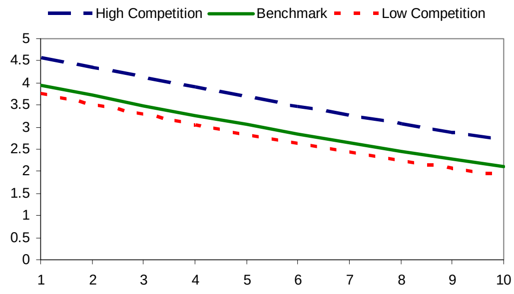
5.4. Entrepreneurs debt



5.5. Households consumption



5.6. Entrepreneurs consumption



Horizontal axis: quarters after the shock; vertical axis:
deviation from the steady state value in percentage points

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