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Firms Endogenous Entry and Monopolistic Banking in a DSGE model

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Abstract

We consider a DSGE model with monopolistic competitive banks together with endogenous firms entry. We find that our model implies higher volatilities of both real and financial variables than those implied by a DSGE model with monopolistic banking sector and a fixed number of firms. The response of the economic activity is also more persistent in response to all shocks. Furthermore, we show that inefficient banks enhance the endogenous propagation of the shocks in respect to a model where banks compete under perfect competition and can fully ensure against the risk of firms default.

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1 Introduction

An important link between the financial market and the real economy is created by firms that finance their activity by borrowing from banks. Studying this link helps to understand one of the most important transmission channel of the financial market to the real economy. Further, as shown in the recent financial crisis, the interaction between the banking sector and the good market sector, may affect not only the intensive margin of the good market but also its extensive margin, that is firm entry and exit decisions. Following these insights, this paper investigates the relationship between firms dynamics and banking, in a DSGE model characterized by flexible prices, monopolistic competitive banking and sticky interest rates, together with endogenous firms' entry decisions, modelled as in Bilbiie Ghironi and Melitz (2012 - BGM henceforth). Using this framework, we seek to understand the transmission channel of real and financial shocks to the real economic activity, disentangling the role played by endogenous firms creation from that played by monopolistic banks. With respect to the latter, we assume that banks cannot ensure against the risk of firms default. This implies that banks can incur in balance sheet losses. We contribute to the literature by finding the following main results. First, in response to both real and financial shocks, a model with endogenous firms creation and inefficient banks implies a stronger amplification of the business cycle and higher volatilities of both real and financial variables than those implied by a DSGE model with monopolistic banking and a fixed number of firms. Second, response of the economic activity is also more persistent in response to all shocks. Third, we show that the presence of inefficient banks enhance the endogenous propagation of the shocks in respect to a model where the banking sector is efficient. Finally, to assess the robustness of our results we consider two different ways of measuring firms sunk entry cost. We show that the main results remain unchanged.

Our paper is motivated by two main empirical facts. First, the big role played by the banking sector in the recent financial crisis both the US and in Europe. Adrian, Colla and Shin (2012) for example have shown that depletion of bank capital from sub-prime losses has forced banks to reduce lending and to raise to costs of credit. Similarly, Neri (2012) shows the EU GDP contraction started in 2008 was almost entirely due to shocks to the banking sector. Second, the strong contraction of the GDP has been accompanied by a strong credit crunch and a reduction in firms entry as well as an increase in exit, which also contributed to deteriorate the quality of the banks balance sheets.

So far, theoretical DSGE models used for business cycle analysis do not investigate the interaction between firms dynamics and banking. Recently, BGM (2012) consider a model with endogenous firms entry and show that the sluggish response of the number of producers (due to the sunk entry costs) generates a new and potentially important endogenous propagation mechanism for real business cycle models. Etro and Colciago (2010) characterize endogenous good market structure under Bertrand and Cournot competition in a DSGE model and show that their model improves the ability of a flexible price model in matching impulse response functions and second moments for US data. Colciago and Rossi (2012) extend this model accounting for search and matching frictions in the labor market. Bergin and Corsetti (2008) and Cavallari (2013) analyze the role of entry in an open economy framework. Nevertheless, all these models embed a perfect financial market. At the same time DSGE models embedding financial market frictions as for example Bernanke, Gertler and Gilchrist (1999), do not consider the direct central bank intermediation as an instrument of monetary policy. An exception are Kiyotaki and Moore (2009), Curdia and Woodford (2009) and more recently, Gertler and Karadi (2011), Gerali et al. (2010) and De Walque (2011), among others. All these models however, consider a constant number of firms and do not investigate the role played by the interaction between firms dynamics and banking. Thus, to the best of our knowledge we are the first to introduce a structured banking sector in a DSGE model characterized by endogenous firms entry decision. Overall, we show that theoretical models cannot disregard the role played by endogenous market structure since they would underestimate the effects of both real and financial shocks.

The remainder of the paper is organized as follows. Section 2 presents the model economy. Section 3 contains the main results. Section 4 presents some robustness and Section 5 concludes. Technical details are left in the supplemental Appendix available online.

2 The model

2.1 Firms

The supply side of the economy is composed by an intermediate good-producing sector and a retail sector that aggregates the intermediate goods. The latter operates under perfect competition, while the former under monopolistic competition.

2.1.1 Firms: the intermediate sector

We assume a continuum of firms producing a differentiated intermediate goods $i \in N$, so that N represents both the mass of available goods and the number of firms. $P^I_{i,t}$ being the nominal price of good i. The intermediate good is sold under fully flexible prices to the retail sector. The production function of firm i is

$$y^I_{i,t} = A_t l_{i,t} \tag{1}$$

where $l_{i,t}$ is the amount of labor hours employed by firm i, and A_t is the aggregate productivity, such that

$$\log\left(\frac{A_t}{A}\right) = \rho_a \log\left(\frac{A_{t-1}}{A}\right) + \varepsilon_{A,t} \tag{2}$$

where $\varepsilon_{A,t}$ is a standard white noise with zero mean and a standard deviation σ_A.

Real profits of the intermediate goods firm, are given by:

$$j_{i,t} = \frac{P_{i,t}^{I}}{P_t} y_{i,t}^{I} + b_{i.t} - w_t l_{i,t} - \left(1 + r_t^b\right) b_{i.t} \tag{3}$$

Here we follow Ravenna and Walsh (2006) setup and we assume that at the beginning of period t firm i finances its working capital by using bank loans. This implies that firm's loan in real terms is $b_{i.t} = w_t l_{i,t}$ (with $w_t = \frac{W_t}{P_t}$). The loan is paid back to the bank at the end of the same period.

The intermediate goods firm chooses the amount of labor and the optimal price in order to maximize expected real profits, subject to $y_{i,t}^{I} = \left(\frac{P_{i,t}^{I}}{P_t}\right)^{-\theta} Y_t$, which is the demand for the intermediate good i, with P_t being the CPI index. First order conditions yield the optimal demand for labor and the optimal price, being respectively:

$$mc_{i,t} = \left(1 + r_t^b\right) \frac{w_t}{A_t} \tag{4}$$

$$\frac{P_{i,t}^{I}}{P_t} = \frac{\theta}{\theta - 1} mc_{i,t} \quad \Rightarrow \quad \rho_t = \frac{\theta}{\theta - 1} mc_{i,t} \tag{5}$$

where $mc_{i,t}$ are firm i real marginal costs and $\frac{P_{i,t}^{I}}{P_t} = \rho_t$ is the intermediate price. Notice that, as in Ravenna and Walsh (2006), real marginal costs depend directly on the nominal interest rate. This introduces the so called *cost channel* of monetary transmission into the model. If firms' costs for external funds rise with the short-run nominal interest rate, then monetary policy cannot be neutral, even in presence of flexible prices and flexible interest rates.

2.1.2 Endogenous Entry

As in BGM (2012), prior to entry firms are identical and face a fixed sunk entry cost f^E. At the beginning of each period N_t^E new firms enter in the economy. Prospective entrants in period t compute their expected value as the present discounted value of their expected profits.

$$v_t = E_t \Sigma_{j=0}^{\infty} \beta^j \left(1 - \eta\right)^j j_{i,t+1}^{I} \tag{6}$$

Then, entry occurs until the firm value is equalized with the fixed entry cost, f^E, leading to the following firm entry condition

$$v_t = f^E \tag{7}$$

Entrants at time $t-1$ will only start producing at time t, so that a one-period time-to-build lag is introduced in the model. After production has occurred, as in BGM (2012) a constant fraction η of firms exit from the market. Thus, the law of motion of number of firms in the economy at period t is:

$$N_t = (1-\eta)\left(N_{t-1} + N_{t-1}^E\right) \tag{8}$$

where η is the exogenous probability of exiting the market.[2]

2.1.3 Firms: Retail Sector

The retail sector aggregates the intermediate goods of each intermediate firm at no cost according to the CES technology

$$Y_t = \left[\int_{i\in N} \left(y_{i,t}^I\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \tag{9}$$

at the price level

$$P_t = \left[\int_{i\in N} \left(P_{i,t}^I\right)^{(1-\theta)} di\right]^{\frac{1}{1-\theta}} \tag{10}$$

As in BGM (2012), the price level of the retail firm can be rewritten as:

$$P_t = N_t^{\frac{1}{1-\theta}} P_t^I \tag{11}$$

The aggregate output is:

$$Y_t = \rho_t A_t L_t \tag{12}$$

where we define $\rho_t = N_t^{\frac{1}{\theta-1}}$ and $L_t = N_t l_t$ is the aggregate amount of labor hours.

2.2 Households

Households maximize their expected utility which depends on consumption and labor hours as follows

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t - \frac{L_t^{1+\phi}}{1+\phi}\right] \tag{13}$$

where $\beta \in (0,1)$ is the discount factor, the variable L_t represents hours worked, while C_t is the consumption index for a set of goods bundled by the retail sector as follows:

$$C_t = \left[\int_{i\in N} C_{i,t}{}^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \tag{14}$$

The parameter and $\theta > 1$ is the elasticity of substitution between goods produced in each sector. Households consume and work. They also decide how much to invest in new firms and in the shares of incumbent firms and how much

[2] We consider also the case in which new entrants can be separated before start producing. We find the main results unchanged. Results are available upon request.

to lend to the banking sector. The households budget constraint in nominal terms is

$$W_t L_t + \left(1 + r_t^d\right) P_t D_t + P_t N_t \gamma_t \left[v_t + j_t^I\right] - P_t C_t - P_t D_t - P_t N_{H,t} \gamma_{t+1} v_t \quad (15)$$

According to BGM (2012), we denote with γ_t the share in a mutual fund of firms held by the representative household. During period t, the representative household buys γ_{t+1} shares in a mutual fund of $N_{H,t}$ firms, where $N_{H,t} = N_t + N_t^E$ represents firms already operating at time t and the new entrants. The mutual fund pays $N_t j_t^I$ profits in each period, which is equal to the total profit of all firms that produce in that period. The main difference between new and old firms is that establishing a new firm requires an entry cost while the shares of an old firm are traded on the stock market. Households' resources are composed by wage earnings ($W_t L_t$), net interest income on previous deposits ($r_t^d D_t$), the value of the shares of firms they own ($N_t \gamma_t v_t$) and firms' dividends from firms survived from the previous period ($N_t \gamma_t j_t^I$) in the same sector. The flow of expenses includes consumption (C_t), deposits made at the end of the period (D_t) and financial investments in firms already operating in the market and in new firms ($N_{H,t} \gamma_{t+1} v_t$).

Combining households FOCs and considering that in equilibrium $\gamma_t = \gamma_{t+1} = 1$, we get

$$C_t = \frac{w_t}{L_t^\phi} \quad (16)$$

$$E_t \beta \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-1} \frac{1}{\pi_{t+1}} \right\} = \frac{1}{\left(1 + r_t^d\right)} \quad (17)$$

$$v_t = \beta E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-1} (1 - \eta) \left[v_{t+1} + j_{t+1}\right] \right\} \quad (18)$$

which respectively are the households' labor supply, the Euler equation for consumption and the Euler equation for share holding.

2.3 Banking Sector

2.3.1 Loans and Deposits Demand

The structure of the banking sector follows Gerali et al. (2010). We assume that deposits from households and loans to entrepreneurs are a composite CES basket of slightly differentiated products, each supplied by a single bank with elasticities of substitution equal to ε_t^b and ε^d respectively. More in detail we assume that the retail branch of banks are monopolistic competitive, so that they enjoy market power in setting interest rates on deposits and loans.[3] As in

[3] The assumption of imperfect competition finds consensus in the literature, based on the existence of a certain degree of market power in banking. See for example Freixas and Rochet (1997).

the standard Dixit–Stiglitz (1977) framework, loans and deposits demands are respectively:

$$b_{j,t} = \left(\frac{r^b_{j,t}}{r^b_t} \right)^{-\varepsilon^b_t} b_t \qquad \text{and} \qquad d_{j,t} = \left(\frac{r^d_{j,t}}{r^d_t} \right)^{-\varepsilon^d} d_t \tag{19}$$

where $b_{j,t}$ is the aggregate demand for loans at bank j, that is $b_{j,t} = \int_{i \in N} b_{i,j,t} di$, and b_t is the overall volume of loans to firms. Then $d_{j,t}$ is the households aggregate demand for deposits to bank j, while d_t is the households overall demand for deposits.

Further, following Gerali et al. (2010) and in line with Smets and Wouters (2003), we assume that the elasticities of substitution in the loan branch follow an AR(1) stochastic process.

$$\varepsilon^b_t = (1 - \rho_b)\, \varepsilon^b + \rho_d \varepsilon^b_{t-1} + u^b_t \tag{20}$$

where u^b_t is normally distributed white noises with zero mean and variance σ^2_b.

The assumption of exogenous shocks is motivated by our interest in analyzing how and to what extent these shocks hitting the bank markup affect the real economy.[4]

2.3.2 Wholesale and Retail

The financial agents are banks, which are divided in three branches: the wholesale branch and the retail branches for loans and deposits. At the wholesale level they operate in perfect competition, while as mentioned above, at the retail level they operate in a regime of monopolistic competition.

The amount of loans issued by each bank can be financed through the amount of deposits collected from households, and through bank capital (bank net worth), which is accumulated out of retained earnings. Banks play a key role in determining the conditions of credit supply. Assuming monopolistic competition between banks, we allow retail banks to have a certain degree of market power in setting or adjusting interest rates on deposits and loans in response to shocks.

Wholesale banks have to obey a balance sheet constraint,

$$B_t = D_t + K^b_t \tag{21}$$

We assume that the wholesale branch issues loans (B_t) to the loans branch of the retail banks by using both deposits collected by deposit branch of the retail banks from households (D_t) and bank capital (K^b_t). All variables are expressed in real terms.

[4] As claimed by Gerali et al. (2010) the innovations to the elasticities of substitution in the banking sector may be interpreted as changes to the banking interest rate spreads arising independently of monetary policy, as for example the exogenous increase in the loan spread occurred during the recent financial crisis.

$$K_t^b = (1-\delta^b)\frac{K_{t-1}^b}{\varepsilon_t^k} + j_t^b \tag{22}$$

where δ^b represents resources used in managing bank capital, j_t^b are overall profits made by the retail branches of the bank, and ε_t^k represents a bank capital shock following an AR(1) process:

$$\varepsilon_t^k = (1-\rho_b)\,\varepsilon^k + \rho_d \varepsilon_{t-1}^k + u_t^k \tag{23}$$

where u_t^k is normally distributed white noises with zero mean and variance σ_k^2.

Wholesale Branch The wholesale branch operates in a competitive way and combines bank capital and deposits to issue wholesale loans. Through the balance sheet constraint it manages the capital position of the bank. The problem for the wholesale branch is thus to choose the amount of loans and deposits to maximize the discounted sum of real cash flows, subject to the balance sheet constraint. Further, as in Gerali et al (2010) we assume that the bank faces quadratic adjustment costs in changing the capital to asset ratio $\frac{K_t^b}{B_t}$, given by

$$ADJ_t^{WB} = \frac{\kappa_{K^b}}{2}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)^2 K_t^b \tag{24}$$

where υ^b is the steady state value of the capital to asset ratio. After some algebra the problem can be reduced to:

$$\max_{\{D_t, B_t\}} R_t^b B_t - R_t^d D_t - \frac{\kappa_{K^b}}{2}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)^2 K_t^b \tag{25}$$

The first order condition of the wholesale bank relates the spread between wholesale loans and deposits rates to the bank leverage $\left(\frac{B_t}{K_t^b}\right)$.

$$R_t^b = R_t^d - \kappa_{K^b}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)\left(\frac{K_t^b}{B_t}\right)^2. \tag{26}$$

The deposit rate is pinned down in the interbank market and it is equal to the policy rate ($R_t^d = r_t$).

$$R_t^b = r_t - \kappa_{K^b}\left(\frac{K_t^b}{B_t} - \upsilon^b\right)\left(\frac{K_t^b}{B_t}\right)^2 \tag{27}$$

Notice that, when $\frac{K_t^b}{B_t}$ decreases relatively to the steady state value (and in turn leverage $\left(\frac{B_t}{K_t^b}\right)$ increases), the difference between R_t^b and r_t increases and margins become wider. In this case, as R_t^b increases, banks increase loan supply because of the greater interest rate on wholesale loans, and thus they increase their profits. But on the other hand, as leverage $\frac{B_t}{K_t^b}$ increases further, the deviation from υ^b becomes more costly, reducing bank profits. So banks face two different forces which push them in opposite directions. In this case, the result given by the first order condition suggests the optimal choice for banks: banks have to choose a level of loans (and thus of leverage, given a level of K_t^b) that keeps the marginal cost of reducing the capital-to-assets ratio equal to the spread between loans and deposits.

2.3.3 Retail Branches (Loans and Deposits)

Retail banks compete under monopolistic competition with other banks. As in Gerali et al. (2010), we use a standard Dixit-Stiglitz aggregator for loans and deposits. This implies that all banks essentially serve all firms, providing slightly differentiated loan contracts. Similarly, banks offer differentiated deposits to the household. Both loans and deposits of banks are indexed to a continuum interval ($j = 0, 1$). Imperfect substitutability between the contracts of different banks will additionally lead to explicit monopolistic mark-ups and mark-downs on these rates.

The loan branch can borrow from the wholesale unit at a rate R_t^b, it differentiates the loans at no cost and resells them to the firms applying a markup. Each retail bank faces a quadratic adjustment cost for changing the loan rates. This cost introduces sticky bank rates in the model.

We assume that banks do not observe the borrower's financial situation, they only observe if the borrower repays the loan. So that banks profits maximization problem is:

$$\max_{\{r_{j,t}^b\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\begin{array}{c} \left(1 + r_{j,t}^b\right) b_{j,t} \left(1 - \eta\right) - (1 + R_t^b) B_{j,t} \\ -\frac{\kappa_b}{2} \left(\frac{r_{j,t}^b}{r_{j,t-1}^b} - 1 \right)^2 r_t^b B_t \end{array} \right]$$

$$s.t.$$

$$b_{j,t} = \left(\frac{r_{j,t}^b}{r_t^b} \right)^{-\varepsilon_t^b} b_t \text{ and } b_{j,t} = B_{j,t} \tag{28}$$

where $b_{j,t} = \left(\frac{r_{j,t}^b}{r_t^b} \right)^{-\varepsilon_t^b} b_t$ is the demand for loans of bank j. From the FOC, after imposing symmetry across banks, i.e. $r_{j,t}^b = r_t^b$, and thus $b_{j,t} = b_t$ and $B_{j,t} = B_t$, we get the equation for the optimal interest rate:

$$\begin{aligned} \varepsilon_t^b \frac{1}{r_t^b} \left(R_t^b + \eta\right) &= (1-\eta)\left(\varepsilon_t^b - 1\right) + \kappa_b \left(\frac{r_t^b}{r_{t-1}^b} - 1 \right) \frac{r_t^b}{r_{t-1}^b} \\ &\quad - E_t \Lambda_{t,t+1} \kappa_b \frac{B_{t+1}}{B_t} \left(\frac{r_{t+1}^b}{r_t^b} - 1 \right) \left(\frac{r_{t+1}^b}{r_t^b} \right)^2 \end{aligned} \tag{29}$$

which under flexible rates it becomes,

$$r_t^b = \frac{\varepsilon_t^b}{\left(\varepsilon_t^b - 1\right)(1-\eta)}\left(R_t^b + \eta\right) \tag{30}$$

Notice that, the newness with respect to Gerali et al. (2010) is that, firms exit probability affects the value of the mark-up in the steady state and also the dynamics of r_t^b under sticky banks rate. Indeed, as the probability of exit η increases, retail banks set higher interest rate. The intuition is straightforward. An higher probability of exit increases the probability of a firm of not repaying the loan, bank that issued that loan faces lower profits and is forced to increase the interest rates.

The retail deposit branch collects deposits from households and gives them to the wholesale unit. The wholesale unit pays them at rate r_t, which is the same rate at which wholesale unit have access to the funds of the Central Bank. The problem for the deposit branch is

$$\begin{aligned} & \max_{\left\{r_{j,t}^d\right\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}\left[R_t^d D_{j,t} - r_{j,t}^d d_{j,t} - \frac{\kappa_d}{2}\left(\frac{r_{j,t}^d}{r_{j,t-1}^d} - 1\right)^2 r_t^d d_t\right] \\ & s.t. \\ d_{j,t} \quad = \quad & \left(\frac{r_{j,t}^d}{r_t^d}\right)^{-\varepsilon_t^d} d_t \text{ and } D_{j,t} = d_{j,t} \end{aligned} \tag{31}$$

where $d_{j,t} = \left(\frac{r_{j,t}^d}{r_t^d}\right)^{-\varepsilon_t^d} d_t$ is the demand for deposits of bank j. From the FOC, after imposing symmetry across banks, i.e. $r_{j,t}^d = r_t^d$, and thus $d_{j,t} = d_t$ and $D_{j,t} = D_t$, we get the optimal interest rate for deposits,

$$\varepsilon_t^d \frac{r_t}{r_t^d} = E_t \Lambda_{t,t+1} \kappa_d \left(\frac{r_{t+1}^d}{r_t^d} - 1\right)\left(\frac{r_{t+1}^d}{r_t^d}\right)^2 \frac{d_{t+1}}{d_t} - \kappa_d \left(\frac{r_t^d}{r_{t-1}^d} - 1\right)\frac{r_t^d}{r_{t-1}^d} + \left(\varepsilon_t^d - 1\right) \tag{32}$$

under flexible rates the equation becomes,

$$r_t^d = \frac{\varepsilon^d}{\varepsilon^d - 1} r_t \tag{33}$$

the interest rate on deposits is mark-down over the policy rate r_t.

2.3.4 Bank Profits

Bank profits are also affected by the probability of exit, since they are the sum of the profits of the wholesale and the retail sector. Bank profits now become:

$$j_t^b = r_t^b B_t (1-\eta) - r_t^d D_t - Adj_t^B - B_t \eta \tag{34}$$

where

$$Adj_t^B = \frac{\kappa_b}{2}\left(\frac{r_t^b}{r_{t-1}^b}-1\right)^2 r_t^b B_t + \frac{\kappa_d}{2}\left(\frac{r_t^d}{r_{t-1}^d}-1\right)^2 r_t^d D_t - \frac{\kappa_{K^b}}{2}\left(\frac{K_t^b}{B_t}-\upsilon^b\right)^2 K_t^b \tag{35}$$

indicates adjustment costs for changing interest rates on loans and deposits and changes in capital-to-asset ratio.

2.4 Monetary Policy

To close the model we need to specify an equation for the Central Bank behavior, i.e. we need to introduce an equation for the nominal interest rate r_t prevailing in the interbank market. In this respect we assume that the monetary authority simply follows a standard Taylor rule given by[5]

$$\ln\left(\frac{1+r_t}{1+r}\right) = \phi_R \ln\left(\frac{1+r_{t-1}}{1+r}\right) + (1-\phi_R)\left[\phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \phi_y \ln\left(\frac{Y_t}{Y}\right)\right] \tag{36}$$

3 Business Cycle Analysis

In what follows we will study the impulse response functions to a productivity shock, to a shock to the bank capital and to a shock to the bank markup. In order to investigate the role played by the endogenous firms creation, we compare the dynamics of our baseline model with endogenous entry and monopolistic banks (labelled as *EEM* model) with that of a standard DSGE model with a fixed number of firms and monopolistic banks, that we label as *Constant Firms* model. Finally, in the second part of the business cycle analysis, to disentangle the contribution of firms creation in respect to that of inefficient banks, we compare the performance of these two models we the performance of two alternative models: i) the EEM model with flexible banks rates, which allow to capture the role of sticky banks rates; ii) a model with endogenous entry and efficient banks. The banking sector is efficient since banks compete under perfect competition and can fully ensure against the risk of incurring in bank capital losses due to firms default. The comparison with this model will help to understand the importance of firms default in the banking problem and consequently in the model dynamics.

[5] Notice that even in the absense of sticky prices, money is not neutral in our model. The main source of money non neutrality comes from the *cost-channel*. Indeed, as in Ravenna and Walsh (2006), real marginal costs depends on the nominal interest rate on loans. This introduces an additional monetary transmission channel to the standard one operating via consumption smoothing. The presence of sticky rates are the second source of non-neutrality, since both the loan rate and the deposity rate do not adjust one to one with the policy rate. As a consequence the real rates on deposits and loans differ from the real policy rate affecting both the monetary transmission channels. We find that, a 1 percent transitory shock to the nominal interest rate implies a decrease in inflation and output, in line with a sticky prices model. Results on this shock are available upon request.

3.1 Calibration

Calibration is set on a quarterly basis. The elasticity of substitution among intermediate goods, θ, is set equal to 4, a value which is in line to that of BGM (2012). Analogously, as in BGM (2012), we set the inverse of Frisch $\phi = 2$, the entry cost $f^E = 1$ and we set the size of the exogenous exit shock η to be 0.025, to match the U.S. empirical level of 10% of firms destruction per year. The steady state of productivity $A = 1$.

We calibrate the banking parameters $\varepsilon^b = 3.12$ and $\varepsilon^d = -1.5$ as in Gerali et al. (2010) so as to replicate their markup, we calibrate the discount factor β to 0.9943 and the steady state value of the capital-to-asset ratio υ^b is 0.09. Adjustments costs in the banking sector are taken from the prior values set in Gerali et al. (2010), which are $\kappa_b = 9.51$, $\kappa_d = 3.63$, $\kappa_{K^B} = 11.49$. For the Taylor rule parameters, we set $\phi_R = 0.8$, $\phi_\pi = 1.75$ and $\phi_y = 0.125$, which guarantee the uniqueness of the equilibrium and are in the range of the parameters usually estimated for both US and EU.[6] Persistence of shocks are set at 0.9 while standard deviations are at 0.01.

3.2 Impulse Response Functions

Figure 1-3 show the impulse response functions (IRFs) to a positive technology shock, a negative shock to bank capital, and to a shock to bank markup. In all figures, the dashed-dotted line represents the *Constant Firms* model[7] whereas the solid line represents the baseline *EEM* model.

3.2.1 Technology shock

As shown in Figure 1, the economy characterized by endogenous firms dynamics (i.e. *EEM* model henceforth) shows higher volatilities of output, inflation, interest rates and loans, than those implied by a standard model with a constant number of firms. A positive technology shock creates expectations of higher future profits which lead to the entry of new firms. Given that entry is subject to a one period time-to-build lag the total number of firms, N_t, does not change on impact, but builds up gradually.

The entry margin leads to a much stronger and more persistent increase in output and to a higher and more persistent increase in the demand for loans. Since the banking sector is imperfectly competitive, interest rates on loans are related to the policy rate. The decline in the policy rate leads to a decline in the interest rate on loans, leading in turn to a wider access to credit for firms, and thus implying an increase in the number of firms asking for loans. Lower interest rates on loans has two effects: lower loan rates, ceteris paribus, imply higher firms profits and thus higher entry, which gives an additional boost to output. After the initial increase of loans, due to the more favorable credit access, lower interest rates generate lower bank profits and lower bank capital and an higher

[6] The main results are not qualitatively affected by change in the parameters.
[7] We normalized the number of firms to 1.

bank leverage ratio. After some periods, higher leverage costs force banks to reduce loans, reduce credit access, so that the number of firms asking for loans decreases and, consequently, all variables turn back to their steady state values.

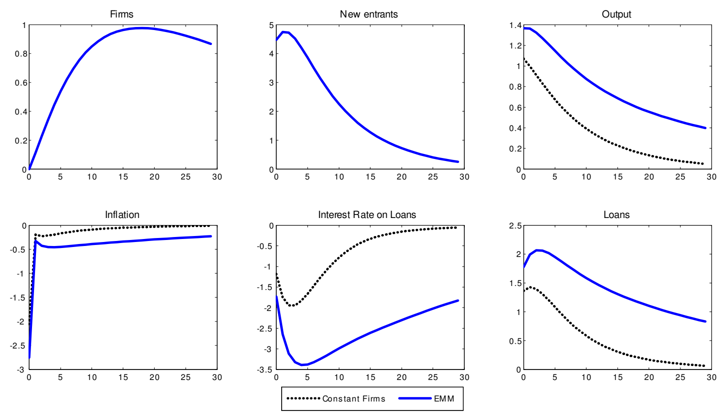

Figure 1: IRFs to 1% positive TFP shock in a monopolistically competitive banking sector. Constant Firms Model (dashed-dotted line). Exogenous exit model (solid line).

3.2.2 Bank Capital Shock

In Figure 2 we present the IRFs to a negative shock to the bank capital. As before, the economy characterized by endogenous firms dynamics shows higher volatilities of output, inflation, interest rates and loans, than those implied by a standard model with a constant number of firms.

Notice that, since bank capital contraction decreases banks' profits, banks are forced to increase interest rates on loans and, as a result, firms marginal costs and profits increase. Given the expectations of lower profits new entrants decrease, so that the total amount of firms and loans decrease. The persistent increase in the interest rate on loans drags real activity down. The higher financing costs push inflation up.

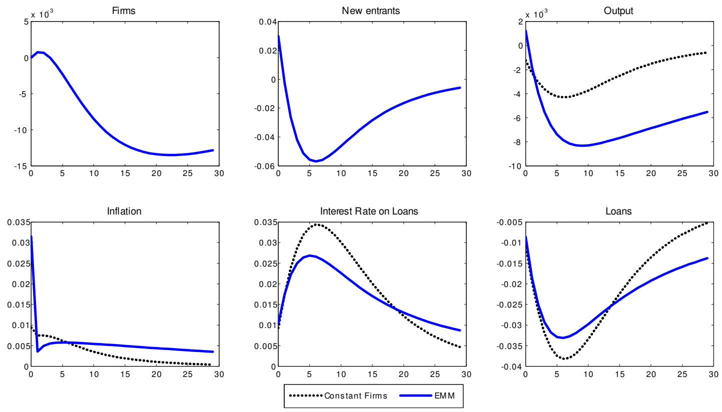

Figure 2: IRFs to 1% negative bank capital shock. Constant Firms Model (dashed-dotted line). Exogenous exit model (solid line).

3.2.3 Bank Markup Shock

We now show the IRFs to a negative shock to bank markup, obtained through a positive shock to the interest rate elasticity of loans. Figure 3 compares the IRFs of the model with endogenous entry with those of the model with a constant number of firms. The increase in the substitutability between loans leads to an increase in the competition between banks, which implies lower banks markups and thus profits, and a decrease in bank capital. Incumbent firms face more convenient credit conditions which lead to an increase in firms new entrants. As inflation decreases, policy rate decrease, then lower interest rates on loans lead to a decrease in the interest rate spread and to an increase in the demand for loans.

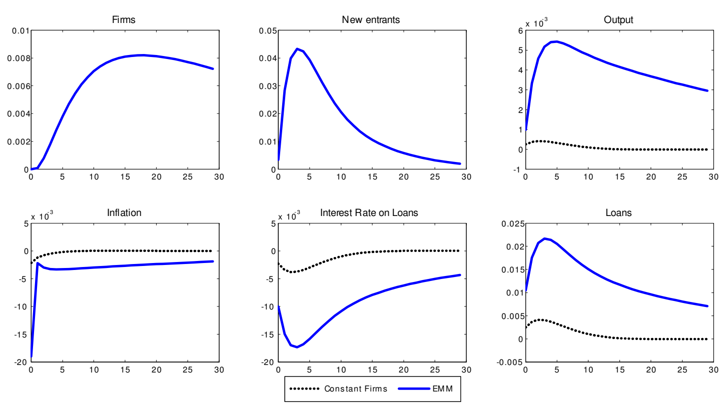

Figure 3: IRFs to 1% negative bank markup shock. Constant Firms Model (dashed-dotted line). Exogenous exit model (solid line).

3.3 The role of banking sector and its interaction with firms dynamics

In order to evaluate the role of the banking sector in the interaction with firms dynamics, we now compare the IRFs to a technology shock in our baseline model (now labelled *EEM sticky rates*, solid lines) and the model with a constant number of firms (labelled as *Constant Firms,* thin solid lines), with two alternative versions of the baseline model: i) the EEM model with flexible bank rates (labelled *EEM flex rates*, dotted lines), which allow us to capture the role of sticky banks rates; ii) a model with endogenous entry and efficient banks (labelled *EEM Efficient Banks*, dashed-dotted lines). In this model, banks are efficient for two reasons: first they compete under perfect competition, so that there is only one interest rate in the economy coinciding with the policy rate. Second, banks can fully insure against the risk of incurring in balance sheet losses in the presence of firms default. This means that bank losses and thus firms default probability are not taken into account in the optimization problem of the loan branch. As a consequence the optimal interest rate on loans does not depend on η.

Figure 4 shows the dynamics of the main variables under the four models, in response to a 1 percent increase in productivity. Notice that, the two models with endogenous entry and inefficient banks, show greater volatility for both real and financial variables, in respect to the model with efficient banks. The presence of inefficient banks implies a stronger and more persistent response of the loan rate. Indeed, since real marginal costs are directly affected by the loan rate, the models with entry and inefficient banks imply also a stronger reaction of the inflation rate. Further, the huge drop in the loan interest rate is followed by an higher increase in the amount of loans to firms, which enhances the endogenous propagation of the shocks. The latter effect is larger in the economy with flexible bank interest rates. Finally notice that the model with efficient banks implies a stronger response of output than a model with a constant number of firms, thus emphasizing the big role played by endogenous entry.

Overall the main message coming from the comparison across these four models can be summarized as followed: i) the extensive margin has an important propagating effect of real and financial shocks, in line with the literature on firms dynamics; ii) the interaction between the extensive margin and the financial markets enhances the endogenous propagation of the shocks. iii) The propagation is even stronger in economies where banks cannot fully ensure against the risk of firms default. We see this result as a contribution in the literature, suggesting to further investigate the role of financial markets and their interaction with firms dynamics.

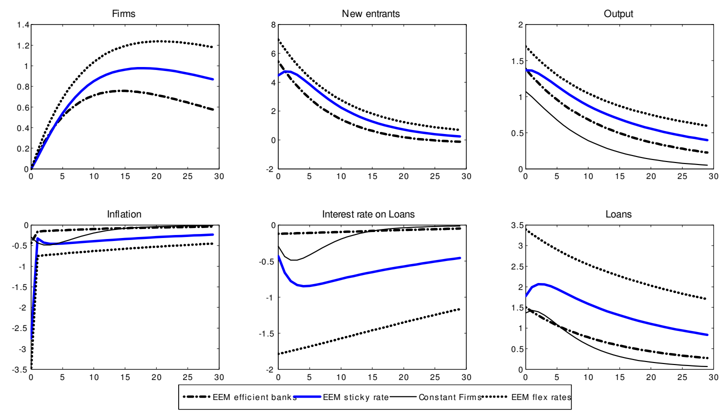

Figure 4: IRFs to 1% positive TFP shock. Comparison between the baseline model (solid lines) and a model with endogenous entry and efficient banks (dashed-dotted line).

4 Robustness

4.1 Considering Different Entry Costs

This section contains a robustness exercise in which we examine the effect of having a different entry costs. In particular, we consider a non-constant entry cost defined in terms of labor units, modelled as in BGM (2012). We show impulse response functions to the three shocks considered so far.

To introduce an entry cost defined in labor units we define total labor as $L_t = L_t^C + L_t^E$, where L_t^C is the amount of labor used to produce consumption goods, whereas $L_t^E = \frac{N_t^E f^E}{A_t}$ is the amount of labor used to create new firms in the intermediate sector. The sunk entry cost is now defined as

$$v_t = \frac{w_t}{A_t} f^E \tag{37}$$

the rest of the model remains unchanged.

4.1.1 Impulse Response Functions

In what follows we study the IRFs to a total factor productivity shock, to a bank capital shock and to a shock to bank markup. We compare the performance of the two models: i) the baseline EEM with a constant cost of entry, and ii) the EEM with an entry cost measured in labor units.

In all figures, the solid line represents the model with constant cost of entry (labelled as CC), whereas the dotted line represents the model with entry cost in labor units (labelled as LU).

Figure 5 shows the IRFs to a positive technology shock. As shown in the Figure the exogenous exit model with a constant entry shows a higher volatility in respect to the model with the entry cost in labor units. This is not surprising since an increase in productivity directly decreases the cost of entry. Despite this, the two models show very similar dynamics, but for the hours used to produce consumption goods: the LU model is characterized by a decrease on impact of hours used in the good-producing sector (labelled as Lc in the subplot of the figure). Labor used to produce new firms (labelled as Le) strongly increases so that total hours worked (labelled as L) increase also in the LU economy.

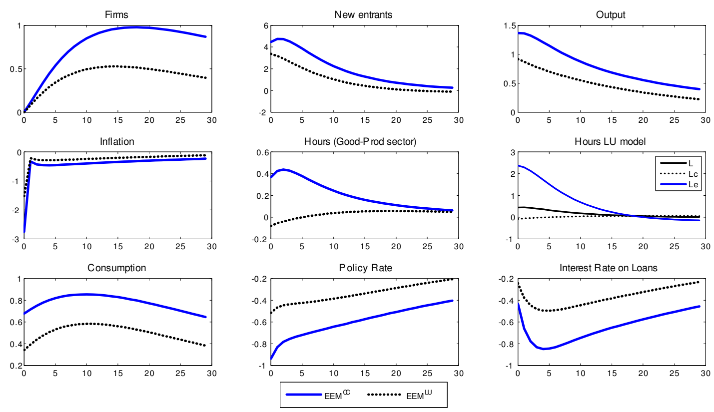

Figure 5: IRFs to 1% positive TFP shock for the model with Constant Entry Cost (CC) (solid line) versus the model with Entry Cost in Labor Units (LU) (dotted line) .

Figure 6 presents the IRFs to a negative shock to bank capital. As before the LU model show a countercyclical response on impact of hours used to produce consumption goods and, consequently, an increase on impact of output instead of a decrease. However, after the first period also the LU economy enters into a downturn.

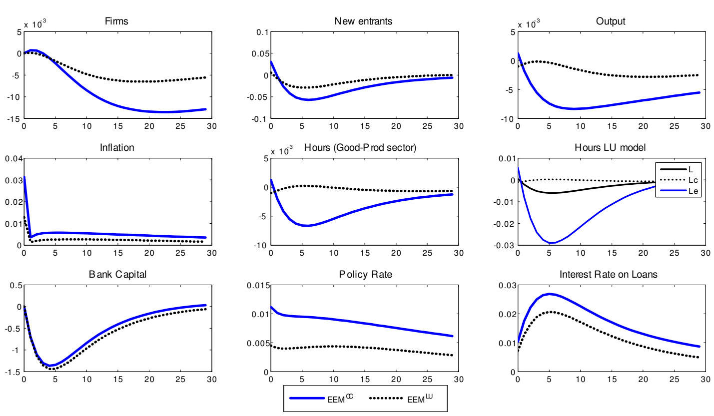

Figure 6: IRFs to 1% negative bank capital shock for the model with Constant Entry Cost (CC) (solid line), versus the model with Entry Cost in Labor Units (LU) (dotted line) .

Figure 7 presents the IRFs to a negative shock to bank markup. For the LU model IRFs show a decrease in output on impact and a countercyclical response of hours in the good-producing sector and also of output which decreases on impact instead of increasing. However, from the first period on also the LU economy enters into a boom.

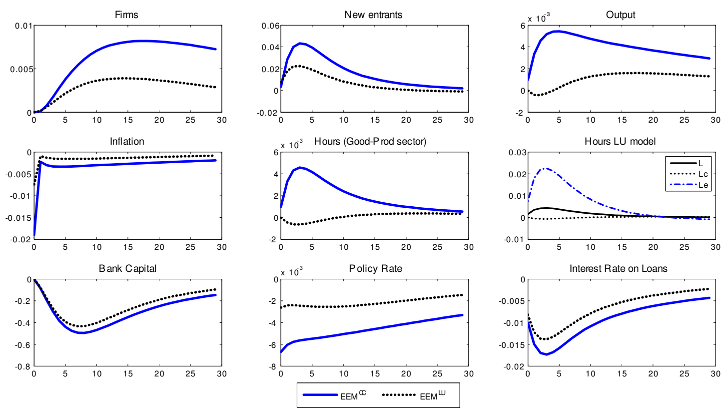

Figure 7: IRFs to 1% negative bank markup shock for the model with Constant Entry Cost (CC) (solid line), versus the model with Entry Cost in Labor Units (LU) (dotted line) .

A second robustness check, not reported in the paper, has been done by introducing sticky prices à la Rotemberg (1982), in the intermediate good sector. We find the main results and thus the message of the paper unchanged.[8]

5 Conclusion

We consider a DSGE model with flexible prices, monopolistic competitive banking sector and sticky interest rates together with endogenous firms' dynamics. We show that in response to both real and financial shocks, economies characterized by endogenous firms dynamics imply higher volatilities of both real and financial variables than those implied by a DSGE model with monopolistic banking sector and a fixed number of firms. The response of the economic activity is also more persistent in response to all shocks. Moreover, we find that the presence of monopolistic competition in the banking sector, together with the assumption that banks cannot fully ensure against the risk of firms default, enhance the endogenous propagation of the shocks. We show that our result are robust to the introduction of alternative entry costs. Overall, we believe

[8] Results on this robustness check are available upon request.

that further investigation is needed on the interaction between firms dynamics and the dynamics of the financial markets. In this respect, our model can be extended along several dimensions. First, we can introduce borrowing against a collateral in order to evaluate the role of the collateral constraints as well as the role of alternative rules on the loan-to-value ratio. Considering non-conventional monetary policy is also part of our research agenda. Finally, investigating the role of firms endogenous exit decisions is also a possible extension and is a work in progress.

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