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FIRMS' ENDOGENOUS ENTRY AND MONOPOLISTIC BANKING IN A DSGE MODEL

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We consider a DSGE model with monopolistically 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 dynamic stochastic general equilibrium (DSGE) model with a 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 with respect to a model where banks compete under perfect competition and can fully ensure against the risk of firms' default.

Keywords: Firms' Endogenous Entry, Firms' Dynamics, Monopolistic Banking, Inefficient Financial Markets

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 channels of the financial market to the real economy. Furthermore, as shown in the recent financial crisis, the interaction between the banking sector and the goods-market sector may affect not only the intensive margin of the goods market, but also its extensive margin, that is, firms' entry and exit decisions. Following these insights, this paper investigates the relationship between firms' dynamics and banking in a dynamic stochastic general equilibrium (DSGE) model characterized by flexible prices, monopolistically competitive banking, and sticky interest rates, together with endogenous firms' entry decisions, modeled as in Bilbiie et al. (2012; henceforth BGM). Using this framework, we seek to understand the transmission channel

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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 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, the response of the economic activity is also more persistent in response to all shocks. Third, we show that the presence of inefficient banks enhances the endogenous propagation of the shocks with 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 in the United States and in Europe. Adrian et al. (2012), for example, have shown that the depletion of bank capital from subprime losses has forced banks to reduce lending and to raise the costs of credit. Similarly, Neri (2012) shows that the European Union gross domestic product (GDP) contraction that 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 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 goods-market structure under Bertrand–Cournot competition in a DSGE model and show that their model improves the ability of a flexible price model in matching impulse response functions (IRFs) and second moments for the U.S data. Colciago and Rossi (2015) 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 et al. (1999), do not consider the direct central bank intermediation as an instrument of monetary policy. Exceptions include Kiyotaki and Moore (1997), Curdia and Woodford (2009), and, more recently, Gertler and Karadi (2011), Gerali et al. (2010), and De Walque et al. (2010), 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 this paper is organized as follows. Section 2 presents the model economy. Section 3 contains the main results. Section 4 discusses the robustness of our results, and Section 5 concludes. Technical details are available in the online supplemental appendix.

2. THE MODEL

2.1. Firms

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

Firms: The intermediate sector. We assume a continuum of firms producing differentiated intermediate goods $i \in N$, so that N represents both the mass of available goods and the number of firms. $P^I_{i,t}$ is 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

$$j_{i,t} = \frac{P^I_{i,t}}{P_t} y^I_{i,t} + b_{i.t} - w_t l_{i,t} - \left(1 + r^b_t\right) b_{i.t}. \tag{3}$$

Here, we follow the 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 the 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 $y^I_{i,t} = (\frac{P^I_{i,t}}{P_t})^{-\theta} Y_t$, which is the demand for intermediate good i, with P_t being the consumer price index.

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First-order conditions yield the optimal demand for labor and the optimal price, being, respectively,

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

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

where $mc_{i,t}$ are the real marginal costs of firm i and $\frac{P_{i,t}^I}{P_t} = \rho_{i,t}$ is the intermediate price. Notice that, as in Ravenna and Walsh (2006), the 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 the monetary policy cannot be neutral, even in the presence of flexible prices and flexible interest rates.

Endogenous entry. As in BGM, 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:

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

Then, the 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, a constant fraction η of firms exits from the market. Thus, the law of motion of the number of firms in the economy at period t becomes

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

where η is the exogenous probability of exiting the market.[1]

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

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

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As in BGM, the price level of the retail firm can be rewritten as follows:

$$P_t = N_t^{\frac{1}{1-\theta}} P_t^I. \quad \textbf{(11)}$$

The aggregate output is

$$Y_t = \rho_t A_t L_t, \quad \textbf{(12)}$$

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:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \frac{L_t^{1+\phi}}{1+\phi} \right), \quad \textbf{(13)}$$

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

$$C_t = \left(\int_{i \in N} C_{i,t}^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}. \quad \textbf{(14)}$$

The parameter $\theta > 1$ 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 to lend to the banking sector. The households' budget constraint in nominal terms is

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

According to BGM, 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 are 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, whereas the shares of an old firm are traded on the stock market. Households' resources are composed of wage earnings ($W_t L_t$), the 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 that 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 ($N_{H,t} \gamma_{t+1} v_t$).

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Combining households' first-order conditions (FOCs) and considering that in equilibrium $\gamma_t = \gamma_{t+1} = 1$, we get

$$C_t = \frac{w_t}{L_t^{\phi}}, \tag{16}$$

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

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

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

2.3. Banking Sector

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. In more details, we assume that the retail branches of banks are monopolistically competitive, so that they enjoy market power in setting interest rates on deposits and loans.[2] As in the standard Dixit and Stiglitz (1977) framework, loans and deposits demands are, respectively,

$$b_{j,t} = \left(\frac{r_{j,t}^b}{r_t^b} \right)^{-\varepsilon_t^b} b_t \quad \text{and} \quad d_{j,t} = \left(\frac{r_{j,t}^d}{r_t^d} \right)^{-\varepsilon^d} d_t, \tag{19}$$

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, whereas d_t is the households' overall demand for deposits.

Furthermore, following Gerali et al. (2010), we assume that the elasticities of substitution in the loan branch follow a first-order autoregressive AR(1) stochastic process:

$$\varepsilon_t^b = (1 - \rho_b)\, \varepsilon^b + \rho_d \varepsilon_{t-1}^b + u_t^b, \tag{20}$$

where u_t^b is normally distributed white noises with zero mean and variance σ_b^2.

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.[3]

Wholesale and retail. The financial agents are banks, which are divided into three branches: the wholesale branch and the retail branches for loans and deposits. At the wholesale level, they operate in perfect competition, whereas, 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 the 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:

$$B_t = D_t + K_t^b. \tag{21}$$

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

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

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. Furthermore, 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 $\left(\frac{B_t}{K_t^b}\right)$:

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

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

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

Notice that when $\frac{K_t^b}{B_t}$ decreases relatively to the steady-state value [and, in turn, leverage $(\frac{B_t}{K_t^b})$ 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.

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 markups and markdowns 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 by 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, the banks' profits maximization problem is

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

s.t.

$$b_{j,t} = \left(\frac{r^b_{j,t}}{r^b_t} \right)^{-\varepsilon^b_t} b_t \text{ and } b_{j,t} = B_{j,t}, \tag{28}$$

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

$$\varepsilon^b_t \frac{1}{r^b_t} \left(R^b_t + \eta\right) = (1-\eta) \left(\varepsilon^b_t - 1\right) + \kappa_b \left(\frac{r^b_t}{r^b_{t-1}} - 1 \right) \frac{r^b_t}{r^b_{t-1}}$$

$$- E_t \Lambda_{t,t+1} \kappa_b \frac{B_{t+1}}{B_t} \left(\frac{r^b_{t+1}}{r^b_t} - 1 \right) \left(\frac{r^b_{t+1}}{r^b_t} \right)^2, \tag{29}$$

which under flexible rates becomes

$$r^b_t = \frac{\varepsilon^b_t}{\left(\varepsilon^b_t - 1\right)(1-\eta)} \left(R^b_t + \eta\right). \tag{30}$$

Notice that the newness with respect to Gerali et al. (2010) is that firms' exit probability affects the value of the markup in the steady state and also the dynamics of r^b_t under a sticky banks rate. Indeed, as the probability of exit η increases, retail banks set higher interest rates. The intuition is straightforward. A higher probability of exit increases the probability of a firm of not repaying the loan; the 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 the wholesale unit have access to the funds of the Central Bank. The problem for the deposit branch is

$$\max_{\{r^d_{j,t}\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[R^d_t D_{j,t} - r^d_{j,t} d_{j,t} - \frac{\kappa_d}{2} \left(\frac{r^d_{j,t}}{r^d_{j,t-1}} - 1 \right)^2 r^d_t d_t \right]$$

s.t.

$$d_{j,t} = \left(\frac{r^d_{j,t}}{r^d_t} \right)^{-\varepsilon^d_t} d_t \text{ and } D_{j,t} = d_{j,t}, \tag{31}$$

where $d_{j,t} = (\frac{r_{j,t}^d}{r_t^d})^{-\varepsilon_t^d} d_t$ 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:

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

which under flexible rates becomes

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

where the interest rate on deposits is a markdown over the policy rate r_t.

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[4]

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

3. BUSINESS-CYCLE ANALYSIS

In what follows, we will study the IRFs 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 (labeled the

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EEM model) with that of a standard DSGE model with a fixed number of firms and monopolistic banks, which we label the *Constant Firms* model. Finally, in the second part of the business-cycle analysis, to disentangle the contribution of firms' creation with respect to that of inefficient banks, we compare the performance of these two models with the performance of two alternative models: (i) the EEM model with flexible banks rates, which allow us to capture the role of sticky banks rates, and (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 bank capital losses due to firms' default. The comparison with this model will help us to understand the importance of firms' default in the banking problem and consequently in the model dynamics.

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 that is in line with that of BGM. Analogously, as in BGM, we set the inverse of Frisch $\phi = 2$, the entry cost $f^E = 1$, and the size of the exogenous exit shock η to be 0.025, to match the U 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 also calibrate the discount factor β to 0.9943 and the steady-state value of the capital-to-asset ratio υ^b is 0.09. Adjustment costs in the banking sector are taken from the prior values set in Gerali et al. (2010), which are $\kappa_b = 9.51$, $\kappa_d = 3.63$, and $\kappa_{K^B} = 11.49$. 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 the United States and the European Union.[5] Persistence of shocks is set at 0.9, whereas standard deviations are set at 0.01.

3.2. Impulse Response Functions

Figure 1–3 show the IRFs to a positive technology shock, to a negative shock to bank capital, and to a shock to bank markup. In all the figures, the dash–dotted line represents the *Constant Firms* model,[6] whereas the solid line represents the baseline *EEM* model.

Technology shock. As shown in Figure 1, the economy characterized by endogenous firms' dynamics (henceforth the *EEM* model) 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 the 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

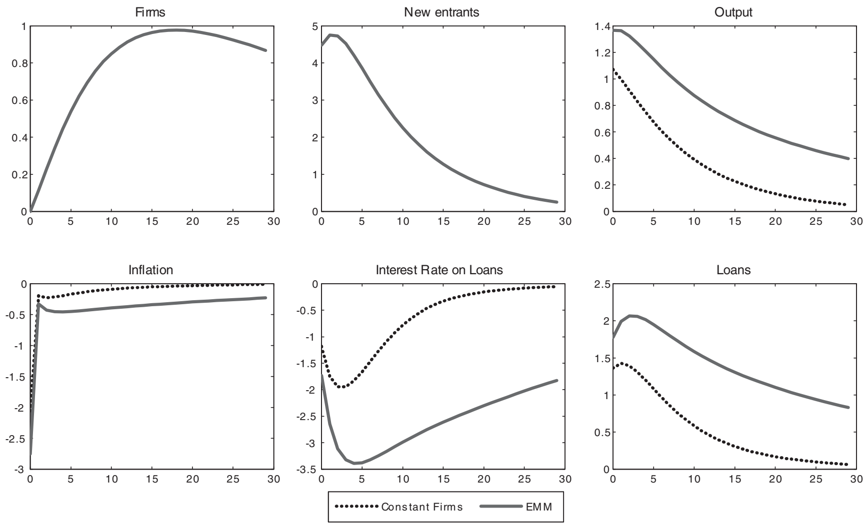

Figure 1. IRFs to a 1% positive TFP shock in a monopolistically competitive banking sector: Constant Firms model (dash–dotted line) and exogenous exit model (solid line).

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

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, the inflow of new entrants decreases, resulting in a decrease in the total number of firms and amount of loans. The persistent increase in the interest rate on loans drags the real activity down. The higher financing costs push the inflation up.

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.

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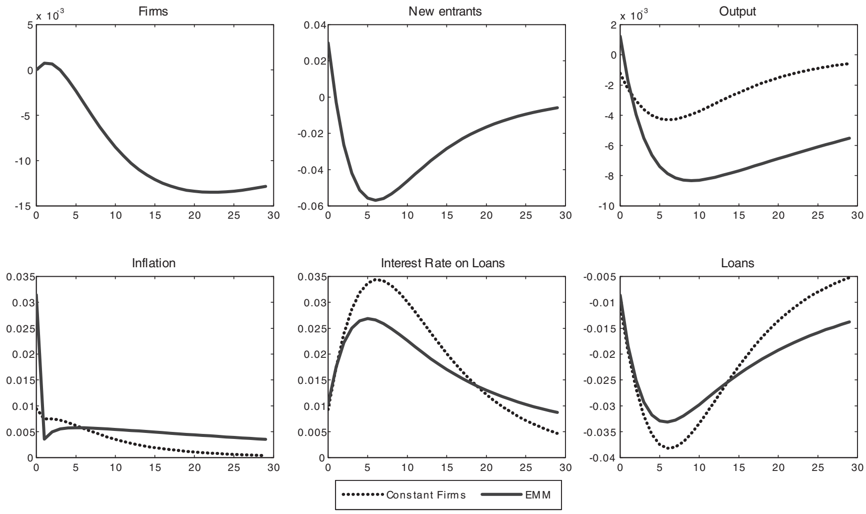

FIGURE 2. IRFs to a 1% negative bank capital shock: Constant Firms model (dash–dotted line) and exogenous exit model (solid line).

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 the number of new entrants. As inflation decreases, the policy rate decreases, and then lower interest rates on loans lead to a decrease in the interest rate spread and to an increase in the demand for loans.

3.3. The Role of the 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 (labeled *EEM sticky rates*, solid lines) and the model with a constant number of firms (labeled *Constant Firms,* thin solid lines), with two alternative versions of the baseline model: (i) the EEM model with flexible bank rates (labeled *EEM flex rates*, dotted lines), which allow us to capture the role of sticky banks rates, and (ii) a model with endogenous entry and efficient banks (labeled *EEM Efficient Banks*, dash–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 ensure against the risk of incurring balance sheet losses in the presence of firms' default. This means that bank losses and thus firms' default probability are not taken into

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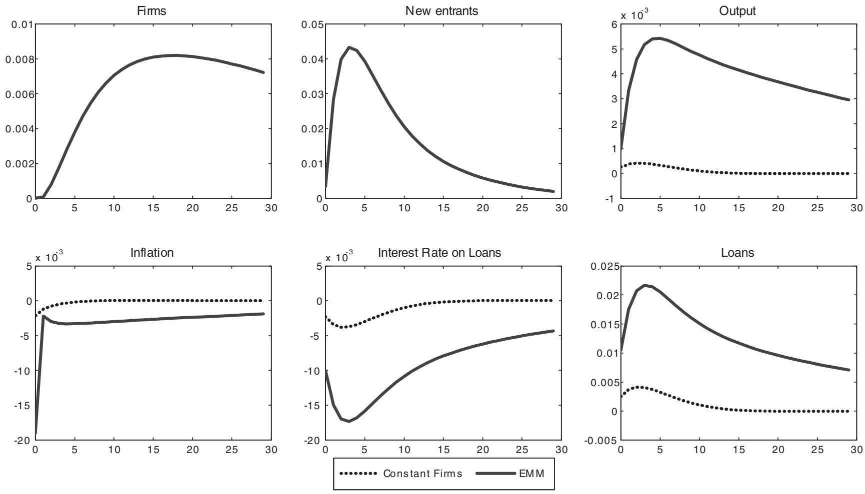

FIGURE 3. IRFs to a 1% negative bank markup shock: Constant Firms model (dash–dotted line) and exogenous exit model (solid line).

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% increase in productivity. Notice that the two models with endogenous entry and inefficient banks show greater volatility for both real and financial variables than 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 endogenous entry and inefficient banks also imply a stronger reaction of the inflation rate. Furthermore, the huge drop in the loan interest rate is followed by a 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 between these four models can be summarized as follows: (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 to the literature, suggesting to further investigate the role of financial markets and their interaction with firms' dynamics.

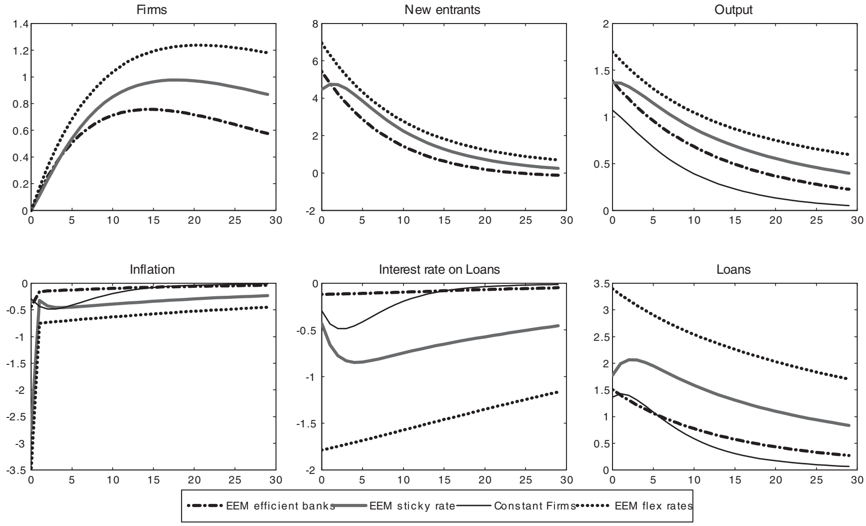

FIGURE 4. IRFs to a 1% positive TFP shock. Comparison between the baseline model (solid lines) and a model with endogenous entry and efficient banks (dash–dotted line).

4. ROBUSTNESS

4.1. Considering Different Entry Costs

This section contains a robustness exercise in which we examine the effect of having different entry costs. In particular, we consider a nonconstant entry cost defined in terms of labor units, modeled as in BGM. We show IRFs 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 and $L_t^E = \frac{N_t^E f^E}{A_t}$ 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.

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 model with a constant cost of entry, and (ii) the EEM model with an entry cost measured in labor units.

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

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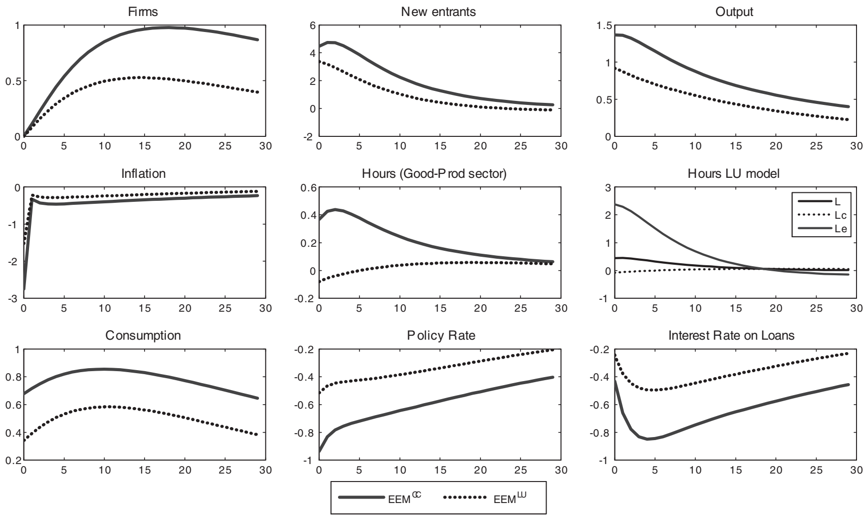

FIGURE 5. IRFs to a 1% positive TFP shock for the model with a constant entry cost (CC) (solid line) versus the model with an entry cost in labor units (LU) (dotted line).

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 than 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 in the impact of hours used in the goods-producing sector (labeled Lc in the subplot of the figure). Labor used to produce new firms (labeled Le) strongly increases so that the total hours worked (labeled L) also increases in the LU economy.

Figure 6 presents the IRFs to a negative shock to bank capital. As before, the LU model shows 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, the LU economy also enters into a downturn.

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 used in the goods-producing sector and also of output, which decreases on impact instead of increasing. However, from the first period on, the LU economy also enters into a boom.

A second robustness check, not reported in this paper, has been done by introducing sticky prices à la Rotemberg (1982), in the intermediate-goods sector. We find that the main results and thus the message of this paper remain unchanged.[7]

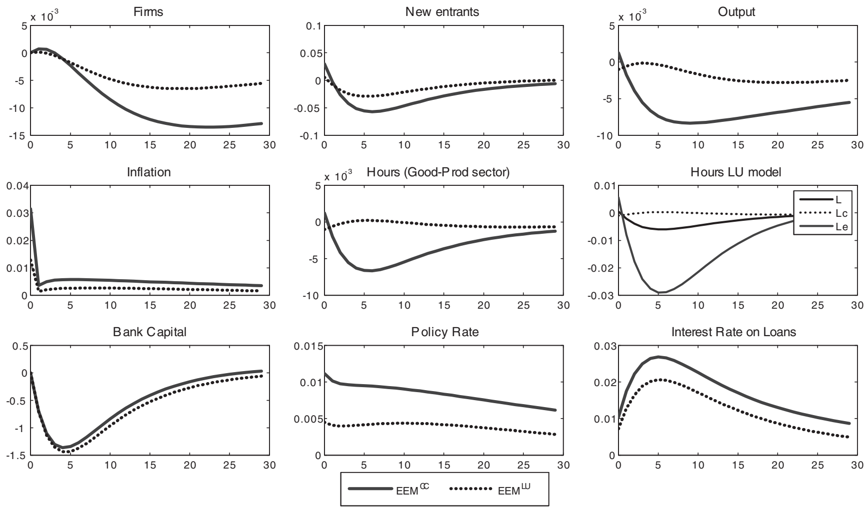

FIGURE 6. IRFs to a 1% negative bank capital shock for the model with a constant entry cost (CC) (solid line) versus the model with an entry cost in labor units (LU) (dotted line).

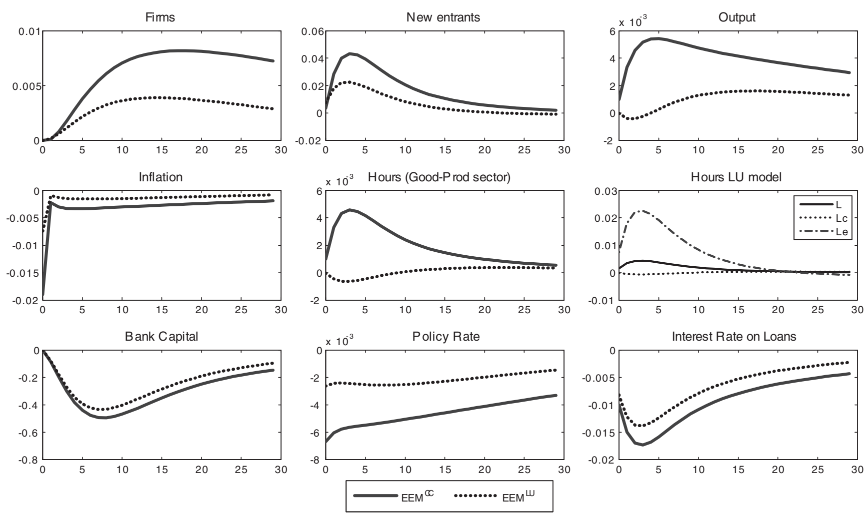

FIGURE 7. IRFs to a 1% negative bank markup shock for the model with a constant entry cost (CC) (solid line) versus the model with an entry cost in labor units (LU) (dotted line).

5. CONCLUSION

We consider a DSGE model with flexible prices, a monopolistically competitive banking sector, and sticky interest rates, together with endogenous firms' dynamics. We show that in response to both real and financial shocks, economies

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characterized by endogenous firms' dynamics imply higher volatilities of both real and financial variables than those implied by a DSGE model with a 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, enhances the endogenous propagation of the shocks. We show that our results are robust to the introduction of alternative entry costs. Overall, we believe 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 in the loan-to-value ratio. Finally, investigating the role of firms' endogenous exit decisions is also a possible extension and is a work in progress.

NOTES

1. We also consider the case in which new entrants can be separated before they start producing. We find the main results unchanged. Results are available upon request.
2. 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).
3. 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 that occurred during the recent financial crisis.
4. Notice that even in the absence of sticky prices, money is not neutral in our model. The main source of money nonneutrality comes from the *cost-channel*. Indeed, as in Ravenna and Walsh (2006), real marginal costs depend 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 is the second source of nonneutrality, since both the loan rate and the deposit 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% 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.
5. The main results are not qualitatively affected by the change in the parameters.
6. We normalized the number of firms to 1.
7. Results on this robustness check are available upon request.

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