Uncertainty Shocks and Firms Dynamics in a Model with Inefficient Banks

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Abstract

Using US data we estimate a small BVAR and we provide evidence showing that an uncertainty shock is recessionary, it implies a decline in firms' creation, an increase in firms' destruction, as well as an increase in banks' markup. To address this evidence we build-up a NK-DSGE model with endogenous firms' creation and destruction, together with an inefficient banking sector. We show that the interaction between firms and inefficient banks makes the recessionary effect of the uncertainty shock more severe with respect to a model where the banking sector is efficient.

Keywords: firms' endogenous exit, bank markup, uncertainty shock, BVAR.

JEL codes: E32; E44; E52; E58

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1 Introduction

This paper contributes to the literature studying the effects of an uncertainty shock in a New-Keynesian Dynamic Stochastic General Equilibrium model - henceforth, NK-DSGE model - with endogenous firms dynamics and inefficient banks. First of all, following the literature on uncertainty shocks, and in particular Leduc and Liu (2016) and Fernandez-Villaverde (2011), we estimate a small BVAR using the CBOE S&P 100 Volatility Index (VXO) as a proxy for aggregate macroeconomic uncertainty. Then, we compute the IRFs to an increase in the economic uncertainty and we show that the shock is recessionary, it implies a reduction in firms creation together with an increase in firms destruction and an increase in the banks' markup. We show that this result is robust to the use of alternative measure of uncertainty and to different priors.

Second, to address this evidence we provide an NK-DSGE model characterized by firms' endogenous entry and exit decisions, together with an inefficient banking sector supplying loans to incumbent firms. Banks are inefficient since they compete under monopolistic competition. Further, they cannot insure against the risk of firms' default and thus they can incur in balance-sheet losses every time a firm exit the market without repaying the loan. As a consequence, to restore their profits, banks endogenously increase their markup when the probability of firms default increases. As a result the banks' markup is endogenous and countercyclical. As in Rossi (2017), firms' exit is modeled using a modified version of the mechanism proposed by Melitz (2003) and Ghironi and Melitz (2005) for exporting firms. In particular, we assume that firms decide to produce as long as their specific productivity is above a cut-off level, which is determined by the level of productivity that makes the their profits equal to zero. In this context, we study the dynamics of the model in response to an uncertainty shock. The main results of the paper can be summarized as follows.

First, we show that the uncertainty shock is recessionary and that the recession is more severe in a model with endogenous firms dynamics. This occurs because the shock is followed by a decline in business creation and by an increase in firms destruction. Thus, as in our BVAR, firms creation is procyclical, while firms destruction is countercyclical in face of an uncertainty shock. The bank markup is also countercyclical and in line with the empirical evidence.[2] We show that the countercyclicality of the bank markup

[2] The countercyclicality of the banks markup - often computed using as a proxy the

implies a stronger and more prolonged recession in the medium run with respect to a model where the banking sector is efficient and banks can completely ensure against the risk of firm default. Finally, the endogenous exit mechanisms of firms amplifies the transmission channel of the shock via the extensive margin with respect to a model with a constant exit probability.

The impact of firms' dynamics on business cycle has been studied in many papers. The seminal paper of BGM (2012) considers a model with endogenous firms entry and shows 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. In this respect, Etro and Colciago (2010) study a DSGE model with endogenous good market structure under Bertrand and Cournot competition 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 (2015) extend this model accounting for search and matching frictions in the labor market.[3] All these papers together with Lewis and Poilly (2012), Jaimovich and Floetotto (2008), also provide evidence that the number of producers varies over the business cycle and that firms dynamics may play an important role in explaining business cycle statistics. Remarkably, Bilbiie, Ghironi and Fujiwara (2014) study optimal monetary policy in the BGM(2012) framework and show that deviations from long-run price stability are optimal in a model with endogenous firms' entry and product variety. Colciago (2015) studies optimal taxation in a model with endogenous firms entry and oligopolistic competition, showing that optimal dividend taxation depends on the form of competition and on the nature of firms sunk entry costs. Several papers, also provide empirical evidence that the number of producers varies over the business cycle and that firms dynamics may play

banks' loan spread - is found in several papers. Examples are Hannan and Berger (1991), Asea and Blomberg (1998) and more recently Lown and Morgan (2008), Nikitin and Smith (2009) and Kwan (2010). In particular, Kwan (2010) reported that the commercial and industrial loan rate spread has been of about 66 basis points higher (or 23% higher) than its long-term average in the aftermath of the recent financial crisis. Dueker and Thornton (1997), Angelini and Cetorelli (2003), and more recently, Olivero (2010) and Aliaga-Diaz and Olivero (2012), all show that banks' markup is countercyclical. However, they do not investigate the effect of an increased uncertainty on banks' markup.

[3] They show that their model contributes to explain the volatility of the labor market variables and also stylized facts concerning the countercyclicality of price markups, the procyclicality of firms profits, the overshooting of the labor share of income and job creation by new firms.

an important role in explaining business cycle dynamics and statistics.[4] Further, using an open economy framework, Ghironi and Melitz (2005 and 2007) study the role of firms dynamics on international trade, whereas Bergin and Corsetti (2008) and Cavallari (2013) analyze the role of monetary policy and international coordination in a model with endogenous firms' entry.

Despite these recent advances in improving the performance of the DSGE models, all these papers consider an exogenous and constant probability of firms default. Furthermore, they do not analyze the interaction between firms' destruction and financial markets in response to an uncertainty shock. This paper try to shed some light on this relationship by considering a model with endogenous firms creation and destruction together with an inefficient banking sector interacting with firms.

To the best of our knowledge few papers try to model firms' exit in a DSGE framework. Exceptions are Totzek (2009), Vilmii (2011), Cavallari (2015), Hamano and Zanetti (2015), Cesares and Poutineau (2014) and Clementi and Palazzo (2016). The closest to our paper are Totzek (2009), Cesares and Poutineau (2014), Hamano and Zanetti (2015). First and foremost, Totzek (2009), Cesares and Poutineau (2014), Hamano and Zanetti (2015) use different timing and a different exit condition.[5] Second, they do not study the effects of an uncertainty shock, neither theoretically nor empirically.

Finally, few papers consider imperfect financial market together with firms dynamics. Bergin at al (2014) and La Croce and Rossi (2014) use a different framework to study the relationship between endogenous firms

[4] Among others, Lewis and Poilly (2012), Lewis and Stevens (2015), Jaimovich and Floetotto (2008) and Colciago and Rossi (2015b).

[5] Totzek (2009) as well as Vilmi (2011) and Cesares and Poutineau (2014) assume that firms exit occurs at the end of the production period. Instead, in our model exit occurs before firms start producing. This implies that the average productivity changes along the business cycle and, as will be discussed in the paper, it also implies a stronger response of output. Importantly, Cesares and Poutineau (2014) assume that the stochastic discount factor is not affected dynamically by the endogenous firms exit probability. This also implies that the exit probability does not affect firms' decision on entering the market as well as firms pricing decisions. Hamano and Zanetti (2015), focus on the importance of product turnover for aggregate fluctuations. Further, they consider a flexible price economy, whereas the final sector of our economy is characterized by sticky prices.

Clementi and Palazzo (2016) extend the analysis of Hopenhayn (1992) and find that entry and exit imply greater persistence and unconditional variation of aggregate time–series. They also consider a perfect financial market and do not replicate the overshooting of firms destruction.

entry and financial imperfections. They show that entry contributes to the propagation of financial shocks. Both models consider endogenous business creation but exogenous firms destruction. Using the same framework provided in this paper, Rossi (2017) studies the effects of a shock to the level of productivity shock. Cacciatore et al. (2015) and Shapiro and Epstein (2017) consider a model with endogenous firms creation and olipopolistics banks to study the effects of structural reforms.

Though the Great Recession of 2008-2009 was characterized by an increase in the economic uncertainty, which, according to many authors, contributed to worsen the recession and to slow the recovery,[6] none of the papers cited above analyzes the effect of an uncertainty shock in a DSGE model with endogenous firms dynamics, neither theoretically, nor empirically. An exception are Brand et al (2017), that study the effect of an uncertainty shock in a model with search and monitoring costs in the credit market and firms dynamics. They estimate their structural model through Bayesian techniques and show that uncertainty in productivity turns out to be a major contributor to both macro-financial aggregates and firm dynamics. We share some results with this paper, though their framework to model financial markets and firms dynamics is completely different. Further, they do not investigate the relationship between non-performing loans, due to defaulting firms and the banks' markup.

The remainder of the paper is organized as follows. Section 2 provides an empirical motivation by reporting the dynamic responses of the US establishments births and deaths, as well as of a proxy of the US banks markup, to an uncertainty shock. Section 3 spells out the model economy, while Section 4 contains the main results of the model. Section 5 estimates a small BVAR and shows the responses to an uncertainty shock. Technical details are left in the Technical Appendix.

[6] See for example, Bloom (2009 and 2014), Bloom et al (2012), Born and Pfeiffer (2014), Leduc and Liu (2016), Fernandez and Villaverde (2011 and 2015) and Castelnuovo et al (2014), among others.

2 Empirical Motivation

3 Empirical Evidence on Uncertainty Shocks

To provide evidence on the relevance of uncertainty shocks, we now estimate a small BVAR model and show the impulse responses to orthogonalized shocks to macroeconomic uncertainty. As a proxy for the aggregate macroeconomic uncertainty we use the CBOE S&P 100 Volatility Index (VXO) downloaded from FRED database. Data on Real GDP, Inflation, firms' Births and Deaths, and Bank Markup are the same used in Section 2. Given the sample size of the series of Births and Deaths we estimate a BVAR using the sample: 1993Q3-2015Q1. Against the short sample background we choose to estimate the model with Bayesian techniques, this avoids sampling errors in estimating error bands for the impulse responses that may occur when estimating a highly over parameterized model (see Sims and Zha, 1998). The BVAR model has the following form:

$$Y_t = c + B_1 Y_{t-1} + ... + B_p Y_{t-p} + \epsilon_t, \qquad \text{where } \epsilon_t \sim N(0, \Sigma),$$

where $Y_t = [VXO, \ln CPI, \ln RGDP, \ln Births, \ln Deaths, BMRKP]$ is the vector of the variable used in the BVAR, i.e.: the CBOE S&P 100 Volatility Index (VXO), the logarithm of the CPI index and that of the real GDP, the logarithm of firms Births and Deaths, the proxy of the Bank Markup. $B_1, B_2 ... B_p$ are autoregressive matrix and Σ is the variance-covariance matrix. We estimate a BVAR(4) and for the prior distribution of the parameters we choose both Minnesota Priors of 0.8 on the autoregressive coefficient of the first lag.[7] Following Leduc and Liu (2016), among many others,[8] we choose a lower triangular Cholesky identification, ordering the VXO index first, such that on impact shocks to the uncertainty index affect the other variables, while shocks to the other variables do not affect the VXO index on impact.

Figure 1 shows the impulse responses to a VXO shock. The median responses of the endogenous variables to one-standard-deviation increase in the innovations to uncertainty are depicted by solid lines, while shaded areas represent 84 percent credible intervals. Notice that, uncertainty shocks have a substantial impact on the other endogenous variables. While real GDP

[7] Figure 2 shows the IRFs obtained with Normal-Diffuse Priors.

[8] This ordering has been largerly used in the literature (see for example., Bloom, 2009).

declines by 0.15 percent and remains below zero for more than 50 periods, establishments births declines by almost 0.3 percent and stays below zero for almost 30 quarters, similarly the number of establishments deaths increases by 0.4 percent. However, it is less inertial than BIRTHS. The bank markup increases by almost 0.05 percent points on impact and shows goes to zero in few quarters.

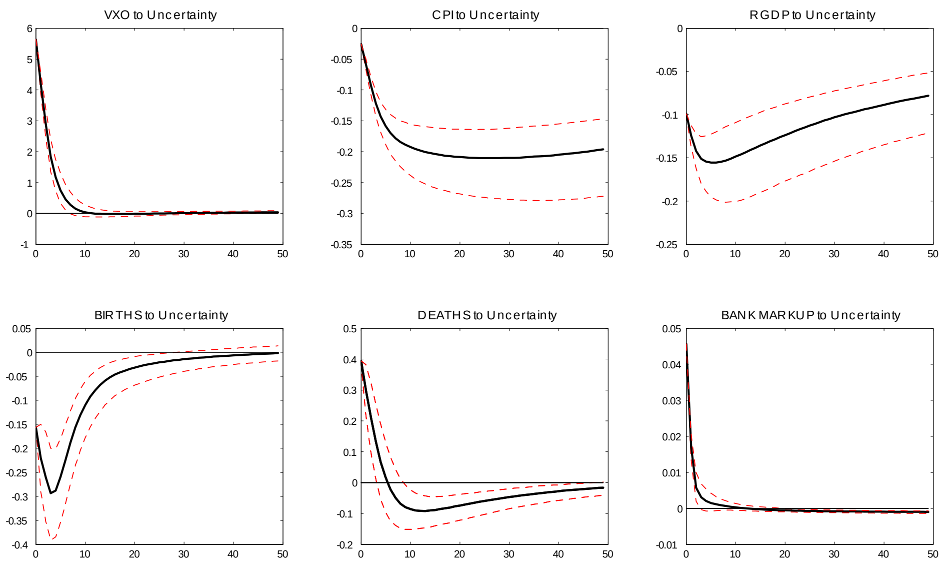

Figure 1. IRFs to an uncertainty shock - Minnesota Priors

Finally, Figure 2 shows the IRFs obtained estimating the same BVAR using Normal Diffuse priors with a 0.8 on the first lag. Notice that, all the results are confirmed. Importantly, the credible intervals for establishments deaths and those for banks' markup are larger, however the responses on impact are still statistically significant.

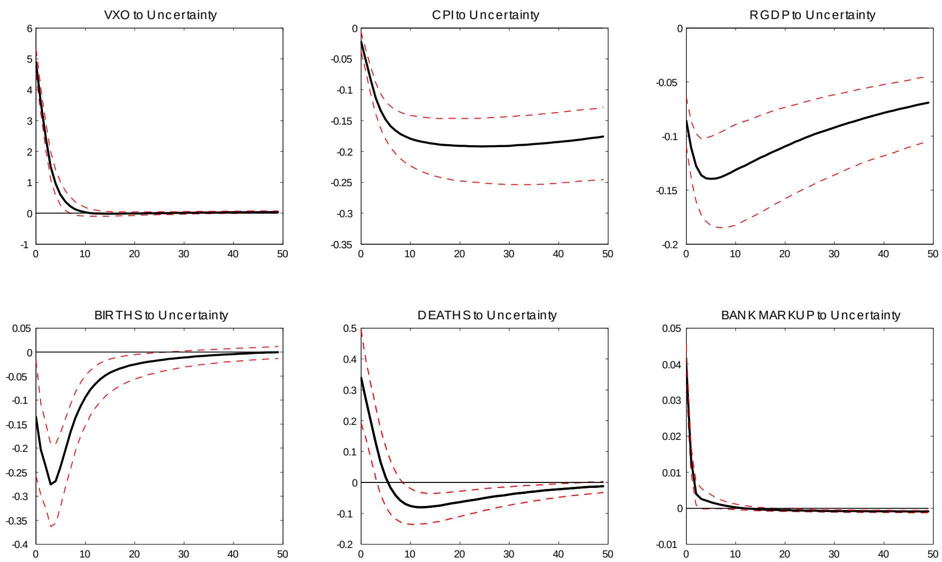

Figure 2. IRFs to an uncertainty shock - Normal Diffuse Priors.

4 The Model

The model considered is a closed economy composed by four agents: households, firms, banks and the monetary authority which is responsible for setting the policy interest rate.

4.1 Firms

The supply side of the economy is composed by: i) the intermediate good-producing firms equally distributed into a continuum of $k \in (0, 1)$ symmetric sectors. Each sector produces a continuum of differentiated goods $i \in N$ under monopolistic competition and flexible prices ii) The retail sector is composed by $j = k$ firms, competing under monopolistic competition. Each firm purchases all goods produced by the sector k, bundles it using a CES technology and set prices à la Rotemberg (1982).[9]

[9] The retail sector is introduced only to separate the sticky price problem from that of firms dynamics.

4.1.1 Firms: the Intermediate Sectors

Each sector k produces a continuum of differentiated intermediate goods $i \in N$, where N represents the mass of available goods produced by the sector. For the sake of simplicity, we assume one-to-one identification between a product and a firm. Firms in each sector k enjoy market power and set prices $P_{i,k,t}$ as a markup over their marginal costs. Since all sectors are identical we consider a representative intermediate sector and we remove the index k. In this context, the production function of firm i is,

$$y_{i,t} = A_t z_{i,t} l_{i,t} \tag{1}$$

where $l_{i,t}$ is the amount of labor hours employed by firm i, while $z_{i,t}$ is a firm specific productivity, which is assumed to be Pareto distributed across firms, as in Ghironi and Melitz (2005). The variable A_t is instead an aggregate AR(1) productivity shock.

The intermediate-goods producing firm i chooses the optimal price $P_{i,t}$ to produce $y_{i,t}$, maximizing its expected real profits, thus solving the following problem:

$$\begin{aligned} & \max E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} j_{i,t}, & (2) \\ & s.t. & \\ y_{i,t} &= A_t z_i l_{i,t}, & (3) \end{aligned}$$

where $j_{i,t}$ are firm i real profits, $\Lambda_{0,t}$ is the real stochastic discount factor, that will be defined below. The demand for the produced good $y_{i,t}$ comes from the retail sector and it is given by $y_{i,t} = \left(\frac{P_{i,t}}{P_t^I}\right)^{-\theta} y_t^R(k)$, where $y_t^R(k)$ is the aggregate demand of the retail firm k, with P_t^I being the Price Index of the intermediate sector and θ being the elasticity of substitution among intermediate goods of the same sector. Real profits, $j_{i,t}$ are given by:

$$j_{i,t} = \frac{P_{i,t}^I}{P_t} y_{i,t} - f^F + b_{i,t} - w_t l_{i,t} - \left(1 + r_t^b\right) b_{i,t}, \tag{4}$$

where $\frac{P_{i,t}^I}{P_t} y_{i,t}$ are total real revenues in term of the CPI index, $b_{i,t}$ is firms i real amount of borrowing from the banking sector at the beginning of time t. It is used by the firm to pay the fixed production cost $f_t^F = f^F$ for the period t to households[10]. Loans are paid back to the bank at the end of the same period at the net interest rate r_t^b. The variable w_t is the real wage and $l_{i,t}$ is firm i labor input. Using the retail sector demand and substituting for $w_t l_{i,t} = mc_{i,t} y_{i,t}$, the optimal problem can be rewritten as follows:

$$\max_{\{P_{i,t}\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\frac{P_t^I}{P_t} \left(\frac{P_{i,t}}{P_t^I} \right)^{1-\theta} y_t^R(k) - mc_{it} \left(\frac{P_{i,t}}{P_t^I} \right)^{-\theta} y_t^R(k) - \left(1 + r_t^b\right) f^F \right]. \tag{5}$$

The FOC with respect to $P_{i,t}$ yields:

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial P_{i,t}^I} &= (1-\theta) \frac{P_t^I}{P_t^I P_t} \left(\frac{P_{i,t}}{P_t^I} \right)^{-\theta} y_t^R(k) + \theta mc_{i,t} \left(\frac{P_{i,t}}{P_t^I} \right)^{-\theta-1} \frac{y_t^R(k)}{P_t^I} \\ &= 0. \end{aligned} \tag{6}$$

Multiplying by $\frac{P_t^I}{y_t^R(k)}$ and rearranging we get:

$$P_{i,t} = \frac{\theta}{\theta - 1} mc_{i,t} P_t. \tag{7}$$

Equation (7) simply states that the optimal price of firm i is a markup over its nominal marginal costs, $mc_{i,t}^{Nom} = mc_{i,t} P_t$.

Then, defining $\rho_{i,t} = \frac{P_{i,t}}{P_t}$ we can rewrite the optimal price in relative terms,

$$\rho_{i,t} = \frac{\theta}{\theta - 1} mc_{i,t} = \mu mc_{i,t}, \tag{8}$$

where $\mu = \frac{\theta}{\theta-1}$ is the gross markup.

Distribution of Productivity Draws According to Melitz (2003) and Ghironi and Melitz (2005), firm productivity draws are Pareto distributed. The cumulative distribution function (CDF) implied for productivity $z_{i,t}$ is $G(z_{i,t}) = 1 - \left(\frac{z_{\min}}{z_{i,t}}\right)^{\xi}$, while we denote by $g(z_{i,t}) = \xi \frac{z_{\min}^{\xi}}{z_{i,t}^{\xi+1}}$ the probability

[10] Since we assume that households are the owner of firms and their plants, the fixed cost can be viewed as a constant cost that a firm pay to household in each period for using its plant. Alternatively, the fixed cost can be viewed as a constant lump-sum tax payed by firms to the Government. Considering the latter assumption would not affect the main results of the paper.

distribution function (PDF). The parameters $z_{\min}$ and $\xi > \theta - 1$ are scaling parameters of the Pareto distribution, representing respectively the lower bound and the shape parameter, which indexes the dispersion of productivity draws. As ξ increases dispersion decreases and firm productivity levels are increasingly concentrated towards their lower bound $z_{\min}$.

Endogenous Entry and Exit Prior to entry firms are identical and face a fixed sunk cost of entry $f^E > 0$. Entrants are forward looking, so that the entry condition will be

$$\tilde{v}_t = \widetilde{j}_t + \beta E_t \left(1 - \eta_{t+1}\right) \tilde{v}_{t+1} = f^E, \tag{9}$$

where $\tilde{v}_t$ is the average firms value, given by the sum of current average profits, $\widetilde{j}_t$, and the next period discounted average value of firms, i.e. $\beta E_t \left(1 - \eta_{t+1}\right) \tilde{v}_{t+1}$. Notice that $\tilde{v}_{t+1}$, is discounted not only by β but also by the probability of firms default in the next period η_{t+1}, which dynamically affects firms decision on entry, thus creating an important transmission channel between exit and entry decisions. Indeed, the higher the probability of firms' default, the lower is firms expected average value and thus the lower will be firms entry. Notice that with respect to Bilbiie at al (2012) the extra term $\widetilde{j}_t$ in the entry condition comes from the fact that we assume that there is no time to build for new entrants. Indeed, our timing assumptions are the following. Upon entrance new entrants borrow from the banks to pay the fixed production cost f^F. This cost is paid at the beginning of each production period by both new entrant and incumbent firms.[11] Immediately after, they both draw their firm specific productivity level from a Pareto distribution. Then, the aggregate shock arrives and firms immediately start producing, unless they decide to exit. Exiting firms do not repay loans to banks. Using this timing assumption, the decision of new entrants to exit the market is identical to the decision of incumbent firms. In particular, both new entrants and incumbent firms decide to produce as long as their specific productivity $z_{i,t}$ is above a cutoff level $\overline{z}_t$. The latter value is the level of productivity that makes the sum of current and discounted future profits (i.e. the firms value) equal to zero. Otherwise, firms will exit the

[11] Notice that the entry cost and the production cost are two different cost. The first one is a sunk-cost payed only once and only by new entrants, before entering the market. While the second one is payed in every period by both firms types, i.e. incumbents and new entrants.

market before producing. The cut off level of productivity, $\overline{z}_t$, is therefore determined by the following exit condition:

$$v_t\left(\bar{z}_t\right) = j_{\bar{z},t}\left(\bar{z}_t\right) + \beta E_t\left\{\left(1-\eta_{t+1}\right)v_{t+1}\left(\bar{z}_{t+1}\right)\right\} = 0, \tag{10}$$

with

$$j_t\left(\bar{z}_t\right) = y_t\left(\bar{z}_t\right) - w_t l_{\bar{z},t} - \left(1+r_t^b\right)f^F, \tag{11}$$

where $j_t\left(\bar{z}_t\right)$ are current profits of the firm with a productivity $z_{i,t} = \overline{z}_t$. In other words, before they start producing both new entrants and incumbents know exactly their time t profits. Consequently, if the sum of these profits and of all their expected future profits is non-positive they will exit the market before producing. The exit probability $\eta_{t+1} = 1 - \left(\frac{z_{\min}}{\bar{z}_{t+1}}\right)^{\xi}$ is thus endogenously determined. As in Ghironi and Melitz (2005), the lower bound productivity $z_{\min}$ is low enough relative to the production costs so that $\overline{z}_t$ is above $z_{\min}$. In each period, this ensures the existence of an endogenously determined number of exiting firms: the number of firms with productivity levels between $z_{\min}$ and the cutoff level $\overline{z}_t$ are separated and exit the market without producing.

Notice that, under these assumptions the number of firms in the economy at period t will be:

$$N_t = \left(1-\eta_t\right)\left(N_{t-1} + N_t^E\right). \tag{12}$$

4.2 Average and Aggregate Variables

From now on for any generic variable x we use $x_{i,t} = x_{i,t}\left(z_{i,t}\right)$ to indicate a variable belonging to the firm with productivity equal to $z_{i,t}$. Analogously $x\left(\tilde{z}_t\right)$ indicates the value of the same variable belonging to the firm whose productivity is equal to the average productivity $\tilde{z}_t$. We define the average value of the variable x as $\tilde{x}$. We show that not always $\tilde{x} = x\left(\tilde{z}_t\right)$. Finally, we define aggregate variables using capital letters.

4.2.1 Firms Average Productivity

Following Ghironi and Melitz (2005), the average productivity of the intermediate good sector is:

$$\tilde{z}_t \equiv \left[\frac{1}{1-G(\bar{z}_t)}\int_{\bar{z}_t}^{\infty} z_{i,t}^{1-\theta}\, dG\left(z_{i,t}\right)\right]^{\frac{1}{\theta-1}}, \tag{13}$$

where $1-G(\bar{z}_t)=\left(\frac{z_{\min}}{\bar{z}_t}\right)^{\xi}$ is the share of firms with a level of productivity $z_{i,t}$ above the cut off level $\overline{z}_t$. In other words, it is the firms' probability to remain in the market and produce at time t.

4.2.2 Aggregate Price Index and the Average Relative Price: the Intermediate Sector

The aggregate price level of the intermediate sector k is defined as

$$\begin{aligned} P_t^I(k) &= \left[\frac{1}{1-G(\overline{z}_t)}\int_{\overline{z}_t}^{\infty} N_t (P_{i,t})^{1-\theta} g(z_i)\, dz_i\right]^{\frac{1}{1-\theta}} \\ &= N_t^{\frac{1}{1-\theta}}\left[\frac{1}{1-G(\overline{z}_t)}\int_{\overline{z}_t}^{\infty} (P_{i,t})^{1-\theta} g(z_i)\, dz_i\right]^{\frac{1}{1-\theta}} \end{aligned} \tag{14}$$

since each intermediate sector k faces the demand of the retail sector k, solving the Dixit Stiglitz problem of the retail sector we find that the demand of good i is $y_{i,t}(z_{i,t})=\left(\frac{P_{i,t}}{P_t^I(k)}\right)^{-\theta} Y_t^R(k)$, where $Y_t^R(k)$ is the aggregate demand of the retailer k. Solving for $P_{i,t}$

$$P_{i,t}=\left(\frac{y_{i,t}(z_{i,t})}{Y_t^R(k)}\right)^{-\frac{1}{\theta}} P_t^I(k) \tag{15}$$

and thus

$$P_t(\tilde{z}_t)=\left(\frac{y_t(\tilde{z}_t)}{Y_t^R(k)}\right)^{-\frac{1}{\theta}} P_t^I(k) \tag{16}$$

is the price of the firm with the average productivity $\tilde{z}_t$. Using (15) we can rewrite (14) as

$$P_t^I(k)=N_t^{\frac{1}{1-\theta}}\left[\frac{1}{1-G(\overline{z}_t)}\int_{\overline{z}_t}^{\infty}\left(\left(\frac{y_{i,t}(z_{i,t})}{Y_t}\right)^{-\frac{1}{\theta}} P_t^I(k)\right)^{1-\theta} g(z_i)\, dz_i\right]^{\frac{1}{1-\theta}}. \tag{17}$$

As shown in Melitz (2003) the relative output shares between two firms imply that $\frac{y_{i,t}(z_i)}{y_{k,t}(z_k)}=\left(\frac{z_{i,t}}{z_{k,t}}\right)^{\theta}$, and then $\frac{y_{i,t}(z_{i,t})}{y_t(\tilde{z}_t)}=\left(\frac{z_{i,t}}{\tilde{z}_t}\right)^{\theta}$. Using this result we can rewrite[12]

$$P_t^I(k)=N_t^{\frac{1}{1-\theta}} P_t^I(k)\left(\frac{y_t(\tilde{z}_t)}{Y_t}\right)^{-\frac{1}{\theta}}, \tag{18}$$

[12] See the Technical Appendix for details.

using equation (16) it implies that

$$P_t^I(k) = N_t^{\frac{1}{1-\theta}} P_t(\tilde{z}_t). \tag{19}$$

Due to symmetry across retail sector firms $P_t^I(k) = P_t^I$. Then, the aggregate price index of the intermediate sector is

$$P_t^I = N_t^{\frac{1}{1-\theta}} P_t(\tilde{z}_t). \tag{20}$$

Finally, since

$$P_t(\tilde{z}_t) = \left[\frac{1}{1-G(\overline{z}_t)} \int_{\overline{z}_t}^{\infty} (P_{i,t})^{1-\theta} g(z_i)\, dz_i\right]^{\frac{1}{1-\theta}}, \tag{21}$$

the average relative price is given by

$$\frac{P_t(\tilde{z}_t)}{P_t^I}\frac{P_t}{P_t} = N_t^{\frac{1}{\theta-1}} \tag{22}$$

and then

$$\rho(\tilde{z}_t) = N_t^{\frac{1}{\theta-1}} \rho_t^I \tag{23}$$

where we define $\rho(\tilde{z}_t) = \frac{P_t(\tilde{z}_t)}{P_t}$ and $\rho_t^I = \frac{P_t^I}{P_t}$.

Similarly, firms average profits are

$$\widetilde{j}_t = j(\widetilde{z}_t) = \rho^I N_t^{-1} Y_t - w_t N_t^{-1} L_t - \left(1 + r_t^b\right) f^F, \tag{24}$$

thus, they coincide with the profits of the firm that obtains the average productivity $\widetilde{z}_t$.[13]

4.2.3 Firms: Retailers

For the sake of simplicity we assume one-to-one relation between the number of retail sectors and the number of intermediate good-producing sectors. Each retailer $k \in (0,1)$ in the retail sector bundles the goods produced by the intermediate sector k under monopolistic competition, facing Rotemberg (1982) price adjustment costs. The new good of the retailer k is thus,

$$Y_t^{\varrho}(k) = \left[\int_{N_t} y_{i,t}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}.$$

[13] The derivation of average real profits and the proof for $\widetilde{j}_t = j(\widetilde{z}_t)$ is in the Technical Appendix.

This good is sold to the household at the price $P^R_{k,t}$. Since all firms in the retail sector are identical, they all set the same price maximizing their real profits, $j^R_{k,t}$ given by:

$$j^R_{k,t} = \frac{P^R_{k,t}}{P_t} Y^R_t(k) - \frac{\int_{N_t} P_{i,t} y_{i,t}}{P_t} - pac_{k,t}, \tag{25}$$

$$s.t. : Y^R_t(k) = \left(\frac{P^R_{k,t}}{P_t}\right)^{-\theta} Y^d_t \tag{26}$$

where $Y^R_t(k) = \left(\frac{P^R_{k,t}}{P_t}\right)^{-\theta} Y^d_t$ is the household demand for the differentiated final good k, with P_t being the CPI index, while Y^d_t is the aggregate demand for output. The term $pac_{kt} = \frac{\tau}{2}\left(\frac{P_{k,t}}{P_{k,t-1}} - 1\right)^2 \frac{P_{k,t}}{P_t} Y^R_t(k)$ represents the Rotemberg (1982), with $\tau > 0$. After solving the Dixit Stiglitz problem, according to which $P^I_t(k) Y_t(k) = \int_{N_t} P(i) y_t(i) di$, profits of the retail firm k can be rewritten as:

$$J^R_{k,t} = \left(\frac{P^R_{k,t}}{P_t} - \frac{P^I_t}{P_t}\right) Y^R_t(k) - \frac{\tau}{2}\left(\frac{P^R_{k,t}}{P^R_{k,t-1}} - 1\right)^2 \left(\frac{P^R_{k,t}}{P_t}\right)^{1-\theta} Y^d_t, \tag{27}$$

and we can write the profit maximization function as

$$\max_{\{P_{k,t}\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\left(\frac{P^R_{k,t}}{P_t} - \frac{P^I_t}{P_t}\right) Y^R_t(k) - \frac{\tau}{2}\left(\frac{P^R_{k,t}}{P^R_{k,t-1}} - 1\right)^2 \left(\frac{P^R_{k,t}}{P_t}\right)^{1-\theta} Y^d_t\right]$$

$$s.t.$$

$$Y^R_t(k) = \left(\frac{P^R_{k,t}}{P_t}\right)^{-\theta} Y^d_t$$

Substituting the constraint and solving for $P^R_{k,t}$ and imposing the symmetric equilibrium, that is $P^R_{k,t} = P_t$ and $Y^R_t(k) = Y_t$ yields to:

$$(1-\theta) + \theta \rho^I_t - \tau(\pi_t - 1)\pi_t - (1-\theta)\frac{\tau}{2}(\pi_t - 1)^2 + E_t\left\{\Lambda_{t,t+1}\tau(\pi_{t+1} - 1)\pi_{t+1}\frac{Y_{t+1}}{Y_t}\right\} = 0 \tag{28}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate and where the stochastic discount factor, $\Lambda_{t,t+1}$, is defined as:

$$E_t \Lambda_{t,t+1} = \beta E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-1} (1 - \eta_{t+1}) \right\}. \tag{29}$$

Notice that, since the exit probability changes along the business cycle, it now affects the dynamics of the stochastic discount factor.

4.3 Aggregate Output and Price

Aggregate output is given by the following CES technology:

$$Y_t = \left[\int_0^1 (Y_{k,t})^{\frac{\theta-1}{\theta}} dk \right]^{\frac{\theta}{\theta-1}}, \tag{30}$$

the aggregate price index is:

$$P_t = \left[\int_0^1 P_{k,t}^{1-\theta} dk \right]^{\frac{1}{1-\theta}}.$$

The Technical Appendix shows that the aggregate price and output can be rewritten as,

$$P_t = N_t^{\frac{1}{1-\theta}} P_t \left(\tilde{z}_t \right) \left(\rho_t^I \right)^{-1}, \tag{31}$$

$$Y_t = N_t^{\frac{\theta}{\theta-1}} y_t \left(\tilde{z}_t \right) = \rho_t \left(\tilde{z}_t \right) A_t \tilde{z}_t L_t. \tag{32}$$

4.4 Households

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

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln C_t - \frac{L_t^{1+\phi}}{1+\phi} \right), \tag{33}$$

where $\beta \in (0,1)$ is the discount factor and the variable L_t represents hours worked, while C_t is the usual consumption index:

$$C_t = \left(\int_0^1 C_{k,t}{}^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{34}$$

where $C_{k,t} = \left(\int_{i\in N} C_{i,t}{}^{\frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}}$ is the good bundled by the retail sector and $C_{i,t}$ the production of the intermediate good-producing firm i. The parameter θ (being $\theta > 1$) is the elasticity of substitution between the 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.

Households enter the period t earning an income from the deposits owned in the previous period $\frac{r^d_{t-1}}{\pi_t} D_{t-1}$, they then invest in a mutual fund of firms given by the sum of the already existing firms N_{t-1} and the new entrants at time t, N^E_t, where γ_t is the share of the mutual fund of firms held by the household, and $\widetilde{v}_t$ is the price paid, i.e. the firm value at the beginning of the period t. As previously discussed, both new entrants and incumbents firms borrow from the banking sector to pay the fixed production cost, they draw their firms specific productivity and then, after observing the aggregate shock, they decide whether to produce or exit the market. Those firms that are not separated produce and distribute their dividends $j_t(\tilde{z})$ to the household at the end of time t. At the end of the same period, the average value of the same share γ_t of mutual fund of firms will be $\widetilde{v}_{t+1}$. In addition to the labor income $w_t L_t$, and to the fixed costs received by the intermediate producers $F^F = N_t f^F$, households use dividends $j_t(\tilde{z})$, the new value of the mutual fund $\widetilde{v}_{t+1}$ and profits from retailers, j^R_t, to consume C_t or to save in the form of new deposits D_t. Thus, the household budget constraint is:

$$w_t L_t + F^F + \frac{r^d_{t-1}}{\pi_t} D_{t-1} + \underbrace{N_t \gamma_t \left(\widetilde{v}_{t+1} + j_t(\tilde{z})\right)}_{\text{End of period } t} + j^R_t = C_t + \left(D_t - \frac{D_{t-1}}{\pi_t}\right) + \underbrace{\left(N_{t-1} + N^E_t\right) \widetilde{v}_t \gamma_t}_{\text{Beginning of period } t}, \tag{35}$$

with

$$N_t = (1-\eta_t)\left(N_{t-1} + N^E_t\right). \tag{36}$$

Taking the first order conditions with respect to γ_t, D_t, C_t, L_t, combining households FOCs and imposing that in equilibrium $\gamma_t = \gamma_{t+1} = 1$, yields:

$$w_t = C_t L^{\phi}_t, \tag{37}$$

$$E_t \beta \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-1} \right\} = \frac{\pi_{t+1}}{\left(1 + r^d_t\right)}, \tag{38}$$

$$\widetilde{v}_t = E_t \beta \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-1} \left(1 - \eta_{t+1}\right) \left[\widetilde{v}_{t+1} + \widetilde{j}_t\right] \right\}, \tag{39}$$

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

4.5 The Banking Sector

4.5.1 Loans and Deposits Branches

The structure of the banking sector is a simplified version of Gerali et al. (2010). We assume that the bank is composed by two branches: the loan branch and the deposit branch. Both are monopolistic competitive, so that deposits from households and loans to entrepreneurs are a composite CES basket of a continuum of slightly differentiated products $j \in (0,1)$, each supplied by a single bank with elasticities of substitution equal to ε^b and ε^d respectively. As in the standard Dixit–Stiglitz (1977) framework, loans and deposits demands are:

$$b_{j,t} = \left(\frac{r^b_{j,t}}{r^b_t}\right)^{-\varepsilon^b} b_t \qquad \text{and} \qquad d_{j,t} = \left(\frac{r^d_{j,t}}{r^d_t}\right)^{-\varepsilon^d} d_t, \tag{40}$$

where $b_{j,t}$ is the aggregate demand for loans at bank j, that is $b_{j,t} = \int_0^1 b_{k,j,t} dk = \int_0^1 \left[\int_{i \in N} b_{i,j,t} di\right]$, where $b_{k,j,t}$ is the total amount of loans demanded to bank j by sector k and b_t is the overall volume of loans to firms. Similarly, $d_{j,t}$ is the households aggregate demand for deposits to bank j, while d_t is the households overall demand for deposits.

The amount of loans issued by the loan branch can be financed through the amount of deposits, D_t, collected from households from the deposit branch or through bank capital (net-worth), denoted by K^b_t, which is accumulated out of retained earnings. Thus, the bank sector obey a balance sheet constraint,

$$B_t = D_t + K^b_t, \tag{41}$$

with the low of motion of the aggregate banking capital given by:

$$\pi_t K^b_t = (1 - \delta^b) K^b_{t-1} + j^b_t, \tag{42}$$

where δ^b represents resources used in managing bank capital, while j^b_t are overall profits made by the retail branches of the bank.

Loans Rates and Deposits Rates Banks play a key role in determining the conditions of credit supply. Assuming monopolistic competition, banks enjoy market power in setting the interest rates on deposits and loans. This leads to explicit monopolistic markups and markdowns on these rates.

Each bank j belonging to the loan branch can borrow from the deposit bank j at a rate R^b_{jt}. We assume that banks have access to unlimited finance at the policy rate r_t from a lending facility at the central bank: hence, by the non-arbitrage condition $R^b_{j,t} = r_t$. The loan branch differentiates the loans at no cost and resell them to the firms applying a markup over the policy rate.[14] As in Curdia and Woodford (2009) we assume that banks are unable to distinguish the borrowers who will default from those who will repay, and so must offer loans to both on the same terms. The problem of the loan bank j is therefore,

$$\max_{\left\{r^b_{j,t}\right\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[r^b_{j,t} b_{j,t} \left(1-\eta_t\right) - r_t B_{j,t} - b_{j,t}\eta_t \right], \tag{43}$$

$$s.t. \quad b_{j,t} = \left(\frac{r^b_{j,t}}{r^b_t} \right)^{-\varepsilon^b} b_t, \tag{44}$$

where $b_{j,t} = \left(\frac{r^b_{j,t}}{r^b_t} \right)^{-\varepsilon^b} b_t$ is the demand for loans of bank j, $r^b_{j,t} b_{j,t} \left(1-\eta_t\right)$ are bank j net revenues, while $r_t B_{j,t}$ is the net cost due to the interest rate paid on the deposit rates. The additional term $b_{j,t}\eta_t$ is the amount of the notional value of the loans that it is not repaid by firms. This is a death weight loss for the bank and represents an extra-cost. 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 $B_{j,t} = B_t = N_t f^F$, we get the equation for the optimal interest rate:

$$r^b_t = \left(\frac{\varepsilon^b}{\left(\varepsilon^b_t - 1\right)\left(1-\eta_t\right)} \right) \left(r_t + \eta_t\right), \tag{45}$$

where $\mu^{Lb}_t = \frac{\varepsilon^b}{\left(\varepsilon^b - 1\right)\left(1-\eta_t\right)}$ is the bank markup and $r_t + \eta_t$ is its marginal cost.[15] The bank marginal cost is the sum of two components: i) r_t, i.e. the net

[14] All banks essentially serve all firms, providing slightly differentiated deposit and loan contracts.

[15] Indeed, in the symmetric equilibrium total costs are given by $CT^b_t = r_t b_t + b_t \eta_t$. Thus bank's marginal costs are $MC^b_t = \frac{dCT^b_t}{db_t} = r_t + \eta_t$.

interest rate that the bank has to pay to the deposit branch for each loan. This is the only effective cost per loan in the case the bank is able to have back the notional value of the loan from defaulting firms. ii) η_t represents instead the additional cost per loan faced by the bank due to firms defaulting and not repaying the loan.

Notice that $\frac{d\left(\mu_t^{Lb}\right)}{d\eta_t} = \frac{1}{\varepsilon^b-1}\frac{\varepsilon^b+1}{(\eta_t-1)^2} > 0$, implying a positive relationship between firms' exit and the value of the bank markup. Indeed, as the expected probability of exit increases, retail banks increase their markup and set higher interest rate. The intuition is straightforward. An increase in the firms' exit probability imply that the probability that a firm do not repay the loan increases. As a consequence the bank that has issued that loan faces lower expected profits. To restore its profits the bank is forced to increase the interest rate on loan.

The deposit branch collects deposits from households and gives them to the loans unit, which pays r_t. The problem for the deposit branch is then

$$\max_{\left\{r_{j,t}^d\right\}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[r_t D_{j,t} - r_{j,t}^d d_{j,t} - \frac{\kappa_d}{2} \left(\frac{r_{j,t}^d}{r_{j,t-1}^d} - 1 \right)^2 r_t^d d_t \right], \quad (46)$$

$$s.t.$$

$$d_{j,t} = \left(\frac{r_{j,t}^d}{r_t^d} \right)^{-\varepsilon^d} d_t \text{ and } D_{j,t} = d_{j,t}, \quad (47)$$

where $d_{j,t} = \left(\frac{r_{j,t}^d}{r_t^d}\right)^{-\varepsilon^d} d_t$ 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,

$$r_t^d = \frac{\varepsilon^d}{\varepsilon^d - 1} r_t \quad (48)$$

$\frac{d\left(\frac{\varepsilon}{\varepsilon-1}\right)}{d\varepsilon} = -\frac{1}{(\varepsilon-1)^2} < 0$, i.e. the interest rate on deposits is markdown over the policy rate r_t.

Aggregate bank profits are the sum of the profits of the branches of the bank. Thus, they are also affected by the firms' exit probability and given by:

$$j_t^b = r_t^b B_t \left(1 - \eta_t\right) - r_t^d D_t - B_t \eta_t. \quad (49)$$

where $B_t \eta_t$ is the total amount of the loans not repaid to the banks.

4.6 Monetary Policy

To close the model we specify an equation for the Central Bank behavior. We simply assume that the monetary authority set the nominal interest rate r_t following a standard Taylor-type rule given by

$$\ln\left(\frac{1+r_t}{1+r}\right) = \phi_R \ln\left(\frac{1+r_{t-1}}{1+r}\right) + (1-\phi_R)\left[\phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \phi_y \ln\left(\frac{Y_t}{Y}\right)\right], \tag{50}$$

where $\ln\left(\frac{\pi_t}{\pi}\right)$ and $\ln\left(\frac{Y_t}{Y}\right)$ are respectively the deviations of inflation and output from their steady state values, ϕ_π and ϕ_y being the elasticities of the nominal interest rate with respect to these deviations. Finally, ϕ_r is the interest rate smoothing parameter.

5 Business Cycle Dynamics

In what follows we study the impulse response functions (IRFs) to two types of productivity shocks: i) a standard productivity shock, i.e. a shock to the level of the aggregate productivity A_t. ii) An uncertainty shock, which is instead a shock to the volatility of the aggregate productivity. We model this shock by using the stochastic volatility approach as proposed by Fernandez-Villaverde et al. (2011), i.e. assuming time varying volatility of the innovation of the aggregate productivity, labeled $\sigma_{a,t}$.

More in details, we assume that the aggregate productivity follows a process of the form:

$$\ln(A_t/A) = \rho_a \ln(A_{t-1}/A) + \sigma_{a,t} u_t^a, \tag{51}$$

where A is the steady state value of A_t and where the innovation u_t^a is a standard normal process. The time-varying standard deviation of the innovations, $\sigma_{a,t}$, that is the uncertainty shock, follows this stationary process:

$$\ln(\sigma_{a,t}/\sigma_a) = \rho_a \ln(\sigma_{a,t-1}/\sigma_a) + \eta_\sigma u_t^\sigma, \tag{52}$$

where the innovation u_t^σ is a standard normal process and η_σ is the (constant) standard deviation of the uncertainty shock. In this Section we study the model dynamics in response to both shocks, by taking into account each shock at the time.

5.1 Calibration

Calibration is set on a quarterly basis. The discount factor, β, is set at 0.99. The inverse of Frisch elasticity of labor supply is $\phi = 4$. As in BGM (2012), we set the steady state value of the exit probability η to be 0.025, this needs that ξ is set equal to 7.76. A value of $\eta = 0.025$ matches the U.S. empirical evidence of 10% of firms destruction per year. The elasticity of substitution among intermediate goods, θ, is set equal to 3.8, a value which is in line with Ghironi and Melitz (2005) and BGM (2012). It also ensures that the condition for the shape parameter $\xi > \theta - 1$ is satisfied in the model with endogenous exit. The lower bound of productivity distribution, $z_{\min}$, is equal to 1. Further, as in BGM (2012), Etro and Colciago (2010) and Colciago and Rossi (2012), we set the entry cost $f^E = 1$. The fixed costs f^F is set such that in all the economies considered they correspond to 5% of total output produced. We translate the Rotemberg cost of adjusting prices, τ, into an equivalent Calvo probability that firms do not adjusted prices equal to 0.67, a value close to the ones obtained in the empirical literature (see for example Christiano et al 2005, among others).

We calibrate the banking parameters as in Gerali et al. (2010). For the deposit rate, we calibrate $\varepsilon^d = -1.46$. Similarly, for loan rates we calibrate $\varepsilon^b = 3.12$. The steady-state ratio of bank capital to total loans, i.e. the capital-to-asset ratio, is set at 0.09. As done for the computation of the correlation with real GDP. When we run the shock to the level of the productivity, we set the parameters as follows: the steady state of productivity A is equal to 1, its standard deviation is 0.0035, while its persistence is set to 0.94, as found by Smets and Wouters (2007), for the labor productivity.

The parameter of the uncertainty shock are calibrated as in the VAR and follows Leduc and Liu (2016) strategy. A one standard deviation shock to uncertainty raises the measure of uncertainty, i.e. the VXO, by 5.63 units relative to the sample mean of 20.6. Thus, the shock is equivalent to a 27.2 percent increase in the level of uncertainty relative to its mean (5.63/20.6 = 0.392). Since we calibrate the mean standard deviation in our model to 1 percent, we set the standard deviation of the uncertainty shock to 0.392in line with the VAR evidence. Our VAR evidence also suggest that the effects of the uncertainty shock on measured uncertainty is persistent, so that in a period of 4 quarters, the VXO falls gradually to about 45.7 percent of its peak. This observation suggests that, if the shock is approximated by an AR(1) process, as in our model, then the persistence parameter should be about 0.822 at quarterly frequencies. Thus, we set $\rho_\sigma = 0.822$.

Finally, we consider a Taylor rule, with $\phi_R = 0.75$, $\phi_\pi = 2.15$ and $\phi_y = 0.125$. This rule guarantees the uniqueness of the equilibrium. Further, these parameters are in the range of the values estimated for the US economy.[16]

5.2 Uncertainty Shocks

We now show the IRFs to an uncertainty shock, which is a shock to the volatility of the aggregate productivity. To examine the dynamic effects of the uncertainty shock, we solve the model using third-order approximations to the equilibrium conditions around the steady state. We follow the procedure suggested by Fernandez-Villaverde et al. (2011) to compute the impulse responses.[17] .

Figure 3 compares the performance of our baseline model (as before labeled as *Endogenous exit MB*) with the endogenous exit model with efficient banks (labeled as *Endogenous Exit EB).*

[16] See for example Smets and Wouters (2007). The qualitative results and the comparison with the exogenous exit model and with the model with efficient banks are not qualitatively altered by the choice of the Taylor rule.

[17] In particular, using Dynare, we first simulate the model (using a third-order approximations to the decision rules) for 2,096 periods, starting from the deterministic steady state. We the drop the first 2,000 periods to avoid dependence on initial conditions and we use the remaining 96 periods to compute the ergodic mean of each variable. Then, starting from the ergodic means, we run two different simulations of 20 periods each, one with an uncertainty shock (i.e. a one-standard-deviation increase in uncertainty in the first period) and the other with no shocks. Finally, we compute the IRFs as the percentage differences between these two simulations.

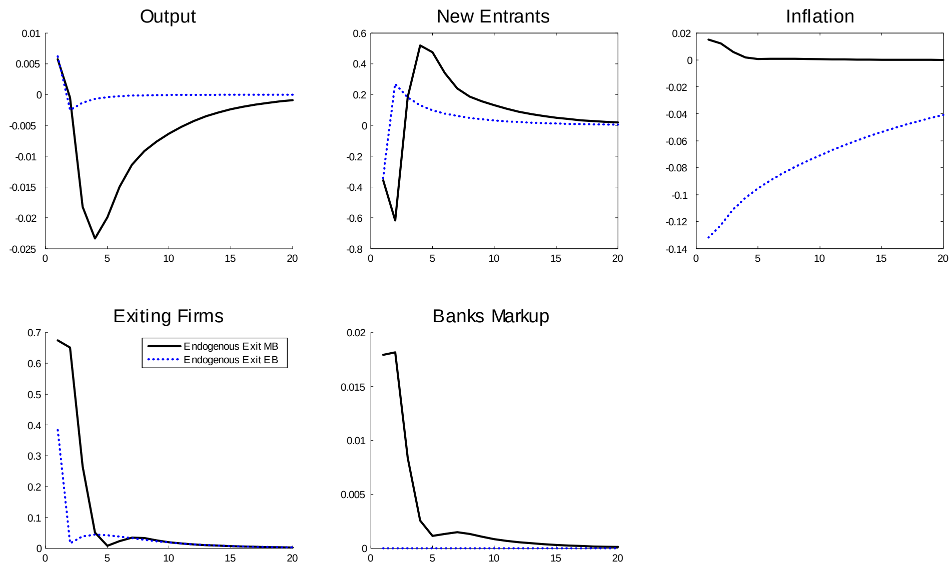

Figure 3. IRFs to an uncertainty shock. Benchmark model (black solid line), Efficient Banks model (blu dotted line).

Notice that in both models an uncertainty shock is followed by an increase in firms exit and a decrease in firms entry, together with a reduction in output. The recessionary effects are stronger in the model with monopolistic banks (black solid lines) than in the model with efficient banks (blue dotted lines). The intuition is simple. In both models the increase in uncertainty reduces firms' expected average profits. The number of defaulting firms increases and new entrants decrease. Since exiting firms do not repay the loans, the number of non-performing loans increases and banks face balance-sheet losses, so that they increase their interest rate on loan to restore their profits. The banks' markup increases, making the cost of loans higher and further reducing firms expected average profits. As a consequence, both firms' exit and the fall in business creation is higher with respect to the model with efficient banks, where the banks markup remains unchanged. This result in a more severe recession.

Finally notice that while the shock is deflationary in the model with efficient banks, the response of inflation is positive and close to zero in our benchmark model. Even though, a positive response of inflation is commonly find in the theoretical literature on uncertainty shocks,[18] this contrasts with

[18] See for example, Fernandez-Villaverde at al (2015), Born and Pfeiffer (2014), Bonciani

the response of inflation found in the VAR.

6 Conclusion

We develop a NK-DSGE model with endogenous firms dynamics and inefficient banks. We analyze the relationship between firms dynamics and banking in response to an increase in the volatility of the aggregate productivity, i.e. to an uncertainty shock. We find the following results. First, estimating a small BVAR, using the CBOE S&P 100 Volatility Index (VXO) as a proxy for the aggregate macroeconomic uncertainty, we find that uncertainty shocks are recessionary and imply a decrease in the number of new entrants, an increase in the number of firms default and an increase in the banks' markup. Second, we provide a theoretical model able to replicate the empirical evidence. Third, we show that our baseline model presents a stronger and more prolonged recession in the medium run than a model with efficient banks.

This paper is only a first attempt to understand the interactions between firms dynamics, and in particular the dynamics of the exit margin and banking. We strongly believe that further investigation, both from a theoretical and an empirical point of view, is needed on this issue. Finally, investigating the role of uncertainty shock in affecting welfare and the optimal monetary prescriptions in a model with endogenous firms dynamics is also part of our agenda.

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