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A note on firm entry, markups and the business cycle☆

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ABSTRACT

This paper proposes a monetary model with firm entry as a means for alleviating the difficulties of real business cycle models in reproducing the smoothness and persistence of macroeconomic variables together with the volatility of profits and markups. Simulations show that my baseline model matches the unconditional moments of consumption, output, hours, markups and profits in US data fairly well. In addition, it implies a positive effect of a monetary expansion on business formation as in the data. Allowing for differences in the composition of the investment and the consumption baskets is essential for these results.

1. Introduction

It is a well-established fact that business formation moves pro-cyclically.[1] Recently, Broda and Weinstein (2010) have documented a pro-cyclical behavior also for the range of varieties. Motivated by this evidence, a novel line of research stresses the role of firm entry and creation of new varieties in propagating business cycle fluctuations. In a number of contributions, including Jaimovich and Floetotto (2008), Colciago and Etro (2010) and Bilbiie et al. (2012), the presence of firm entry improves the capacity to match stylized business cycle facts compared to standard (fixed-variety) real business cycle models. Yet, a lot remains to be done. Entry models are still relatively unsuccessful in capturing a number of regularities in the data. They typically fail to match the smoothness of consumption, investment and hours, overstate their cyclicality and understate their persistence. In addition, they largely downplay the volatility of markups and profits. This paper shows that a monetary model with firm entry can help alleviate these difficulties.

Early studies combining firm entry and sticky prices include, among others, Bilbiie et al. (2008), Bergin and Corsetti (2008), Lewis (2009), Lewis and Poilly (2012), Cavallari (2007, 2010, in press) and Uusküla (2008). With the exception of Cavallari (in press) and Bilbiie et al. (2008) that will be discussed further in the paper, these works do not provide a quantitative assessment of the performance of the model in terms of unconditional moments as is done in this paper. The contribution of the paper in the literature, however, can be read along more than one dimension.

A first dimension concerns the specification of the entry costs. As is now well understood, modeling these costs as wages has counterfactual implications in monetary models: a monetary expansion leads to a fall in business formation at odds with the empirical evidence.[2] The monetary easing, in fact, pushes on labor demand, thereby raising wages and entry costs. For this reason, Bergin and Corsetti (2008) propose entry costs in terms of capital goods while Lewis (2009) considers wage stickiness in a setup with labor entry costs. A contribution of the present paper is to clarify that varying the composition of the entry costs alters the transmission of business cycle shocks. In the model, differences in the composition of the consumption and the investment baskets are essential for reducing the gap with the data.

The other dimension relates to entry as a form of investment. The point that firm entry acts much like investments at the intensive margin in standard (fixed-variety) models was first shown by Bergin and Corsetti (2008). In their model, the presence of the extensive margin amplifies the real effects of monetary policy. In a similar vein, business formation amplifies the transmission of productivity shocks in my setup. In order to see why, consider a positive shock to productivity. The productivity rise reduces the price of investment in terms of consumption, shifting the allocation of resources from the p-r-o-

☆ I wish to thank three anonymous referees for useful comments on previous drafts. Remaining errors are mine.

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[1] In the US, net business formation and the incorporation measures are strongly pro-cyclical (see Chatterjee and Cooper (1993), Dunne et al. (1988), Campbell (1998) and more recently Jaimovich and Floetotto (2008), Bilbiie et al. (2012) and Lewis (2009)).

[2] Using US data, Bergin and Corsetti (2008) document that a monetary easing, i.e. a drop in the nominal interest rate, has a positive impact on business formation. See also Lewis (2009) and Uusküla (2008).

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duction of existing goods to the creation of new varieties. This in turn translates into a persistent increase in the stock of producers.

As is common practice in models with entry, I consider an economy where producers are subject to a sunk entry cost, a one-period production lag and an exogenous exit shock. Each of them produces a unique variety in a monopolistic competitive market and sets the price of his product subject to price rigidity à la Calvo (1983). Following Bergin and Corsetti (2008), the setup of a new firm requires entrants to buy a basket of investment goods whose composition may differ from that of the consumption basket. Entry costs therefore coincide with the price of investment goods relative to the price of existing varieties. This assumption represents the main departure from a setup à la Bilbiie et al. (2008, 2012) where the entry costs are specified as wages. I will argue below that it plays an important role in the model.

Simulations show that the baseline model matches key unconditional moments in the data. Remarkably, it attenuates the difficulties common to standard business cycle and endogenous entry models in capturing the persistence and smoothness of output, consumption and hours worked. In addition, it matches the cyclicality of profits and markups in the data. On a less positive tone, the model understates the smoothness of markups and slightly overstates the smoothness of profits. Differences in the consumption and the investment baskets are essential for these results.

The remainder of the paper is organized as follows. Section 2 presents the model and discusses the solution strategy. Section 3 illustrates the performance of the model in reproducing the unconditional moments in the data. Section 4 contains conclusive remarks.

2. The economy

I consider a closed economy version of the model in Cavallari (in press). The economy is populated by a continuum of agents of unit mass indexed by i. Firms are monopolistic competitors, each producing a different variety $j \in (0, N_t)$, where N_t is the number of firms active at time t. The stock of producers is determined endogenously in the model.

A typical agent supplies L_t hours of work each period for the nominal wage W_t and maximizes inter-temporal utility $E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}U(C_s, L_s)\right]$, where C is consumption, β is the subjective discount factor and E is the expectation operator. The period utility is the additive-separable function $U_t = \frac{(C_t)^{1-\rho}}{1-\rho} - \frac{\varphi\chi}{1+\varphi}(L_t)^{\frac{1+\varphi}{\varphi}}$ with $\rho > 0$ and $\varphi \geq 0$.

The consumption basket takes the form $C_t = X^{\gamma}Z_t^{1-\gamma}$ where X is a homogeneous endowment good and Z_t is the CES aggregator $Z_t = \left[\int_0^{N_t} Z_t(j)^{\frac{\theta-1}{\theta}}dj\right]^{\frac{\theta}{(\theta-1)}}$ with $\theta > 1$ denoting the elasticity of substitution among the varieties $Z(j)$. Without loss of generality, I normalize the price of the homogeneous good to one, so that the welfare-based consumer price index is $P_t = P_{Zt}^{1-\gamma}$. The producer price index is $P_{Zt} = \left[\int_0^{N_t} P_t(j)^{1-\theta}dj\right]^{\frac{1}{(1-\theta)}}$ where $P(j)$ denotes the price of a variety j.

Producers face an identical linear technology in the labor input $y_t(j) = A_t L_t(j)$, where A is an aggregate shock to labor productivity. In each period, in addition to incumbent firms there is a finite mass of entrants, N_t^e. As in Ghironi and Melitz (2005), all firms entered in a given period are able to produce in all subsequent periods until they are hit by a death shock, which occurs with a constant probability $\delta \in (0,1)$.

In order to start the production in period $t+1$, at time t an entrant needs to pay an exogenously given sunk entry cost f^e. Following Bergin and Corsetti (2008), this cost is specified in terms of product prices. The creation of a new firm requires purchasing f^e units of a composite basket of investment goods $K_t = X^{\sigma}Z_t^{1-\sigma}$ at a price $P_{Kt} = P_{Zt}^{1-\sigma}$. Note that the composition of the investment basket may differ from that of the consumption basket, namely $\gamma \neq \sigma$. Clearly, when $\gamma = \sigma$ entry costs are constant in real terms (i.e. in units of consumption), a case examined by Auray and Eyquem (2011) and Bilbiie et al. (2008). As will be clear soon, the composition of investment goods has relevant consequences for the dynamics of the model.

Others, as Bilbiie et al. (2008, 2012) and Cavallari (2007), model entry costs as wages.[3] As is now well-understood, this may have counterfactual implications in monetary models: a monetary expansion may lead to a fall in business formation at odds with the empirical evidence. The reason is that a monetary expansion pushes on labor demand, thereby increasing real wages and entry costs. I will show below that the impulse responses to a monetary policy shock are in line with the estimated responses in my setup with entry costs in terms of goods.

Entrants are forward looking and decide to start a new firm whenever its real value, v, given by the present discounted value of the expected stream of profits $\{d_s\}_{s=t+1}^{\infty}$, covers entry costs:

$$\nu_t = E_t\left[\sum_{s=t+1}^{\infty}\beta(1-\delta)\left(\frac{C_{s+1}}{C_s}\right)^{-\rho}d_s\right] = f^e\frac{P_{Kt}}{P_t}. \tag{1}$$

The free entry condition holds so long as the mass of entrants in positive. Macroeconomic shocks are assumed to be small enough for this condition to hold in every period. Note that upon entry, firms' profits vary and may even turn negative for a while. This is a key difference relative to early models of frictionless entry, where the absence of sunk costs leads profits to zero in every period. The timing of entry and the one-period production lag imply the following law of motion for producers:

$$N_t = (1-\delta)\left(N_{t-1} + N_{t-1}^e\right). \tag{2}$$

Finally, a typical agent enters period t with nominal bond holdings B_t and mutual fund share holdings s_t. He receives labor income, interest income on bond holdings at the risk-free rate i_t and dividend income on mutual fund share holdings and the value of selling his initial share position. The agent allocates these resources between purchases of bonds and shares to be carried into next period and consumption. The period budget constraint (in units of consumption) is:

$$\frac{B_{it}}{P_t} + s_t\left(N_t + N_t^e\right)\nu_t \leq \frac{B_{it-1}}{P_t}(1+i_t) + s_{t-1}(\nu_t + d_t) + \varpi_t L_{it} - C_{it} \tag{3}$$

where $\varpi_t = \frac{W_t}{P_t}$ is the real wage.

2.1. Equilibrium conditions

2.1.1. Consumers

Consumers' first order conditions are given by:

$$\frac{(C_t)^{-\rho}}{P_t} = \beta E_t\left[\frac{(C_{t+1})^{-\rho}i_{t+1}}{P_{t+1}}\right] \tag{4}$$

$$(C_t)^{-\rho} = \beta(1-\delta)E_t\left[\frac{d_{t+1}+\nu_{t+1}}{\nu_t}(C_{t+1})^{-\rho}\right] \tag{5}$$

$$C_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\theta}C_t \tag{6}$$

$$\varpi_t = \chi(L_t)^{\frac{1}{\varphi}}(C_t)^{\rho}. \tag{7}$$

[3] For a monetary model with entry that combines labor and capital entry costs see Cavallari (2012).

2.1.2. Firms

Each producer sets the price for its own variety facing a downward-sloping market demand:

$$y_t(j)=\left(\frac{P_t(j)}{P_{Zt}}\right)^{-\theta}\left((1-\gamma)(P_{Zt})^{-\gamma}C_t+(1-\sigma)(P_{Zt})^{-\sigma}f^eN_t^e\right). \tag{8}$$

I introduce nominal rigidity through a Calvo-type contract. In each period a firm can set a new price with a fixed probability $1-\alpha$ which is the same for all firms, both incumbent firms and new entrants, and is independent of the time elapsed since the last price change. In every period there will therefore be a share α of firms whose prices are pre-determined. In a symmetric equilibrium, pre-set prices at a given point in time coincide with the average price chosen by firms active in the previous period, i.e. $(P_{Zt})^{1-\theta}=\frac{(P_{Z,t-1})^{1-\theta}}{N_{t-1}}$.

The assumption that entrants behave like incumbent firms is without loss of generality. Allowing entrants to make their first price-setting decision in an optimal way would have only second-order effects in a setup with Calvo pricing. In a context where firms face costs of price adjustment, instead, this assumption would introduce heterogeneity of the price level across cohorts of firms entered at different points in time (see Bilbiie et al. (2008)). As the number of price-setters that face no cost of adjusting to a past pricing decision moves over the cycle, the aggregate degree of price stickiness becomes endogenous. The analysis of endogenous changes in price stickiness is beyond the scope of this paper.

Each firm sets the price for its own variety so as to maximize the present discounted value of future profits, taking into account market demand and the probability that she might not be able to change the price in the future, yielding:

$$P_t(j)=\frac{\theta}{\theta-1}\frac{E_t\sum_{k=0}^{\infty}(\alpha\beta(1-\delta))^k\frac{W_{t+k}}{A_{t+k}}\frac{y_{t+k}(j)}{P_{t+k}C_{t+k}^{-\rho}}}{E_t\sum_{k=0}^{\infty}(\alpha\beta(1-\delta))^k\frac{y_{t+k}(j)}{P_{t+k}C_{t+k}^{-\rho}}} \tag{9}$$

Clearly, when $\alpha=0$ optimal pricing implies a constant markup $\frac{\theta}{\theta-1}$ on marginal costs at all dates. With $\alpha>0$, prices may respond more or less than proportionally to a marginal cost shock, implying time-varying markups.

Recalling the definition of P_Z, the Calvo state equation corrected for firm entry is given by:

$$(P_{Zt})^{1-\theta}=\alpha\frac{N_t}{N_{t-1}}(P_{Zt-1})^{1-\theta}+(1-\alpha)N_t(P_t(j))^{1-\theta}. \tag{10}$$

Note that an increase in the number of producers over time reduces the aggregate price level and the more so the higher the elasticity θ. This is a consequence of love for variety: a wider range of varieties raises the value of consumption per unit of expenditure, implying a fall in aggregate prices.

2.1.3. Aggregate constraints

Define real GDP as $Y_t\equiv\int_0^{N_t}\frac{P_t(j)}{P_t}y_t(j)dj$ where $y(j)$ is given by Eq. (8). Goods market clearing requires output to equalize aggregate demand, $Y_t=C_t+N_t^e\nu_t$. Labor market clearing implies:

$$L_t\equiv\int_0^1 L_{it}di\geq\int_0^{N_t}\frac{y_t(j)}{A_t}dj. \tag{11}$$

The model is closed by specifying a monetary policy rule. I assume the monetary instrument is the one-period risk-free nominal interest rate, i_t, and monetary policy belongs to the class of feedback rules.

2.2. The log-model

The model is log-linearized around a symmetric steady state with zero inflation. In the steady state stochastic shocks are muted at all dates, $A_t=1$ (the steady state and the full log-linear model are in the Appendix A).

The Euler equation for bond holdings is given by:

$$E_t\widehat{C}_{t+1}=\widehat{C}_t+\frac{1}{\rho}\left(\widehat{i}_t-E_t\pi_{t+1}\right) \tag{12}$$

where a hat over a variable denotes the log-deviation from the steady state and $\pi_{t+1}=\ln\frac{P_{t+1}}{P_t}-1$ is the CPI inflation. In Eq. (12), an increase in the real interest rate raises the return on bonds, therefore making it more attractive to postpone consumption in the future.

The Euler equation for share holdings is:

$$E_t\widehat{C}_{t+1}=\widehat{C}_t+\widehat{\nu}_t+\frac{1}{\rho}E_t\left(\frac{i+\delta}{1+i}d_{t+1}+\frac{1-\delta}{1+i}\widehat{\nu}_{t+1}\right)$$

Arbitrage in financial markets equalizes the real returns on shares and bonds at all times.

Labor supply is given by:

$$\widehat{L}_t=-\rho\varphi\widehat{C}_t+\varphi\widehat{\varpi}_t \tag{13}$$

Using the definition of GDP and the labor market equilibrium (11), it is convenient to derive a log-linear approximation to the aggregate production function $\widehat{Y}_t=\widehat{L}_t+\widehat{A}_t+\widehat{P}_{C,t}$ where $\widehat{P}_{C,t}\equiv\ln\frac{P_t(j)}{P_t}$ is the price of a variety in consumption units.

Consider now the optimal price (9). Using market demand (8) and labor supply (7), re-arranging and linearizing gives:

$$E_t\sum_{k=0}^{\infty}\alpha\beta(1-\delta)^k\left[\widehat{P}_{Z,t+k}-\left(\rho+\frac{1}{\varphi}\right)\widehat{C}_{t+k}+\left(1+\frac{1}{\varphi}\right)\widehat{A}_{t+k}-\frac{1}{\varphi}\widehat{N}_{t+k}+\frac{\theta}{\varphi}\widehat{P}_{Z,t}\right]=0$$

where $\widehat{P}_{Z,t}\equiv ln\frac{P_t(j)}{P_{Zt}}$ and $\widehat{P}_{Z,t+k}\equiv ln\frac{P_t(j)}{P_{Zt+k}}$. Note that by definition $\widehat{P}_{Z,t+k}=\widehat{P}_{Z,t}-\sum_{s=1}^{k}\pi_{t+s}^Z$, where $\pi_{t+s}^Z=\ln\frac{P_{Zt+s}}{P_{Zt}}-1$ is the producer inflation. Intuitively, the change in the price of a variety (in units of production) is given by the so-called variety effect, the first addend, less inflation. Using Eq. (10), the variety effect is:

$$\widehat{P}_{Z,t}=\frac{\alpha}{1-\alpha}\pi_t^Z+\frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_t-\frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{t-1}.$$

With $\alpha=0$, an increase in the number of producers raises the price of each variety and the more so the lower the elasticity of substitution θ. The presence of sticky prices affects the variety effect along two dimensions. First, it gives firms an incentive to adjust their markup to cyclical conditions (recall Eq. (9)). This implies that $\widehat{P}_{Z,t}$ will increase in periods of high inflation. Second, the slow adjustment of prices amplifies the persistence of $\widehat{P}_{Z,t}$. Combining the two equations above and re-arranging gives the new-Keynesian Phillips curve corrected for firm entry:

$$\pi_t^Z=\zeta\left[\left(\rho+\frac{1}{\varphi}\right)\widehat{C}_t-\frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_t-\frac{(1+\varphi)}{\varphi}A_t+\frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{t-1}\right]+\beta(1-\delta)E_t\pi_{t+1}^Z \tag{14}$$

where $\zeta=\frac{(1-\alpha\beta(1-\delta))(1-\alpha)}{\alpha(\varphi+\theta)}$. The inflation rate depends on next period expected inflation as well as on deviations of consumption, the number of producers and productivity from their steady state values. These deviations reflect changes in current marginal costs as is usual in a new-Keynesian Phillips curve. In order to see why, consider an increase in C. The rise in aggregate demand pushes up labor demand, thereby increasing real wages. The hike in marginal costs fuels inflation. A rise in productivity, on the contrary, directly reduces marginal costs and inflation. The number of producers is related to inflation via the variety effect.

A log-linear approximation to the number of entrants is obtained from the aggregate resource constraint:

$$\widehat{N}^e_t = \frac{\theta(1-\beta(1-\delta))}{\beta\delta}\widehat{Y}_t + \left(1-\frac{\theta(1-\beta(1-\delta))}{\beta\delta}\right)\widehat{C}_t \tag{15}$$

Note that there is a trade-off between investments in new varieties and consumption of existing goods (the coefficient on C is negative). As will become apparent soon, changes in the price of investments in new firm relative to the production of existing varieties constitute the main transmission mechanism in the model.

The law of motion of firms is:

$$\widehat{N}_t = (1-\delta)\widehat{N}_{t-1} + \delta\widehat{N}^e_{t-1}. \tag{16}$$

Using the optimal price (9) together with the definition of the aggregate markup $\mu_t = \int_0^{N_t} P_t(j)A_t/W_t$, one obtains[4]:

$$\widehat{\mu}_t = \alpha\beta(1-\delta)\left(E_t\widehat{P}_{Z,t+1} - \widehat{\varpi}_t + A_t\right) \tag{17}$$

In the model, markup fluctuations arise from a disconnect between changes in the variety price and changes in marginal costs. As in New-Keynesian models, variable margins of profits are powered by exogenous price stickiness (markups are constant with flexible prices, i.e. with $\alpha = 0$). In principle, sticky prices are by no means essential for replicating time-varying markups.[5] I will discuss below the advantage of including sticky prices in a model with firm entry.

Using the property that markups coincide with the inverse of the labor share, $\frac{YP}{WL}$, together with the log-linear production function, the real wage is given by:

$$\widehat{\varpi}_t = \widehat{A}_t - \widehat{\mu}_t + \widehat{P}_{C,t}. \tag{18}$$

The log-model is closed with the Taylor rule $\widehat{i}_t = \phi_i\widehat{i}_{t-1} + \phi_\pi\pi^Z_t + \phi_y\widehat{Y}_t$.[6] For ease of comparison with flexible price models, I also consider a Wicksellian regime in which the nominal interest rate reproduces a flexible price equilibrium with zero inflation. The Wicksellian interest rate mimics changes in the natural (real) interest rate $\widetilde{i}_t = \rho\left(E_t\,\widehat{C}_{t+1} - \widehat{C}_t\right)$. As is well-known, the Wicksellian policy can be implemented by means of a credible threat to deviate from a zero inflation target, i.e. $i_t = \widetilde{i}_t + \vartheta\pi_t$ with $\vartheta > 1$.

3. Simulations

The model is simulated using first-order perturbation methods. For ease of comparison with real business cycle models, I first consider productivity shocks as the exogenous source of business cycle fluctuations. I then consider interest rate innovations with the aim of clarifying the mechanism of monetary transmission in the model.

3.1. Calibration

The model is calibrated to the United States. In the simulations, periods are interpreted as quarters and $\beta = 0.99$ as is usual in quarterly models of the business cycle. The size of the exogenous exit shock is $\delta = 0.025$ as in Bilbiie et al. (2012) to match the rate of firm disappearance in the US.

To the best of my knowledge, there is no evidence about the shares of homogenous and differentiated goods in the consumption and the investment basket. In the absence of a prior on the values of γ and σ, I set rather arbitrarily $\gamma = 0.2$ and $\sigma = 0.6$ in the baseline calibration and then experiment with a full range of admissible values for these parameters. In particular, I will focus on the special case $\gamma = \sigma$ where entry costs are fixed in units of consumption.

The elasticity of substitution among varieties is $\theta = 7.88$ as in Rotemberg and Woodford (1999) to match the average margin of profits of 18% in US data. Studies based on disaggregated data usually find a much lower θ, roughly around 4, implying profit margins above 40%. I have experimented with $\theta = 3.8$ as in Bilbiie et al. (2012), obtaining qualitatively identical results (available upon request). Other preference parameters are $\varphi = 4$ and $\rho = 1$ as in Bilbiie et al. (2012).

The degree of price stickiness is $\alpha = 0.49$ to match the middle point in the range of values estimated by Galì et al. (2001) for the US. This implies an average duration of nominal contracts of 2.3 quarters.

The vector of productivity shocks A_t follows a univariate autoregressive process with persistence 0.975 and standard deviation of innovations 0.0072 as in King and Rebelo (1999). The parameters of the Taylor rule draw on Bilbiie et al. (2008), $\phi_i = 0.8$, $\phi_y = 0$ and $\phi_\pi = 0.3$. I have also considered positive values for the coefficient on output in the Taylor rule, in the range $\phi_y \in (0.01,0.5)$, without remarkable changes in qualitative results. Finally, as fixed costs do not affect the dynamics of the model I set $f^e = 1$ without loss of generality.

3.2. Productivity shocks

This section assesses the performance of the model at replicating the dynamics in US data in the wake of a productivity shock. In comparing the model to properties of the data, all the variables expressed in units of consumption are divided by the relative price $P(j)_t/P_t$ so as to net out the effect of changes in the range of available varieties (for any variable X in units of consumption the empirical-relevant measure will be $X^R_t = P_tX_t/P(j)_t$). As stressed by Ghironi and Melitz (2005), the correction is necessary because statistical measures of CPI inflation are unable to adjust for the availability of new products as in the welfare-based price index. In what follows, all variables are Hodrick–Prescott filtered with a smoothing parameter equal to 1600 as in the data.[7]

I start with an intuitive account of the functioning of the model in the wake of a positive technology shock. Fig. 1 displays the impulse response functions of selected macroeconomic variables to a one standard deviation increase in productivity. For consistence with the second moments below, the shock has a persistence of 0.975. The vertical axis shows percentage deviations from the steady state (a value of, say, 1 denotes a 1 percent deviation) and the horizontal axis shows the number of periods after the shock. The impulse responses are calculated with the baseline calibration.

More favorable business conditions attract new entrants in the economy. Note that the response of entrants is very large (5 times as large as the shock) and concentrated in the initial phase of the transition. Business formation translates into a gradual increase in the number of producers over time, amplifying the effects of the productivity shock and the persistence in the model. The increase in the stock of producers, in turn, pushes on labor demand, raising wages and marginal costs (not shown in Fig. 1). On the other side, it reduces inflation through the variety effect. As a consequence, firms' markups decline. The productivity rise reduces the real interest rate inducing agent to anticipate

[4] I used the following log-linear approximation to Eq. (9) in deriving the expression for markups: $\widehat{P}(j)_t = (1-\alpha\beta(1-\delta))\left(\widehat{W}_t - A_t\right) + \alpha\beta(1-\delta)E_t\left(\widehat{P}(j)_{t+1}\right)$.

[5] In a setup with flexible prices, Atkeson and Burstein (2008) show that firms adjust their markups to local market conditions. Alessandria (2009) points to consumers' search as a reason for variable markups.

[6] Taylor rules have been widely used in the last decades when the objective of price stability has gained a major role in monetary policy-making. Interest rate smoothing reflects a need to reduce the swings in interest rates in an environment characterized by long and variable lags in monetary transmission.

[7] I have also experimented with a Band-pass filter as well as with non-filtered variables. The properties of the model are robust to the filtering method.

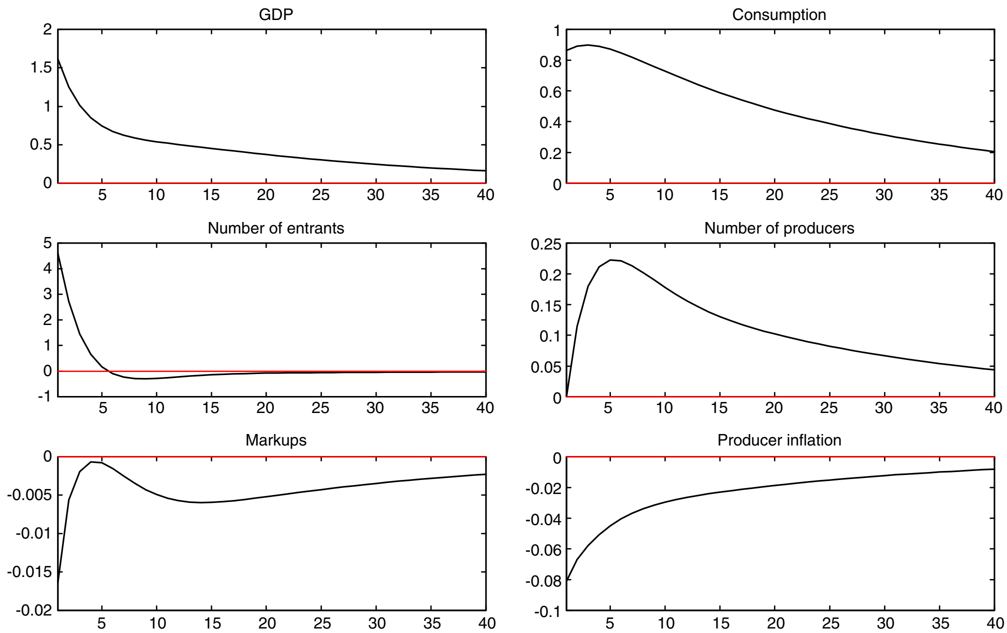

Fig. 1. Impulse responses to a one standard deviation increase in labor productivity.

their consumption plans in the early part of the transition. The boost in consumption together with the hike in investment lead GDP above the steady state level.

Next, I compare the second moments of key macroeconomic variables in the model with US data and with the moments implied by the translog model of Bilbiie et al. (2012), BGM hereafter. The statistics on US data are taken from Colciago and Etro (2010). These authors follow the approach of Rotemberg and Woodford (1999) in calculating the aggregate markup as the inverse of the labor share, consistently with the property of markups in my model. Panels A, B and C in Table 1 report, respectively, the standard deviation (ratio to GDP), the correlation with GDP and the first order auto-correlation of consumption C, hours worked L, investments νN^e, markups μ and profits Π. The columns in Table 1 refer to the baseline model, the model with flexible prices ($\alpha = 0$), the model with fixed entry costs ($\sigma = \gamma$), a calibration with $\sigma = 0.2$ and $\gamma = 0.6$, the BGM Translog and US data. The moments of the BGM model reproduce Table 3 in Bilbiie et al. (2012) augmented with my own simulations for profits and markups in their model. US data are from Table 1 in Colciago and Etro (2010).

The benchmark model matches the moments of output, hours and investments fairly well.[8] The theoretical measures of smoothness, cyclicality and persistence for these variables are close to US data, outperforming the BGM model.[9] In addition, the baseline model captures counter-cyclical markups and pro-cyclical profits as in Rotemberg and Woodford (1999) and in previous models of firm entry (see, for instance, Bilbiie et al. (2012) and Colciago and Etro (2010) in a setup with flexible prices and Faia (2012) in a sticky price context).[10] On a less positive tone, the model understates the smoothness of markups and slightly overstates the smoothness of profits. The performance of the model is almost identical in the specification with $\sigma = 0.2$ and $\gamma = 0.6$. Simulations not reported in Table 1 show that it is robust to changes in the values of σ and γ in the admissible range provided that $\sigma \neq \gamma$. As will be clear soon, changes in the real costs of investments play a key role in the model.

A comparison between the baseline model and the flexible price economy provides interesting insights on the role of sticky prices. The performance of the model deteriorates with flexible prices. It understates the volatilities of hours and investments in the data while overstating the volatility of consumption. The low volatility of hours reflects a small incentive to smooth labor effort over time when real wages are constant. The volatilities of investments and consumption, on the other side, reflect the ability of agents to shift resources at no cost between the production of existing goods (used for consumption) and the creation of new varieties (used for investment). A positive shock to technology, by increasing the marginal value of current consumption above the marginal value of future consumption, moves production efforts towards the current period.[11] With sticky prices, on the contrary, the productivity rise increases the attractiveness of creating new varieties, translating into a higher volatility of investments.

At this point, it is worth analyzing the role of entry costs in more detail. To this end, consider the specification with entry costs fixed in units of consumption, i.e., $\gamma = \sigma$ so that $P^K/P = 1$. The performance of the model deteriorates as in the flexible price economy and essentially for the same reason. With fixed entry costs, a rise in aggregate productivity implies a higher productivity in the sector that produces existing goods relative to the sector that creates new varieties. Agents therefore move resources towards the production of existing goods.

Two consequences may be driven from the analysis above. First, firm entry amplifies the transmission of productivity shocks, bringing the model closer to the data. Second, endogenous movements in entry costs, i.e. changes in the price of investments relative to the production

[8] Entry behaves similarly to investments (Lewis, 2009). In US data, the correlation between output and net entry as measured by Net Business Formation, NBF, is 0.71. The standard deviation of NBF relative to that of output is 2.19.

[9] Bilbiie et al. (2012) show that the introduction of physical capital outperforms their baseline model in terms of the variability of output and hours. The variability of consumption and the correlations pertaining to entry and markups, however, remain almost unaltered.

[10] Given the unobservable nature of the marginal cost, the cyclical properties of markups may vary with the methodological approach. Most studies find counter-cyclical markups (see Rotemberg and Woodford (1999) and Bils (1987) in the US and Martins et al. (1996) in a panel of OECD economies). In contrast with these studies, Nekarda and Ramey (2013) document pro-cyclical or a-cyclical markups in the US.

[11] This is analogous to a two-sector real business cycle model where agents move production effort in the sector with a high technology shock. Clearly, in my setup the shift occurs over time as the allocation of resources between the production of existing goods and the creation of new varieties is given in each period.

Table 1
Second moments of consumption, labor, investment, markups and profits.

	Baseline	Flex prices	$\sigma=\gamma$	$\sigma=0.2$ $\gamma=0.6$	BGM translog	US data
A: standard deviation (ratio to GDP)						
C^R	0.86	1.06	0.82	0.90	0.60	0.75
L	0.69	0.18	0.94	0.58	0.39	1.10
$v^R N^e$	3.02	1.43	0.91	2.98	3.42	2.99
μ	0.39	0	0.83	0.35	0.12	0.60
Π^R	5.42	0.78	0.89	5.30	0.48	4.87
B: correlation with GDP						
C^R	0.88	0.98	0.98	0.87	0.95	0.76
L	0.79	0.90	0.58	0.46	0.95	0.88
$v^R N^e$	0.85	0.63	0.87	0.65	0.96	0.79
μ	−0.37	0	−0.28	−0.43	−0.22	−0.28
Π^R	0.68	0.46	0.55	0.54	0.99	0.67
C: first order auto-correlation						
C^R	0.82	0.86	0.85	0.97	0.78	0.78
L	0.94	0.96	0.96	0.66	0.66	0.90
$v^R N^e$	0.91	0.98	0.97	0.71	0.66	0.87
μ	0.83	1	0.85	0.77	0.94	0.79
Π^R	0.89	0.47	0.95	0.74	0.69	0.76

of existing goods, play a key role in this context. In the model, sticky prices together with differences in the composition of the consumption and investment baskets imply a real rigidity of the entry costs. This in turn exacerbates the volatility of investments in new varieties and helps reducing the gap with the volatility of investments in the data.

These findings constitute a relevant departure from Bilbiie et al. (2008). The theoretical moments in their baseline model or in a specification with translog preferences are very similar with sticky and flexible prices. The reason is the extent to which sticky prices affect entry costs and investment behavior. In the BGM framework, labor entry costs imply a direct link between asset prices and inflation that is absent in my setup. Consider for instance a temporary drop in the nominal interest rate that reduces the real return on bonds and shares. In the BGM model, the fall in the return on shares is brought about by an increase in today's price of equity relative to tomorrow's. This discourages entry of new firms in contrast with what found in the data. The price of equity (the value of the firm) is tied to labor marginal costs by the free entry condition, therefore marginal costs rise, markups fall and, through the Phillips curve, inflation boosts. Sticky prices will have only a small effect on entry whenever inflation is moderate, as is the case with Taylor rules.

In my setup, on the contrary, the price of equity is not directly related to labor marginal costs. Sticky prices imply a rigidity in the real costs of entry that affects the allocation of resources between the creation of new varieties and the production of existing goods. This mechanism is obscured when entry costs are fixed in units of consumption ($\gamma=\sigma$) or when prices are flexible (so that P and P_K move at the same pace).

3.2.1. Monetary policy shocks

In order to provide further insight on the mechanism of monetary transmission in the model, this section describes the effects of a temporary monetary expansion. Fig. 2 displays the impulse response functions of selected variables to a one standard deviation fall in the nominal interest rate. The impulse responses are calculated under the standard calibration (solid line) and in a specification with $\sigma=0.2$ and $\gamma=0.6$ (dashed line).

The monetary expansion boosts aggregate demand so long as prices are sticky, leading to a spike in consumption and a burst in inflation. Over time, as prices slowly return to their natural levels, consumption converges to the steady state. The rise in consumption reflects a drop in the real interest rate, i.e. a drop in the return on bonds. Arbitrage in financial markets requires the real return on shares to fall as well. The decrease in the real return on shares is brought about by a fall in the return ($v_{t+1}+d_{t+1}$) relative to today's price of equity v_t. The price of equity is tied to the cost of acquiring investments goods by the free entry condition in the model (1). The monetary expansion, by producing inflation, reduces entry costs in real terms and favors investments in new firms.

The impulse responses in Fig. 2 are almost identical in the baseline and the alternative specification for entry costs. As already discussed, the dynamics of the model is robust to changes in the values of the parameters σ and γ. I have also experimented with a positive value for output in the Taylor rule (not shown in Fig. 2) in the range (0.01, 0.5). Simulations show that a positive weight of the output target does not

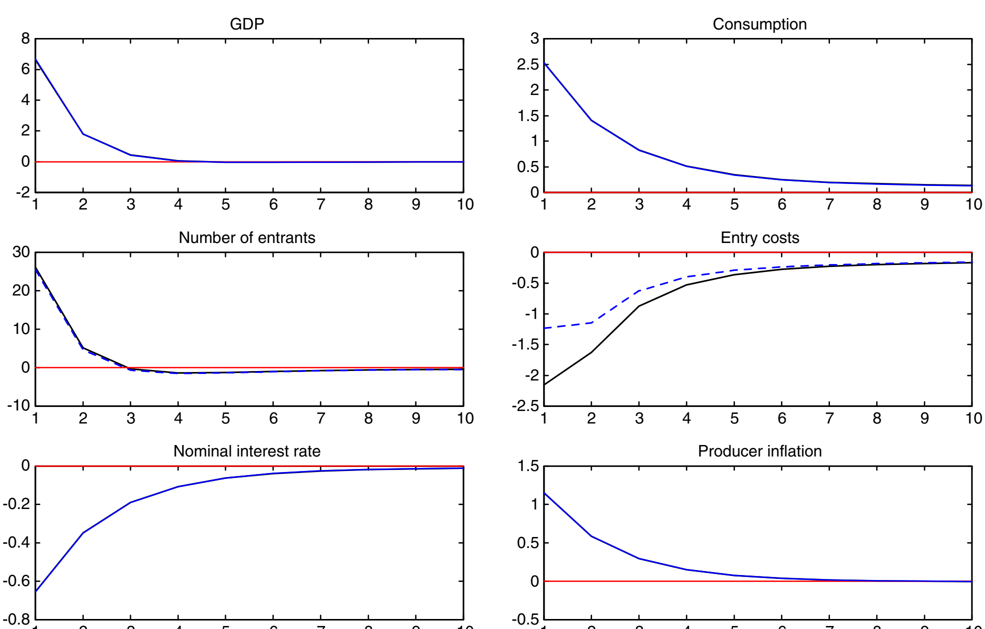

Fig. 2. Impulse responses to a one percent fall in the nominal interest rate in the standard calibration (solid line) and with $\sigma=0{:}2$ and $\gamma=0{:}6$ (dashed line).

alter the qualitative features of the monetary transmission in the model. It leads to more persistence in the impulse responses of all the variables considered and to a larger response of inflation. When the weight of the output target is larger than that of the inflation target (0.3), consumption drops on impact.

4. Conclusions

This paper proposes a monetary model with firm entry as a means for alleviating the difficulties of standard real business cycle models in reproducing the smoothness and persistence of macroeconomic data together with the volatility of profits and markups.

Simulations show that the baseline model matches the second moments of consumption, output and hours in US data fairly well while at the same time capturing the cyclicality of profits and markups. In addition, it implies a positive effect of a monetary expansion on business formation as found in the data. A different composition of the investment and the consumption baskets is essential for these results.

The ability to reduce the gap between the theoretical economy and the data is important especially for the sake of policy evaluation. The findings in the paper suggest two implications. First, sticky price models with firm entry may perform better than was previously thought. Second, varying the composition of entry costs alters the transmission of business cycle fluctuations. Rethinking the way entry costs and nominal rigidity are jointly modeled remains high on the research agenda.

Appendix A

A.1. Steady state

The model is solved in log-deviations from a symmetric steady state equilibrium with zero inflation. Assuming $A = 1$, the steady state of the economy is such that:

$$N = \left(\frac{\theta(1-\beta(1-\delta))-\delta\beta}{\beta(1-\delta)}\right)^{\frac{\theta-1}{2-\theta}}.$$

Other variables are given by:

$$i = \frac{1-\beta}{\beta},\quad v = f^e P_Z^{\gamma-\sigma},\quad d = \frac{(1-\beta(1-\delta))}{\beta(1-\delta)},\quad \mu = \frac{\theta}{(\theta-1)},$$

$$\frac{P(j)}{P_Z} = N^{\frac{1}{\theta-1}}\Pi = dN$$

$$C = \theta N\left[\frac{1-\beta(1-\delta)}{\beta(1-\delta)} - \frac{\delta}{\theta(1-\delta)}\right], L = \theta dN^{\frac{2-\theta}{1-\theta}}, Y = \theta dN,$$

$$N^e = \frac{\delta}{(1-\delta)}N \quad P_Z = \mu N^{\frac{1}{1-\theta}} L^{\frac{1}{\varphi}} C^{\rho}.$$

A.2. Loglinear model

Loglinearized conditions for households are:

$$E_t\widehat{C}_{t+1} = \widehat{C}_t + \frac{1}{\rho}\left(\widehat{i}_t - E_t\pi_{t+1}\right)$$
$$E_t\widehat{C}_{t+1} = \widehat{C}_t + \widehat{\nu}_t + \frac{1}{\rho}E_t\left(\frac{i+\delta}{1+i}\widehat{d}_{t+1} + \frac{1-\delta}{1+i}\widehat{\nu}_{t+1}\right)$$
$$L_t = -\rho\varphi\widehat{C}_t + \varphi\widehat{\varpi}_t.$$

Loglinearized conditions for firms are:

$$\widehat{N}_t = (1-\delta)\widehat{N}_{t-1} + \delta\widehat{N^e}_{t-1}$$
$$\widehat{\mu}_t = \alpha\beta(1-\delta)\left(\widehat{P}_{Z,t+1} - \widehat{\varpi}_t + A_t\right)$$
$$\pi_t^Z = \zeta mc_t + \beta(1-\delta)E_t\pi_{t+1}^Z$$

where mc denotes an index of current marginal costs defined by the term in squared brackets in Eq. (14) in the main text.

Other log-linear equilibrium conditions are:

$$\widehat{P}_{Z,t} = \frac{\alpha}{1-\alpha}\pi_t^Z + \frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_t - \frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{t-1}$$
$$\widehat{P}_{C,t} = \frac{\alpha+\gamma(1-\alpha)}{1-\alpha}\pi_t^Z + \frac{1}{(1-\alpha)(\theta-1)}\widehat{N}_t - \frac{\alpha}{(1-\alpha)(\theta-1)}\widehat{N}_{t-1}$$
$$\pi_t = (1-\gamma)\pi_t^Z$$
$$\widehat{Y}_t = \widehat{A}_t + \widehat{L}_t + \widehat{P}_{C,t}$$
$$\widehat{N}_t^e = \frac{\theta(1-\beta(1-\delta))}{\beta\delta}\widehat{Y}_t + \left(1 - \frac{\theta(1-\beta(1-\delta))}{\beta\delta}\right)\widehat{C}_t - \widehat{\nu}_t$$
$$\widehat{\varpi}_t = \widehat{A}_t - \widehat{\mu}_t + \widehat{P}_{C,t}$$
$$\widehat{\Pi}_t = \frac{\widehat{d}_t}{N} + \frac{\widehat{N}_t}{d}$$
$$\widehat{\nu}_t = (\gamma-\sigma)\pi_t^Z$$

The model is closed with the interest rate rule in the text.

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.econmod.2013.07.039.

References

Alessandria, G., 2009. Consumer search, price dispersion and international relative price fluctuations. International Economic Review 50 (3), 803–829.
Atkeson, A., Burstein, A., 2008. Pricing to market, trade costs and international relative prices. American Economic Review 98 (5), 1998–2031.
Auray, S., Eyquem, A., 2011. Do changes in product varieties matter for fluctuations and monetary policy in open economies? International Finance 14 (3), 507–539.
Bergin, P., Corsetti, G., 2008. The extensive margin and monetary policy. Journal of Monetary Economics 55 (7), 1222–1237.
Bilbiie, F., Ghironi, F., Mélitz, M., 2008. Monetary policy and business cycles with endogenous entry and product variety. In: Acemoglu, D., Rogoff, K., Woodford, M. (Eds.), NBER Macroeconomic Annual 2007. MIT Press, Cambridge (MA), pp. 299–353.
Bilbiie, F., Ghironi, F., Mélitz, M., 2012. Endogenous entry, product variety, and business cycles. Journal of Political Economics 120 (2), 304–345.
Bils, M., 1987. The cyclical behavior of marginal cost and price. American Economic Review 77 (5), 838–855.
Broda, C., Weinstein, D., 2010. Product creation and destruction: evidence and price implications. American Economic Review 100 (3), 691–723.
Calvo, G., 1983. Staggered prices in a utility-maximizing framework. Journal of Monetary Economics 12, 983–998.
Campbell, J., 1998. Entry, exit, embodied technology and business cycles. Review of Economic Dynamics 1, 371–408.
Cavallari, L., 2007. A macroeconomic model of entry with exporters and multinationals. The B.E. Journal of Macroeconomics 7, 1 ((Contributions), Article 32).
Cavallari, L., 2010. Exports and FDI in an endogenous-entry model with nominal and real uncertainty. Journal of Macroeconomics 32, 300–313.
Cavallari, L., 2012. Modelling entry costs: does it matter for business cycle transmission? CREI Working Paper No.7/2012.
Cavallari, L., 2013. Firms' entry, monetary policy and the international business cycle. Journal of International Economics. http://dx.doi.org/10.1016/j.jinteco.2013.07.002 (in press).
Chatterjee, S., Cooper, R., 1993. Entry and exit, product variety and the business cycle. NBER Working Paper 4562.
Colciago, A., Etro, F., 2010. Endogenous market structures and the business cycle. The Economic Journal 120, 1201–1233.
Dunne, T., Roberts, M.J., Samelson, L., 1988. Patterns of firm entry and exit in U.S. manufacturing industries. The RAND Journal of Economics 19 (4), 495–515.
Faia, E., 2012. Oligopolistic competition and optimal monetary policy. Journal of Economic Dynamics and Control 36 (11), 1760–1774.

Galì, J., Gertler, M., Lopez-Salido, D., 2001. European inflation dynamics. European Economic Review 45 (7), 1237–1270.
Ghironi, F., Melitz, M., 2005. International trade and macroeconomic dynamics with heterogeneous firms. Quarterly Journal of Economics 20, 865–915.
Jaimovich, N., Floetotto, M., 2008. Firms dynamics, markups variations and the business cycle. Journal of Monetary Economics 55 (7), 1238–1252.
King, R., Rebelo, S., 1999. Resuscitating real business cycles. In: Taylor, J.B., Woodford, M. (Eds.), The Handbook of Macroeconomics, vol. 1. Elsevier, Amsterdam, pp. 927–1007.
Lewis, V., 2009. Business cycle evidence on firm entry. Macroeconomic Dynamics 13, 605–624.
Lewis, V., Poilly, C., 2012. Firm entry, markups and the monetary transmission mechanism. Journal of Monetary Economics 59 (7), 670–685.
Martins, J., Scarpetta, S., Pilat, D., 1996. Markups ratios in manufacturing industries: estimates for 14 OECD countries. OECD Economic Department Working Papers no. 162.
Nekarda, C., Ramey, V., 2013. The cyclical behavior of the price–cost markup. NBER Working Paper No.19099.
Rotemberg, J., Woodford, M., 1999. The cyclical behavior of prices and costs. In: Taylor, J.B., Woodford, M. (Eds.), The Handbook of Macroeconomics, volume 1. Elsevier, Amsterdam, pp. 1051–1135.
Uusküla, L., 2008. Limited participation or sticky prices? New evidence on firm entry and failures. Bank of Estonia Working Papers No. 07.