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A NOTE ON MARKPUS AND ENTRY

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A note on markups and entry

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Abstract

This note studies the synchronization of firm entry and markups in a dynamic stochastic general equilibrium model with nominal frictions. Simulations show that the model matches the comovements of markups and entry observed in the data while at the same time reproducing empirically plausible moments for macroeconomic variables. I stress that sticky prices are essential for these results.

Keywords: endogenous entry, firm dynamics, monopolistic competition, market power, markups

JEL codes: E31; E32; E52

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1 Introduction

It is a well-established fact that firm entry behaves in a pro-cyclical way while markups move counter-cyclically.¹ Motivated by this evidence, a novel line of research has stressed the role of firm entry and creation of new varieties in propagating business cycle fluctuations. Prominent contributions in this area, including Jaimovich and Floetotto (2008), Colciago and Etro (2010) and Bilbiie et al. (2012), argue that accounting for firm entry ameliorates the performance of theoretical economies in replicating the dynamics observed in the data compared to standard (fixed-variety) business cycle models. Yet, a lot remains to be done. Endogenous entry models are still relatively unsuccessful in capturing the high volatility of markups observed in the data. Besides, they fail to capture the persistence and synchronization of macroeconomic variables simultaneously. This note makes a first step in this direction by showing that a sticky price model of endogenous entry can match these stylized facts better than was previously thought. As will become apparent soon, an appropriate specification of entry costs is essential for this purpose.

Early studies have stressed the business cycle implications of entry in a setup characterized by nominal rigidity including, among others, Bilbiie et al. (2007), Bergin and Corsetti (2008), Lewis (2009), Lewis and Poilly (2012), Cavallari (2007, 2010) and Uusküla (2010). With the exception of Bilbiie et al. (2007) that will be discussed further in the paper, these contributions do not explicitly provide a quantitative assessment of the performance of the model as is done in this paper. The ability to reproduce empirically plausible moments is important especially when using the model for policy evaluation.

As is common practice in endogenous entry models, 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 nominal rigidity à la Calvo (1983). Financial markets are complete. Following Bergin and Corsetti (2008), I assume that starting-up 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 vary with the price of investment goods. This assumption represents the main departure from a setup à la Bilbiie et al. (2007, 2012) where entry costs are specified in units of labor. I will argue below that it plays an important role in the model by influencing the extent to which entry costs are subject to nominal rigidity.²

¹In the US, the cyclical properties of entry have been documented by Chatterjee and Cooper (1993), Dunne et al. (1998) and Campbell (1997). More recently, see also Jaymovich and Floetotto (2008), Bilbiie et al. (2012) and Lewis (2009). The counter-cyclical behavior of markups is documented, among many others, by Rotemberg and Woodford (1999) and Bils (1987).

²How to model entry costs is an open question well beyond the scope of this paper. Cavallari (2012b) shows that
Simulations show that my baseline model matches the dynamics observed in the data fairly well. Remarkably, it overcomes the difficulties common to standard business cycle and endogenous entry models in capturing the persistence, smoothness and cyclicality of macroeconomic variables. Besides, it matches the synchronization of entry and markups. I stress that sticky prices are essential for these results.

The remainder of the paper is organized as follows. Section 1 presents the model and discusses the solution strategy. Section 2 illustrates the performance of the model in reproducing the dynamics in the data. Section 3 contains conclusive remarks.

2 The economy

I consider a closed economy version of the model in Cavallari (2012). The economy is populated by a continuum of agents of unit mass indexed by \( i \). Firms are monopolistic competitors, each producing a different variety \( j \in (0, N) \), where \( N \) is the number of firms.

A typical agent supplies \( L_t \) hours of work each period for the nominal wage \( W_t \) and maximizes inter-temporal utility \( E \left[ \sum_{s=t}^{\infty} \beta^{s-t} U(C_s, L_s) \right] \), where \( C \) is consumption and \( \beta \) the subjective discount factor. The period utility is the additive-separable function \( U_t = \left( \int_0^N C(j)^{\varphi+1} \, dj \right)^{(\varphi+1)} \) with elasticity \( \theta > 1 \) and the corresponding price index is \( P = \left( \int_0^N P(j)^{1-\theta} \, dj \right)^{(1-\theta)} \).

Producers face an identical linear technology in the labor input \( y_t(j) = Z_t L_t(j) \), where \( Z \) is an aggregate shock to labor productivity. In each period, in addition to incumbent firms there is a finite mass of entrants, \( N_e \). As in Ghironi and Mélibot (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 units of investment goods. The creation of a new firm requires purchasing \( f_e \) units of a composite basket of investment goods \( K = \left[ \int_0^N K(j)^{\varphi+1} \, dj \right]^{(\sigma+1)} \) at a price \( P^K = \left[ \int_0^N P(j)^{1-\sigma} \, dj \right]^{(1-\sigma)} \). Without loss of generality, I follow this contribution and assume that capital required in the setup of new firms depreciates completely after one period. Note that the composition of the investment basket may differ from that of the consumption basket, namely \( \theta \neq \sigma \). Clearly, when \( \theta = \sigma \) entry costs are

\[ \text{the performance of endogenous entry models may not be robust to varying the composition of entry costs.} \]

\[ \text{Alternatively, entry costs can be modelled in labor units as, among others, Bilbié et al. (2012), Auray et al. (2012) and Cavallari (2007).} \]
constant in real terms (i.e. in units of consumption), a case examined by Auray and Eyquem (2011) and Bilbiie et al. (2007). As will be clear soon, the composition of investment goods has relevant consequences for the dynamics of the model.

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

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

The free entry condition holds as 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:

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

Finally, I assume complete financial markets. Agents can invest their wealth in a set of nominal state-contingent bonds, $B$, that span all the states of nature $\Omega$. In addition to bonds, they hold a share $s$ of a well-diversified portfolio of firms. The budget constraint of a typical agent $i$ is given by:

$$\sum_{\Omega} q_t (\Omega_{t+1}) \frac{B_{it}}{P_t} + s_t (N_t + N_t^e) \nu_t \leq \frac{B_{it-1}}{P_t} + s_{t-1} (\nu_t + d_t) + \frac{W_t L_{it}}{P_t} - C_{it}$$ (3)

where $q$ is the bond price.

### 2.1 Equilibrium conditions

#### 2.1.1 Consumers

Consumers’ first order conditions are given by:

$$\frac{q_t \left( s_{t+1} \right)}{P_t} \left( C_t \right)^{-\rho} = \beta E_t \left( \frac{C_{t+1}}{P_{t+1}} \right)^{-\rho}$$ (4)

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

$$C_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\theta} C_t$$ (6)
\[
\frac{W_t}{P_t} = \chi (L_t)^{\frac{1}{2}} (C_t)^{\alpha} \tag{7}
\]

### 2.1.2 Firms

Each producer sets the price for its own variety facing a downward-sloping market demand \( y_t(j) = (P_t(j) / P_t)^{-\theta} (C_t + \nu_t N_t^c) \). 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 \( \alpha \) of firms whose prices are pre-determined.\(^4\)

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:

\[
P_t(j) = \frac{\theta}{\theta - 1} \frac{E_t \sum_{k=0}^{\infty} \left( \alpha \beta (1 - \delta) \right)^k \frac{W_{t+k} y_{t+k}(j)}{Z_{t+k} P_{t+k} C_{t+k}^{\alpha}}}{E_t \sum_{k=0}^{\infty} \left( \alpha \beta (1 - \delta) \right)^k \frac{y_{t+k}(j)}{P_{t+k} C_{t+k}^{\alpha}}} \tag{8}
\]

The above expression can be re-arranged in a more familiar form as:

\[
P_t(j) = \frac{\theta}{\theta - 1} \left( 1 - \alpha \beta (1 - \delta) \right) \frac{W_t}{Z_t} + \alpha \beta (1 - \delta) E_t P_{t+1}(j) \tag{9}
\]

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

Aggregating (9) across firms and using the definition of \( P \) yields the Calvo state equation corrected for firm entry:

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

Note that an increase in the number of producers over time reduces consumer prices and the more so the higher the elasticity \( \theta \).\(^5\) 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. An analogous state equation holds for the price of investment goods \( P^K \).

---

\(^4\)The simplifying 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 my setup with Calvo pricing.

\(^5\)This point was originally made by Méńitz (2003).
2.1.3 Aggregate constraints

Define real GDP as $Y \equiv \int_0^N P(j) y(j) dj$. Goods market clearing requires output to equalize aggregate demand, $Y_t = C_t + N_t \nu_t$. Labor market clearing implies:

$$L_t \equiv \int_0^1 L_t d\bar{i} \geq \int_0^N y_t(j) Z_t d j$$

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-linearization

The model has no closed-form solution. It is log-linearized around a symmetric steady state with zero inflation where stochastic shocks are muted at all dates, $Z_t = 1$ (the steady state and the log-linear model are in the Appendix).

The Euler equation for bond holdings is given by:

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

where a hat over a variable denotes the logdeviation from the steady state, $\pi_{t+1} = \ln P_{t+1}/P_t$ is inflation and $E$ is the expectation operator. In (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:

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

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

Labor supply is given by:

$$\bar{L}_t = -\rho \varphi \bar{C}_t + \varphi \left( \bar{W}_t - \bar{P}_t \right)$$

Using the definition of GDP and the labor market equilibrium (11), it is convenient to derive an aggregate production function $\bar{Y}_t = \bar{L}_t + \bar{Z}_t + \bar{P}_{t,t}$ where $\bar{P}_{t,t} \equiv \ln P_{t,(j)}/P_t$ is the real price of each variety.

Consider now the optimal price (8). Using market demand and (7), re-arranging and linearizing gives:
where \( \hat{P}_{t,t+k} = \ln P_t(j)/P_{t+k} \). Note that by definition \( \hat{P}_{t,t+k} = \hat{P}_t - \sum_{s=1}^{k} \pi_{t+s} \), namely changes in real prices are given by the so-called variety effect, the first addend, less inflation. Using (10), the variety effect is:

\[
\hat{P}_{t,t} = \frac{\alpha}{1 - \alpha} \pi_t + \frac{1}{(1 - \alpha)(\theta - 1)} \hat{N}_t - \frac{\alpha}{(1 - \alpha)(\theta - 1)} \hat{N}_{t-1}
\]

With \( \alpha = 0 \), an increase in the number of producers raises the real price of each variety and the more so the lower the elasticity of substitution \( \theta \). Note that sticky prices can alter the dynamics of variety effects, increasing their persistence through inflation as well as through current and lagged changes in the stock of producers. Combining the two equations above and re-arranging gives the new-Keynesian Phillips curve corrected for firm entry:

\[
\pi_t = \zeta \left[ \left( \rho + \frac{1}{\varphi} \right) \hat{C}_t - \frac{1}{(1 - \alpha)(\theta - 1)} \hat{N}_t - \frac{1 + \varphi}{\varphi} \hat{Z}_t + \frac{\alpha}{(1 - \alpha)(\theta - 1)} \hat{N}_{t-1} \right]
\]

where \( \zeta = \frac{(1 - \alpha)(1 - \delta)(1 - \alpha)}{\alpha(\varphi + \theta)} \). An analogous expression holds for inflation in the investment sector, \( \pi^K_t = \ln P^K_t/P^K_{t-1} \), where \( \sigma \) replaces \( \theta \).

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

\[
\hat{N}_t^e = \frac{\theta (1 - \beta (1 - \delta))}{\beta \delta} \hat{Y}_t + \left( 1 - \frac{\theta (1 - \beta (1 - \delta))}{\beta \delta} \right) \hat{C}_t
\]

Note that there is a trade-off between investments in new varieties and consumption of existing goods (the coefficient on \( C \) is negative).

The law of motion of firms is:

\[
\hat{N}_t = (1 - \delta) \hat{N}_{t-1} + \delta \hat{N}_{t-1}^e
\]

Optimal pricing (8) together with the definition of aggregate markup \( \mu \equiv \int_0^N P(j)/W^Z dj \) yield a useful expression for markups:

\[
\hat{\mu}_t = \alpha \beta (1 - \delta) \left( \hat{P}_t - \hat{P}_{t,t-1} + \pi_t \right)
\]
Markups rise above the steady state level so long as variety prices grow more rapidly than inflation. As will be apparent soon, markup movements play a key role in the model. To begin with, they affect the expected dividends from investing in a new firm, influencing entry behavior through the free entry condition (1). A change in the stock of producers over time, in turn, modifies the allocation of resources between production of existing goods and creation of new varieties. Last but not least, markups coincide with the inverse of the labor share, $\frac{\bar{Y}P}{\bar{W}L}$. One can therefore substitute away the real wage in (7) and together with the GDP definition obtain an expression for aggregate labor. In log-linear terms, this gives:

$$\hat{L}_t = -\rho\varrho\hat{C}_t + \varphi\left(\hat{Z}_t - \hat{\mu}_t + \hat{P}_{t,t}\right)$$  \hspace{1cm} (18)

Finally, monetary policy follows a Taylor rule $\hat{i}_t = \phi_\pi\hat{\pi}_t + \phi_y\hat{y}_t$ with interest rate smoothing. Taylor rules have been widely used especially 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 swings in interest rates in an environment characterized by long and variable lags in monetary transmission. For ease of comparisons with flexible price models, I also consider a Wicksellian regime in which the nominal interest rate is set so as to reproduce a flexible price equilibrium with zero inflation. The Wicksellian interest rate mimics changes in the natural (real) interest rate $\tilde{r}_t = \rho\left(E_t\hat{C}_{t+1} - \hat{C}_t\right)$. As is well-known, the Wicksellian policy can be implemented recurring to a credible threat to deviate from a zero inflation target, i.e. $i_t = \tilde{i}_t + \theta\pi_t$ with $\theta > 1$.

### 3 Simulations and conclusions

The model is simulated using first-order perturbation methods. In line with real business cycle models, I consider productivity shocks as the main source of business cycle volatility, abstracting from interest rate innovations.

#### 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 suggested by Bilbiie et al. (2007). The rate of firm disappearance is consistent with a 10 percent rate of job destruction per year as found in the US.

The elasticity of substitution among consumption goods is $\theta = 7.88$ as in Rotemberg and Woodford (1999), yielding an average markup of approximately 18 percent as in US data. The elasticity
of substitution among investment goods is set at $\sigma = 10.83$ to capture the elasticity found in the US investment sector compared to that in the consumption sector.$^6$ Studies based on micro data usually find a much lower $\theta$, roughly around 4, while there is no comparable evidence, to the best of my knowledge, for the investments sector. I have experimented with $\theta = 4$ and $\sigma = 5.5$ so as to maintain the relative size of these elasticities unchanged, obtaining qualitatively identical results (available upon request). Other preference parameters are $\varphi = 2.13$ as in Rotemberg and Woodford (1999) and $\rho = 1$ as in Bilbiie et al. (2007).

Gali et al. (2001) estimate a value for the degree of nominal rigidity between 0.407 and 0.66 in the US. I take the middle point from this interval and set $\alpha = 0.49$, implying an average duration of nominal contracts of 2.3 quarters.

The vector of productivity shocks $Z_t$ 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. (2007), $\phi_i = 0.8$, $\phi_y = 0$ and $\phi_{\pi} = 0.3$. I have also considered positive values for the coefficient on output in the Taylor rule, in the range $\phi_y \in (0.4, 1.5)$, 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 Moments

To evaluate the properties of the model, this section computes the second moments of key macroeconomic variables and compares them to those of the data and those implied by the baseline model in Bilbiie et al. (2012), hereafter BGM. This latter provides a natural benchmark as a workhorse model in business cycle studies with firm entry.

In comparing the model to properties of the data, theoretical variables 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 $X$ the corrected measure will be $X_t^R = P_tX_t/P(j)_t$). As stressed by Ghironi and Mélitz (2005), the correction is necessary because statistical measures of CPI inflation are unable to adjust for availability of new products as in the welfare-based price index. In the model, investments are measured by the real value of household investments in new firms ($\nu^R N^e$).

Table 1 reports statistics of the model’s artificial time series together with statistics in US data. As with the data, statistics refer to Hodrey-Prescott filtered variables with smoothing parameter of 1600. The first column displays the moments implied by the baseline model, the second column

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$^6$Using BEA input-output tables, Floetotto et al. (2009) estimate the elasticities in US investment and consumption sectors. They find that investment goods are more substitutable than consumption goods by a factor of roughly 0.72 percent.
refers to the flexible price economy, the third column reports the moments generated by the BGM model and the last column reports US data from Table 1 in Rotemberg and Woodford (1999).

Table 1:

<table>
<thead>
<tr>
<th></th>
<th>Benchmark model</th>
<th>Flex price model</th>
<th>BGM model</th>
<th>US data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma_X/\sigma_Y$</td>
<td>$\sigma_{XY}$</td>
<td>$\rho_X$</td>
<td>$\sigma_X/\sigma_Y$</td>
</tr>
<tr>
<td>$C^R$</td>
<td>0.87</td>
<td>0.90</td>
<td>0.93</td>
<td>1.16</td>
</tr>
<tr>
<td>$H^R$</td>
<td>0.89</td>
<td>0.89</td>
<td>0.86</td>
<td>0.06</td>
</tr>
<tr>
<td>$\nu^R N^e$</td>
<td>2.95</td>
<td>0.64</td>
<td>0.78</td>
<td>0.39</td>
</tr>
<tr>
<td>$\mu^R$</td>
<td>0.49</td>
<td>-0.57</td>
<td>0.92</td>
<td>0</td>
</tr>
</tbody>
</table>

$\sigma_X$ is the standard deviation of variable $X$, $\sigma_{XY}$ is the correlation of variable $X$ with output, and $\rho_X$ is the auto-correlation of variable $X$.

The benchmark model matches the dynamics observed in the data fairly well.\(^7\) It replicates the volatility, persistence and synchronization of consumption, hours, investments and markups, overcoming the well-known difficulties of business cycle models to reproduce these facts simultaneously. In this respect, it fares better than the BGM model. Markups, however, are far more counter-cyclical than in the data.

To get an intuitive account of the functioning of my model, consider a positive technology shock. More favorable business conditions attract new entrants in the economy, translating into a gradual increase in the number of producers over time (see equation (16)). This in turn pushes on labor demand, raising wages and marginal costs. As sticky prices will adjust only gradually, firms’ markups need to decline (see equation (17)). The drop in markups is more accentuated the slower the adjustment of prices (large $\alpha$) and the higher the demand elasticity (large $\theta$).

Sticky prices are in principle not essential for replicating counter-cyclical markups. Early studies, such as Jaimovich and Floetotto (2008), Colciago and Etro (2010) and Bilbiie et al. (2012) have shown this stylized fact in models with endogenous entry without relying on the sticky price assumption.\(^8\) In these contributions, however, markup volatility is typically underestimated. Colciago and Etro (2010) stress the need for further work on the microfoundations of market structure in order to match the volatility of markups better. The findings in Table 1 suggest that nominal frictions may play an important role in this regard.

Comparing theoretical moments in the baseline and the flexible price specification provides interesting insights on the role of nominal rigidity. The performance of the model deteriorates with

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\(^7\)Entry behaves similarly to investments (Lewis, 1999). 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.

\(^8\)When the number of firms is exogenously given, sticky price models as Kimball (1995) and Galì et al. (2007) can capture counter-cyclical markups. Clearly, they fail to match the synchronization with entry observed in the data.
flexible prices, displaying too low volatilities of hours and investments compared to the data while
the volatility of consumption is excessive. A low volatility of hours worked arises as a consequence
of smoothing labor effort over time. Agents have a strong incentive to stabilize their labor supply
so long as real wages are stable over the cycle (as is apparent in equation (9) with \( \alpha = 0 \)).

The volatility of investments and consumption reflects the ability of agents to use inputs where
they are most productive. With flexible prices, they are able to shift resources costlessly between pro-
duction of existing goods (used for consumption) and creation of new varieties (used for investment).
A positive shock to technology therefore induces agents to move production efforts towards existing
goods. 9 Sticky prices, by affecting the real costs of acquiring investment goods, may alter this in-
centive. I have checked the robustness of the model to varying the composition of investment goods
by experimenting with entry costs fixed in units of consumption (i.e., \( \theta = \sigma \)) so that \( P^K/P = 1 \).
The performance of the model deteriorates displaying excessive volatility for consumption (equal
to 0.89) and too low volatilities for hours and investments (equal to 0.28 and 0.22, respectively).
The reason is similar to that in the flexible price economy. With fixed entry costs, a rise in aggre-
gate productivity implies a higher productivity in the sector that produces existing goods. Agents
have therefore a strong incentive to move resources towards current production. Differences in the
composition of the consumption and investment baskets are therefore essential for mitigating this
incentive and reproducing the dynamics of investments observed in the data.

In contrast with the findings above, Bilbiie et al. (2007) show that the moments implied by their
model are very similar with sticky and flexible prices. The reason is a different account of the extent
to which nominal frictions 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 that discourages entry of new firms. 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
affect entry only marginally whenever simple monetary rules manage to control inflation, as is the
case with Taylor rules. This need not be the case in a setup like the one in this paper where the
price of equity is not directly related to labor marginal costs.

The importance of sticky prices for firm entry is consistent with a recent evidence stressing a

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9 This is analogous to what implied by two-sector real business cycle models, where agents move production effort
in the sector with a high technology shock. Clearly, in my setup the shift occurs over time. The allocation of resources
between production of existing goods and creation of new varieties is in fact predetermined in each period.
negative correlation between investments in new firms and monetary policy innovations (see Bergin and Corsetti (2008) and Lewis and Poilly (2012) and Uusküla (2010)). These studies show that modeling firm entry in a setup with sticky prices allows to reproduce impulse responses in line with the evidence above. However, they do not provide a quantitative assessment of the performance of sticky price models as is done in this note.

4 Conclusions

This note studied the synchronization of firm entry and markups in a dynamic stochastic general equilibrium model with nominal frictions. Simulations show that the model matches the comovement of markups and entry observed in the data while at the same time reproducing empirically plausible moments for key macroeconomic variables. I stress that sticky prices are essential for these results.

The ability to match stylized business cycle facts is important especially when using the model for policy evaluation. My findings suggest two implications in this regard. First, sticky price models with endogenous entry may perform better than was previously thought. Second, the extent to which entry costs are subject to nominal rigidity may alter the transmission of business cycle fluctuations. Rethinking the way entry costs and nominal rigidity are jointly modeled remains high on the research agenda.

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## 5 Appendix

### 5.1 Steady state

The model is solved in log-deviation from a symmetric steady state equilibrium without inflation. Assuming $Z = 1$, the steady state of the economy is such that:

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

Other variables are given by:
\[ i = \frac{1 - \beta}{\beta}, \quad v = 1, \quad d = \frac{(1 - \beta (1 - \delta))}{\beta (1 - \delta)}, \quad \mu = \frac{\theta}{(\theta - 1)}, \quad \frac{P(j)}{P} = N^{\frac{1}{\theta - 1}} \]
\[ C = \theta N \left[ \frac{1 - \beta (1 - \delta)}{\beta (1 - \delta)} - \frac{\delta}{\theta (1 - \delta)} \right], \quad L = \theta d N^{\frac{2 - \theta}{\theta}}, \quad Y = \theta d N, \quad N^e = \frac{\delta}{(1 - \delta)} N \]

### 5.2 Loglinear model

Loglinearized conditions for households are:

\[ E_t \tilde{C}_{t+1} = \tilde{C}_t + \frac{1}{\bar{\rho}} \left( \tilde{e}_t - E_t \pi_{t+1} \right) \]
\[ E_t \tilde{C}_{t+1} = \tilde{C}_t + \tilde{\nu}_t + \frac{1}{\bar{\rho}} E_t \left( \frac{i + \delta}{1 + i} d_{t+1} + \frac{1 - \delta}{1 + i} \tilde{\nu}_{t+1} \right) \]
\[ \tilde{L}_t = -\rho \varphi \tilde{C}_t + \varphi (\tilde{W}_t - \tilde{P}_t) \]

Loglinearized conditions for firms are:

\[ \tilde{N}_t = (1 - \delta) \tilde{N}_{t-1} + \delta \tilde{N}^e_{t-1} \]
\[ \tilde{\mu}_t = \alpha \beta (1 - \delta) \left( \tilde{P}_{t,t+1} - \tilde{P}_{t,t} + E_t \pi_{t+1} \right) \]
\[ \pi_t = \zeta MC_t + \beta (1 - \delta) E_t \pi_{t+1} \]
\[ \pi^K_t = \xi MC_t + \beta (1 - \delta) E_t \pi^K_{t+1} \]

where \( MC \) denotes an index of current marginal costs defined by the term in squared brackets in equation (14) in the main text and \( \xi = \frac{(1 - \alpha \beta (1 - \delta))(1 - \alpha)}{\alpha (\varphi + \sigma)} \).

Other log-linear equilibrium conditions are:

\[ \tilde{P}_{t,t} = \frac{\alpha}{1 - \alpha} \bar{\pi}_t + \frac{1}{(1 - \alpha)(\theta - 1)} \tilde{N}_t - \frac{\alpha}{(1 - \alpha)(\theta - 1)} \tilde{N}_{t-1} \]
\[ \tilde{P}^K_{t,t} = \frac{\alpha}{1 - \alpha} \bar{\pi}^K_t + \frac{1}{(1 - \alpha)(\sigma - 1)} \tilde{N}_t - \frac{\alpha}{(1 - \alpha)(\sigma - 1)} \tilde{N}_{t-1} \]
\[ \tilde{Y}_t = \tilde{Z}_t + \tilde{H}_t + \tilde{P}_t \]
\[ \tilde{N}^e_t = \frac{\theta (1 - \beta (1 - \delta))}{\beta \delta} \tilde{Y}_t + \left( 1 - \frac{\theta (1 - \beta (1 - \delta))}{\beta \delta} \right) \tilde{C}_t - \tilde{\nu}_t \]
\[ \tilde{W}_t - \tilde{P}_t = \tilde{Z}_t - \tilde{\mu}_t + \tilde{P}_{t,t} \]
\[ \tilde{\nu}_t = \tilde{P}^K_{t,t} - \tilde{P}_{t,t} \]
The model is closed with the interest rate rule indicated in the text.