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**Endogenous Market Structures and the  
Business Cycle**

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# Endogenous Market Structure and the Business Cycle

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## Abstract

We introduce endogenous strategic interactions under competition in quantities and in prices together with endogenous entry in a dynamic stochastic general equilibrium model with flexible prices. The endogenous mark ups depend on the form of competition and on the degree of substitutability between goods, and they vary countercyclically while profits are procyclical. Positive temporary shocks to productivity and government spending attract entry. Entry strengthens competition between firms, which temporarily reduces mark ups and prices: this creates an intertemporal substitution effect which provides an extra boost to consumption. The model outperforms the standard RBC framework in matching impulse response functions and second moments for US data.

*JEL classification:* L11, E32.

*Keywords:* Endogenous Market Structure, Firms' Entry, Business Cycle.

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# 1 Introduction

The neoclassical theory of the business cycle, which is well represented by the work of Kydland and Prescott (1982), is based on perfect competition and constant returns to scale. In this environment goods are priced at the marginal cost, there is no room for profits and the structure of the markets is indeterminate (i.e.: the number of firms and their individual production are irrelevant). However, a wide theoretical and empirical literature has emphasized the importance of market power to explain the behavior of the economy along the business cycle.<sup>2</sup> For this reason the new-keynesian theory, starting with Blanchard and Kiyotaki (1987), has introduced product differentiation and imperfect competition in general equilibrium models. Most of this literature departed from the neoclassical framework assuming monopolistic competition *à la* Dixit-Stiglitz (1977) between an exogenous number of firms producing differentiated goods. This approach rapidly became the standard framework for the analysis of macroeconomic policy, with a focus on monetary policy in the presence of simple forms of price stickiness. Nevertheless, also the monopolistic competition approach leads to an exogenous market structure. As such it neglects the role of strategic interactions between firms of the same sectors, it neglects the endogeneity of the number of firms, and it neglects the impact of entry on the same strategic interactions. The result is that the structure of the sectors of the economy remains a sort of “black box” whose main components, mark ups and number of competitors, are exogenous.

In this paper we try to open the “black box” of the market structure and link the endogenous behavior of firms at the sectoral level with the general equilibrium properties of the economy, and in particular with its business cycle properties. We consider distinct sectors, each one characterized by many firms supplying homogenous goods (as in the basic neoclassical framework) or differentiated goods (as in the new-keynesian literature), taking strategic interactions into account and competing either in prices (Bertrand competition) or in quantities (Cournot competition).<sup>3</sup> Building on recent work by Bilbiie *et al.* (2007a,b), we introduce fixed costs of entry to endogenize the number of firms in each sector, however in our context the number of firms affects the equilibrium prices and mark ups in each sector. Therefore mark ups are endogenous and depend on the form of competition, on the degree of substitutability between goods and on the number of firms. For instance, in the presence of homogenous goods Cournot competition allows to preserve substantial mark ups as long as the endogenous market structure is concentrated enough. The rest of the economy operates as in a standard dynamic flexible price model.

In this context, a temporary supply shock induces a novel propagation mechanism: it initially increases profits, which attracts entry of firms, which in turn strengthens competition and reduces the mark ups. For instance, in the above mentioned case of highly concentrated sectors with Cournot competition, the reduction in the mark ups is quite strong. The associated temporary reduction of the prices induces a stronger intertemporal substitution effect in favor of current consumption, which magnifies the effect of the shock compared to a perfectly competitive model. Finally, the temporary increase in demand has a positive feedback effect on profits which keeps the propagation mechanism alive. Compared to a standard RBC model, this framework can perform better in terms of output and consumption volatil-

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<sup>2</sup>See Hall (1986, 1990), Bilal (1987), Rotemberg and Woodford (1992) and more recently Galí (2007a).

<sup>3</sup>We also consider a conjectural variation model that generalizes competition in quantities to forms of imperfect collusion and a Stackelberg model. An important early work on endogenous mark ups in a dynamic stochastic general equilibrium model is Rotemberg and Woodford (1992), which relies on a perfectly collusive framework. However, even if it is able to generate countercyclical mark ups, the Rotemberg-Woodford model does not endogenize the entry process.

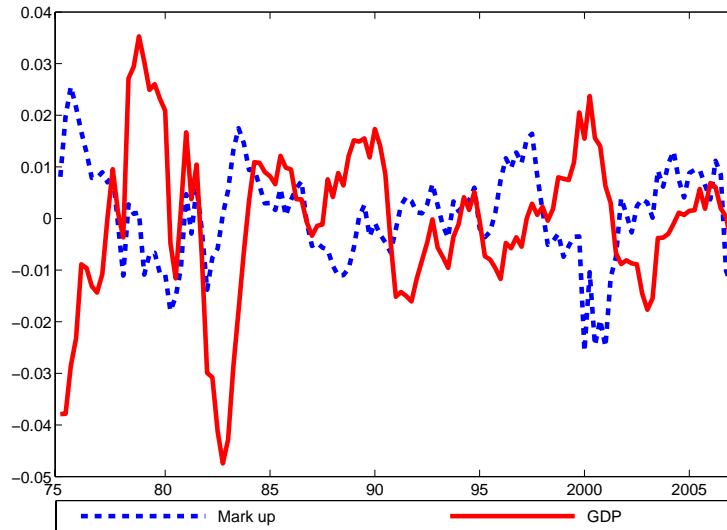


Figure 1: Price Mark Up and Real GDP.

ity, and it allows to generate procyclical movements of aggregate profits and countercyclical movements of the mark ups.

Notice finally that the endogeneity of the market structures allows to generate realistic impulse response functions for demand shocks as well. A temporary increase in government spending creates a boom as in the RBC framework, but, contrary to the latter, it increases profits on impact, attracts entry, reduces the mark ups, increases the real wages, and allows to obtain a delayed consumption boom.

As argued by Bilbiie *et al.* (2007b), the emphasis on markup countercyclical and profit procyclical is not misplaced.<sup>4</sup> We constructed a labor-share based measure of the markup for the U.S. along the lines suggested by Rotemberg and Woodford (1999). Figure 1 plots the HP filtered series of the price markup together with HP filtered real GDP at a quarterly frequency from 1975:1 to 2007:2. The contemporaneous correlation between the two variables is -0.31. Figure 2 plots, instead, HP filtered GDP together with the HP filtered series of real corporate profits for the same period specified above. The contemporaneous correlation is positive and equal to 0.60. The picture documents that profits are extremely volatile, with respect to GDP, at the business cycle frequencies.<sup>5</sup>

This paper borrows inspiration from an emerging literature on endogenous market structures in different fields. A closer attention to endogenous entry and endogenous mark ups has characterized the recent industrial organization literature on the microeconomic behavior of firms and also the macroeconomic literature on general equilibrium models for closed and open economies.<sup>6</sup> Endogenous entry and strategic interactions in the competition for

<sup>4</sup>For a recent empirical work providing extensive evidence on the crucial role of entry along the business cycle see Broda and Weinstein (2007).

<sup>5</sup>All variables have been logged. When a detrending process is involved we use the HP filter with a smoothing parameter equal to 1600 (given quarterly frequency). See the Data Appendix for a description of the data series.

<sup>6</sup>On the microeconomic applications see Etro (2006, 2008b) and on the macroeconomic applications see

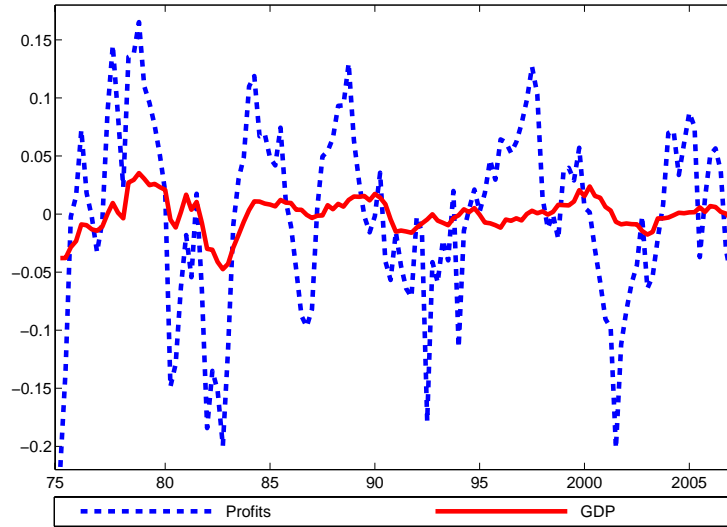


Figure 2: Real Profits and Real GDP.

the market have been recently introduced in dynamic general equilibrium growth models for closed and open economies (Etro, 2004, 2008a). Most importantly, after early attempts to endogenize entry with fixed costs of production in each period (notably Chatterjee and Cooper, 1993, and Devereux *et al.*, 1996),<sup>7</sup> the recent work of Bilbiie *et al.* (2007a,b) has provided an important contribution on endogenous entry in a stochastic dynamic general equilibrium model. This line of research does not take in consideration the strategic interactions between firms and the impact of entry on them, but it focuses on the traditional case of constant mark ups due to monopolistic competition.<sup>8</sup> More recently, Jaimovich (2007) has augmented the model of Devereux *et al.* (1996) with mark ups depending on the number of firms - according to the extension of the Dixit-Stiglitz model due to Yand and Heijdra (1993). That model endogenizes entry through fixed costs of production in each period, so that profits are again zero at all times, and not procyclical as in our framework, and it focuses on different issues, nevertheless it complements our work suggesting a crucial role for market structures in explaining the business cycle.

The article is organized as follows. Section 2 describes the model and its dynamic properties under competition in quantities and in prices. Section 3 calibrates and simulates the model. Section 4 concludes. Technical details are left in the Appendix.

Ghironi and Melitz (2005) and Etro (2007).

<sup>7</sup>Cooper (1999) surveys this early literature. Chatterjee *et al.* (1993) endogenize entry as well, but their focus is on sunspots equilibria in an OLG model.

<sup>8</sup>Bilbiie *et al.* (2007a,b) and Bergin and Corsetti (2005) have introduced the translog preferences (due to Feenstra, 2003) to derive an elasticity of substitution between products that depends on the number of firms. As long as entry increases the substitutability between the existing goods, this generates mark ups depending on the number of goods, but such an *ad hoc* explanation is unrelated to endogenous motivations on the supply side.

## 2 The Model

The structure of the economy is extremely simple and standard. Consider a representative agent with utility:

$$U = E_t \sum_{t=0}^{\infty} \beta^t \left\{ \sum_{k=1}^M \log C_{kt} - \frac{v L_t^{1+1/\varphi}}{1+1/\varphi} \right\} \quad v, \varphi \geq 0 \quad (1)$$

where  $\beta \in (0, 1)$  is the discount factor,  $L_t$  is labor supply and  $C_{kt}$  is a consumption index for the goods produced in sector  $k = 1, 2, \dots, M$ . The representative agent supplies labor for a nominal wage  $W_t$  and allocates his or her savings between bonds or stocks. The intratemporal optimality conditions for the optimal choices of  $C_{kt}$  and  $L_t$  require:

$$P_{1t}C_{1t} = P_{2t}C_{2t} = \dots = E_t \quad (2)$$

$$\left( \frac{W_t}{P_{kt}} \right) C_{kt}^{-1} = v L_t^{\frac{1}{\varphi}} \quad (3)$$

where  $E_t$  is total expenditure allocated to the goods produced in each sector in period  $t$  and  $P_{kt}$  is the price index for consumption in sector  $k$ : due to the unitary elasticity of substitution, total expenditure is equally shared between the sectors.

Each sector  $k$  is characterized by different firms  $i = 1, 2, \dots, N_{kt}$  producing the same good in different varieties, and the consumption index  $C_{kt}$  is:

$$C_{kt} = \left[ \sum_{i=1}^{N_{kt}} C_{kt}(i)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (4)$$

where  $C_{kt}(i)$  is the production of firm  $i$  of this sector, and  $\theta > 1$  is the elasticity of substitution between the goods produced in each sector. The distinction between different sectors and different goods within a sector allows to realistically separate limited substitutability at the aggregated level, and high substitutability at the disaggregated level. Contrary to many macroeconomic models with imperfect competition, our focus will be on the market structure of disaggregated sectors: *intrasectoral substitutability* (between goods produced by firms of a same sector) is high or perfect (when  $\theta \rightarrow \infty$ ), while *intersectoral substitutability* is low.

Each firm  $i$  in sector  $k$  produces a good with a linear production function. To abstract from capital accumulation issues, we assume that labor is the only input. Output of firm  $i$  in sector  $k$  is then:

$$y_{kt}(i) = A_t L_{kt}(i) \quad (5)$$

where  $A_t$  is total factor productivity at time  $t$ , and  $L_{kt}(i)$  is total labor employed by firm  $i$  in sector  $k$ . This implies that the production of one good requires  $1/A_t$  units of labor, and the marginal cost of production is  $W_t/A_t$ .

Since each sector can be characterized in the same way, in what follows we will drop the index  $k$  and refer to a representative sector (alternatively think of  $M = 1$ ). Further details are provided in the Appendix.

### 2.1 Endogenous Market Structures

In each period, the same expenditure for each sector  $E_t$  is allocated across the available goods according to the standard direct demand function derived from the maximization of

the consumption index (4):

$$C_t(i) = C_t \left( \frac{p_t(i)}{P_t} \right)^{-\theta} = \frac{p_t(i)^{-\theta}}{P_t^{1-\theta}} C_t P_t = \frac{p_t(i)^{-\theta} E_t}{P_t^{1-\theta}} \quad i = 1, 2, \dots, N_t \quad (6)$$

where  $P_t$  is the standard price index:

$$P_t = \left[ \sum_{j=1}^{N_t} p_t(j)^{-(\theta-1)} \right]^{\frac{-1}{\theta-1}} \quad (7)$$

such that total expenditure satisfies  $E_t = \sum_{j=1}^{N_t} p_t(j) C_t(j) = C_t P_t$ . Inverting the direct demand functions, we can derive the system of inverse demand functions:

$$p_t(i) = \frac{x_t(i)^{-\frac{1}{\theta}} E_t}{\sum_{j=1}^{N_t} x_t(j)^{\frac{\theta-1}{\theta}}} \quad i = 1, 2, \dots, N_t \quad (8)$$

where  $x_t(i)$  is the consumption of good  $i$ .

We assume that firms cannot credibly commit to a sequence of strategies, therefore their behavior is equivalent to maximize current profits in each period taking as given the strategies of the other firms. Each good is produced at the constant marginal cost common to all firms. A main interest of this paper is in the comparison of equilibria where in each period firms compete in quantities and in prices, taking as given their marginal cost of production and the aggregate expenditure of the representative consumer.<sup>9</sup> Under different forms of competition we obtain symmetric equilibrium prices satisfying:

$$p_t = \frac{\mu(\theta, N_t) W_t}{A_t} \quad (9)$$

where  $\mu(\theta, N_t) > 1$  is the mark up depending on the degree of substitutability between goods  $\theta$  and on the number of firms  $N_t$ . In the next sections we characterize this mark up under competition in quantities and in prices, and we sketch how to consider other forms of competition including conjectural variations and Stackelberg models.

### 2.1.1 Competition in quantities

First, let us consider competition in quantities, which has been systematically ignored in general equilibrium macroeconomic models. Using the inverse demand function (8), we can express the profit function of a firm  $i$  as a function of its output  $x_t(i)$  and the output of all the other firms:

$$\begin{aligned} \Pi_t [x_t(i)] &= \left[ p_t(i) - \frac{W_t}{A_t} \right] x_t(i) = \\ &= \frac{x_t(i)^{\frac{\theta-1}{\theta}} E_t}{\sum_{j=1}^{N_t} x_t(j)^{\frac{\theta-1}{\theta}}} - \frac{W_t x_t(i)}{A_t} \end{aligned} \quad (10)$$

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<sup>9</sup>Of course, both of them are endogenous in general equilibrium, but it is reasonable to assume that firms do not perceive marginal cost and aggregate expenditure in the sector as affected by their choices.

Assume now that each firm chooses its production  $x_t(i)$  taking as given the production of the other firms. The first order conditions:

$$\left(\frac{\theta-1}{\theta}\right) \frac{x_t(i)^{-\frac{1}{\theta}} E_t}{\sum_j x_t(j)^{\frac{\theta-1}{\theta}}} - \left(\frac{\theta-1}{\theta}\right) \frac{x_t(i)^{\frac{\theta-2}{\theta}} E_t}{\left[\sum_j x_t(j)^{\frac{\theta-1}{\theta}}\right]^2} = \frac{W_t}{A_t}$$

for all firms  $i = 1, 2, \dots, N_t$  can be simplified imposing symmetry of the Cournot equilibrium. This generates the individual output:

$$x_t = \frac{(\theta-1)(N_t-1)E_t A_t}{\theta N_t^2 W_t} \quad (11)$$

Substituting into the inverse price, one obtains the equilibrium price  $p_t = W_t \theta N_t / A_t (\theta - 1)(N_t - 1)$ , which is associated with the equilibrium mark up:

$$\mu^Q(\theta, N_t) = \frac{\theta N_t}{(\theta-1)(N_t-1)} \quad (12)$$

where the index  $Q$  stands for competition in quantities. Notice that the mark up is decreasing in the degree of substitutability between products  $\theta$ , with an elasticity  $\epsilon_\theta^Q = 1/(\theta-1)$ . The markup remains positive for any degree of substitutability, since even in the case of homogenous goods, we have  $\lim_{\theta \rightarrow \infty} \mu^Q(\theta, N_t) = N_t/(N_t-1)$ . This allow us to consider the effect of strategic interactions in an otherwise standard setup with perfect substitute goods within sectors (which has been traditionally studied only under perfect competition in the neoclassical tradition). Finally, in the general formulation the markup is decreasing and convex in the number of firms and it tends to  $\theta/(\theta-1) > 1$  for  $N_t \rightarrow \infty$ . Its elasticity is  $\epsilon_N^Q = 1/(N-1)$ , which is decreasing in the number of firms (the mark up decreases with entry at an increasing rate) and independent from the degree of substitutability between goods.

Given the nominal profits  $\Pi_t^Q = (p_t - W_t/A_t)x_t$ , the individual profits in real terms can be expressed as:

$$\pi_t^Q(\theta, N_t) = \frac{(N_t + \theta - 1)C_t}{\theta N_t^2} \quad (13)$$

which are clearly decreasing in the number of firms and in the substitutability level.

### 2.1.2 Competition in prices

Let us now consider competition in prices. In each period, the gross profits of firm  $i$  can be expressed as:

$$\Pi_t [p_t(i)] = \frac{[p_t(i) - W_t/A_t] p_t(i)^{-\theta} E_t}{\left[ \sum_{j=1}^{N_t} p_t(j)^{-(\theta-1)} \right]} \quad (14)$$

Firms compete by choosing their prices. Contrary to the traditional Dixit-Stiglitz (1977) approach which neglects strategic interactions between firms, we will take these into consideration and derive the exact Bertrand equilibrium. Each firm  $i$  chooses the price  $p_t(i)$  to maximize profits taking as given the price of the other firms.<sup>10</sup> The first order condition for

<sup>10</sup>Since total expenditure  $E_t$  is equalized between sectors by the consumers, we assume that it is also perceived as given by the firms. Under the alternative hypothesis that consumption  $C_t$  is perceived as given,



any firm  $i$  is:

$$\left\{ p_t(i)^{-\theta} - \theta \left[ p_t(i) - \frac{W_t}{A_t} \right] p_t(i)^{-\theta-1} \right\} = \frac{(1-\theta)p_t(i)^{-\theta} \left[ p_t(i) - \frac{W_t}{A_t} \right] p_t(i)^{-\theta}}{\sum_{i=1}^{N_t} p_t(i)^{1-\theta}}$$

Notice that the term on the right hand side is the effect of the price strategy of a firm on the price index: higher prices reduce overall demand, therefore firms tend to set higher mark ups compared to monopolistic competition. Imposing symmetry between the  $N_t$  firms, the equilibrium price  $p_t$  must satisfy:

$$\left[ p_t^{-\theta} - \theta \left( p_t - \frac{W_t}{A_t} \right) p_t^{-\theta-1} \right] N_t p_t^{-(\theta-1)} = (\theta-1) p_t^{-\theta} \left( p_t - \frac{W_t}{A_t} \right) p_t^{-\theta}$$

Solving for the equilibrium we have  $p_t = W_t(\theta N_t + \theta - 1)/A_t(\theta - 1)(N_t - 1)$ , which generates the mark up:

$$\mu^P(\theta, N_t) = \frac{1 + \theta(N_t - 1)}{(\theta - 1)(N_t - 1)} \quad (15)$$

The mark up under competition in prices is always smaller than the one obtained before under competition in quantities, as well known for models of product differentiation (see for instance Vives, 1999). As in the previous case, the mark up is decreasing in the degree of substitutability between products  $\theta$ , with an elasticity  $\epsilon_\theta^P = \theta N_t / (1 - \theta + \theta N_t)(\theta - 1)$  which is always higher than  $\epsilon_\theta^Q$ : higher substitutability reduces mark ups faster under competition in prices. Moreover, contrary to the case of competition in quantities, the mark up under competition in prices vanishes in case of perfect substitutability:  $\lim_{\theta \rightarrow \infty} \mu^P(\theta, N_t) = 1$ . Finally, the mark up is again decreasing in the number of firms, with an elasticity  $\epsilon_N^P = N / [1 + \theta(N - 1)](N - 1)$ . Since  $\epsilon_N^Q > \epsilon_N^P$  for any number of firms or degree of substitutability, we can conclude that entry decreases mark ups faster under competition in quantities compared to competition in prices. Moreover, the elasticity of the mark up to entry under competition in prices is decreasing in the level of substitutability between goods, and it tends to zero when the goods are approximately homogenous. These results will play a crucial role in our subsequent analysis of the propagation mechanism of the business cycle under different forms of competition.

In conclusion, with competition in prices the individual profits can be expressed in real terms as:

$$\pi_t^P(\theta, N_t) = \frac{C_t}{1 + \theta(N_t - 1)} \quad (16)$$

which is again a decreasing function of the number of firms and of the substitutability between goods.

### 2.1.3 Other forms of competition

Our framework can be used to study other forms of competition. To give the flavor of these possibilities we briefly report two simple extensions for the case of homogenous goods. Other

we would obtain the higher mark up:

$$\tilde{\mu}^P(\theta, N_t) = \frac{\theta(N_t - 1)}{(\theta - 1)(N_t - 1) - 1}$$

which leads to similar qualitative results. This case would correspond to the equilibrium mark up proposed by Yang and Heijdra (1993). A similar version is also adopted by Jaimovich (2007), whose mark up, however, depends on the degree of substitutability between (intermediate) goods produced in different sectors as well.

interesting extensions would include the analysis of multiproduct firms which choose the production or price levels of their goods to maximize the joint profits.

Our first extension of the Cournot model with homogenous goods belongs to the traditional *conjectural variations approach*. Assuming that each firm takes as given the differential impact of its output choice on the output choice of the other firms  $\lambda \equiv \partial x_t(j)/\partial x_t(i)$ , the equilibrium mark up can be obtained as:

$$\mu^{CV}(N_t) = \frac{N_t}{(N_t - 1)(1 - \lambda)} \quad (17)$$

which nests the case of Cournot competition in quantities for  $\lambda = 0$ , tends to the (indeterminate) case of perfect collusion for  $\lambda \rightarrow 1$ . More importantly, intermediate situations with  $\lambda \in (0, 1)$  describe cases of imperfect collusion between the firms which achieve mark ups above the Cournot level but below the perfect collusion level.

The second extension introduces asymmetries between firms building on the theory of Stackelberg competition.<sup>11</sup> Let us assume that a single leader is always active and  $N_t$  followers are active in each period. In Stackelberg equilibrium the mark up is:

$$\mu^S(N_t) = \frac{N_t}{N_t - 1/2} \quad (18)$$

which is lower compared to the mark up under pure Cournot competition. The profits of the leader and the representative follower are respectively larger and smaller than the profits under Cournot competition.<sup>12</sup>

### 2.1.4 Endogenous Entry

In this model, households choose how much to save in riskless bonds and in the creation of new firms through the stock market according to standard Euler and asset pricing equations. The average number of firms per sector follows the equation of motion:

$$N_{t+1} = (1 - \delta)(N_t + N_t^e) \quad (19)$$

where  $N_t^e$  is the average number of new firms and  $\delta \in (0, 1)$  is the exogenous rate of exit.<sup>13</sup> The real value of a firm  $V_t$  is the present discounted value of its future expected profits, or in recursive form:

$$V_t = \beta(1 - \delta)E_t \left[ \frac{V_{t+1} + \pi_{t+1}(\theta, N_{t+1})}{1 + r_{t+1}} \right] \quad (20)$$

where  $r_t$  is the real interest rate. Entry requires a fixed cost of production equal to  $\eta/A_t$  units of labor, where  $\eta > 0$ . In each period entry is determined endogenously to equate the value of firms to the entry costs. Since the real cost of a unit of labor can be derived from the equilibrium pricing relation (9) as:

$$w_t = \frac{A_t p_t}{\mu(\theta, N_t) P_t} = \frac{A_t N_t^{1/(\theta-1)}}{\mu(\theta, N_t)} \quad (21)$$

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<sup>11</sup>The assumption that also the leader cannot commit to a sequence of strategies is crucial here. If the leader could commit, it would engage in aggressive strategies aimed at reducing or deterring entry in the long run. See Etro (2008b) for a recent analysis of Stackelberg competition with commitment and endogenous entry.

<sup>12</sup>We are grateful to Amhad Naimzada for the derivation of the static Stackelberg equilibrium.

<sup>13</sup>It would be interesting to endogenize the exit rate as a countercyclical factor: this would strengthen our propagation mechanism, since it would enhance the countercyclicality of mark ups.

where we used the fact that  $P_t = p_t N_t^{1/(1-\theta)}$  in the symmetric equilibrium, the endogenous value of a single firm must be equal to the fixed cost of entry, or:

$$V_t = \frac{\eta N_t^{1/(\theta-1)}}{\mu(\theta, N_t)} \quad (22)$$

The representative agent supplies labor which is employed to produce goods and to create new firms, and pays lump sum taxes. Assuming budget balance without loss of generality (since Ricardian equivalence holds), in each period taxes are equal to public consumption  $G_t$ , which is spent exactly as private consumption.

Market clearing in the markets for goods, labor and credit determines the dynamics of the economy, which can be expressed in terms of a system of two equations for the evolution of  $N_t$  and  $C_t$  (eventually depending on the evolution of total factor productivity  $A_t$  and government spending  $G_t$ ). We leave the details of the derivation to the Appendix and report here the equilibrium relations for the number of firms and for consumption of the representative agent, derived by substituting all the equilibrium conditions into (19) and (20).

In particular, under competition in quantities we have:

$$N_{t+1} = (1 - \delta) \left[ N_t + \frac{A_t^{1+\varphi}}{\eta} \left( \frac{(\theta - 1)(N_t - 1)N_t^{\frac{2-\theta}{\theta-1}}}{v\theta C_t} \right)^\varphi - \frac{C_t + G_t}{\eta N_t^{1/(\theta-1)}} \right] \quad (23)$$

$$E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-1} \left[ \frac{\eta(\theta - 1)(N_t - 1)N_t^{\frac{2-\theta}{\theta-1}}}{\theta} + \frac{(N_t + \theta - 1)(C_{t+1} + G_{t+1})}{\theta N_{t+1}^2} \right] \right\} = \frac{\eta(\theta - 1)(N_t - 1)N_t^{\frac{2-\theta}{\theta-1}}}{\beta(1 - \delta)\theta} \quad (24)$$

while under competition in prices we have:

$$N_{t+1} = (1 - \delta) \left[ N_t + \frac{A_t^{1+\varphi}}{\eta} \left( \frac{(\theta - 1)(N_t - 1)N_t^{\frac{1}{\theta-1}}}{v[1 + \theta(N_t - 1)]C_t} \right)^\varphi - \frac{C_t + G_t}{\eta N_t^{1/(\theta-1)}} \right] \quad (25)$$

$$E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-1} \left[ \frac{\eta(\theta - 1)(N_t - 1)N_t^{\frac{1}{\theta-1}}}{1 + \theta(N_t - 1)} + \frac{C_{t+1} + G_{t+1}}{1 + \theta(N_{t+1} - 1)} \right] \right\} = \frac{\eta(\theta - 1)(N_t - 1)N_t^{\frac{1}{\theta-1}}}{\beta(1 - \delta)[1 + \theta(N_t - 1)]} \quad (26)$$

The cases of conjectural variations and Stackelberg competition can be derived similarly, but in the rest of this section we will focus on the baseline cases characterized above. Moreover, in the following theoretical analysis we will assume inelastic labor demand ( $\varphi = 0$ ) and focus on the deterministic model with  $G_t = 0$  for any  $t$ .

## 2.2 Dynamics under competition in quantities

Under competition in quantities the deterministic equilibrium system becomes:

$$\begin{aligned} N_{t+1} &= (1 - \delta) \left( N_t + \frac{A_t}{\eta} - \frac{C_t}{\eta N_t^{1/(\theta-1)}} \right) \\ C_{t+1} &= C_t \left( \frac{\beta(1 - \delta)N_t^{(\theta-2)/(\theta-1)}}{\eta(\theta - 1)(N_t - 1)} \right) \left( \frac{\eta(\theta - 1)(N_{t+1} - 1)}{N_{t+1}^{(\theta-2)/(\theta-1)}} + \frac{(N_{t+1} + \theta - 1)C_{t+1}}{N_{t+1}^2} \right) \end{aligned}$$

Given a constant value of the TFP, these two relations provide a simple characterization of the steady state through two simple relations between consumption and the number of firms. These relations can be easily represented in a phase diagram  $(N, C)$ . Inverting the first one we obtain:

$$C^* = AN^{*\frac{1}{\theta-1}} - \frac{\delta\eta N^{*\frac{\theta}{\theta-1}}}{1-\delta} \quad (27)$$

At least for low levels of substitutability (low  $\theta$ ), this expression for  $C^*$  is an inverse-U relation in  $N^*$  (see Figure 3): with few firms in steady state, the consumption index increases with the number of firms because of the “love for variety” component, but with a large number of firms in steady state the consumption index is affected negatively by an increase in the number of firms due to the high savings necessary to create new firms. The steady state number of firms that maximizes steady state consumption (and utility) can be derived as:

$$N^{GR} = \frac{(1-\delta)A}{\delta\eta\theta} \quad (28)$$

where we referred to this as the *golden rule* number of firms/goods, which is increasing in the productivity level  $A$  and decreasing in the degree of substitutability between goods  $\theta$ , in the rate of exit of the firms  $\delta$  and in the parameter of the fixed cost  $\eta$ . Any steady state with a number of goods larger than  $N^{GR}$  would be dynamically inefficient, in the sense that higher levels of consumption could be permanently reached by reducing entry of firms.

The second equilibrium equation in steady state becomes:

$$C^* = \frac{\eta[1-\beta(1-\delta)](\theta-1)N^{*\frac{\theta}{\theta-1}}}{\beta(1-\delta)[1+\theta/(N^*-1)]} \quad (29)$$

which represents a positive and convex relation between the number of firms and consumption (see Figure 3).

This positive relation is due to the role of the firms in producing consumption goods. The steady state must satisfy both conditions, and it can be verified that it always implies dynamic inefficiency, in the sense that the endogenous number of firms/goods is always above the golden rule level.<sup>14</sup>

Figure 3 shows the phase diagram of the model with the two steady state relations (in solid lines) and the saddle-path (in dashed line). The equilibrium is saddle-path stable, and, starting from a situation with a low number of firms, it implies monotonic convergence to the steady state through an increase of both consumption and the number of firms.

Finally, notice that in case of high substitutability between goods (high  $\theta$ ) we have a simpler situation. The “love for variety” factor is weak and, according to the first steady state relation, consumption is always decreasing in the number of firms: in such a case, a single firm would maximize steady state consumption. Nevertheless, the inefficient entry process generates an equilibrium with an excessive number of firms.

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<sup>14</sup>A similar result in a dynamic general equilibrium framework emerges in the model of Etro (2004), where endogenous entry implies too many firms (see also Etro, 2008a).

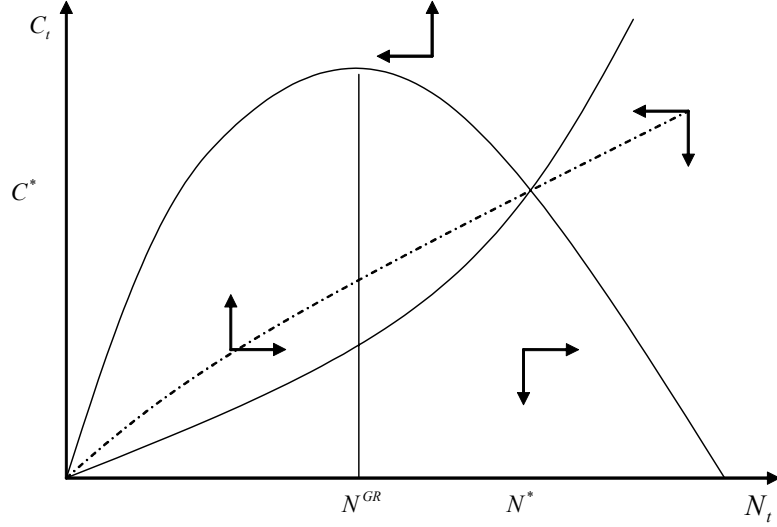


Figure 3: Phase Diagram

### 2.3 Dynamics under competition in prices

Under competition in prices we have:

$$N_{t+1} = (1 - \delta) \left( N_t + \frac{A_t}{\eta} - \frac{C_t}{\eta N_t^{1/(\theta-1)}} \right)$$

$$C_{t+1} = \frac{\beta(1 - \delta) [1 + \theta(N_t - 1)] C_t}{\eta(\theta - 1)(N_t - 1)N_t^{1/(\theta-1)}} \left( \frac{\eta(\theta - 1)(N_{t+1} - 1)N_{t+1}^{1/(\theta-1)}}{1 + \theta(N_{t+1} - 1)} + \frac{C_{t+1}}{1 + \theta(N_{t+1} - 1)} \right)$$

This system can be analyzed in a similar way to the one studied earlier under competition in quantities, also because, under our assumption of exogenous labor supply, the first equilibrium relation is the same as before. The second one, however, is complicated by the different mark up and profit functions emerging under competition in prices.

Given a constant value of the TFP, the steady state can be characterized as follows:

$$N^* = \frac{(1 - \delta) [A - C^*/N^{*1/(\theta-1)}]}{\delta\eta} \quad (30)$$

$$C^* = \frac{(\theta - 1)\eta[1 - \beta(1 - \delta)]N^{*\frac{1}{\theta-1}}(N^* - 1)}{\beta(1 - \delta)} \quad (31)$$

These two expressions can be easily represented in a phase diagram  $(N, C)$ . The first one is the same hump shaped relation that we obtained in the model with competition in quantities,<sup>15</sup> and the considerations made earlier apply here as well. The second expression is a positive

<sup>15</sup>Further differences emerge in case of endogenous labor supply, but in this section we have assumed exogenous labor supply.

and convex relation due to the role of the firms in producing consumption goods. Given the same structural parameters, the steady state implies a smaller number of firms compared to the case of competition in quantities.

Finally, the equilibrium is again saddle-path stable, and, starting from a situation with a low number of firms, it implies monotonic convergence through an increase of both consumption and the number of firms.

### 3 Business Cycle Analysis

This section has multiple purposes. First of all, we wish to evaluate the relative success of the models considered above at replicating the empirical facts described in the introduction, namely countercyclical markups together with procyclical profits and procyclical firms' entry. Secondly, we want to identify the extent to which the market structure influences the propagation of technology and government spending shocks throughout the economy. Finally, we try to compare the performance of our model with endogenous market structures and that of a standard RBC model.

Calibration of structural parameters is standard and follows King and Rebelo (2000). The time unit is meant to be a quarter. The discount factor,  $\beta$ , is set to 0.99, while the rate of business destruction,  $\delta$ , equals 0.025 implying an annual rate of 10 %. The value of  $v$  is such that steady state labor supply is constant and equal to one. The Frish elasticity of labor supply reduces to  $\varphi$ , to which we assign a value of four as in King and Rebelo (2000). We set steady state productivity to  $A = 1$ . The baseline value for the entry cost is set to  $\eta = 1$ . Notice that the combination of  $A$  and  $\eta$  affects the endogenous level of market power because a low entry cost compared to the size of the market leads to a larger number of competitors and thus to lower markups, and *viceversa*. However, the impulse response functions below are not qualitatively affected by values of  $\eta$  within a reasonable range.<sup>16</sup> Finally, we set the share of government spending over aggregate output to 20 % as in many other studies of the business cycle.

In what follows we will first study the impulse response functions to supply shocks and demand shocks, and finally we will evaluate the second order moments. Our model allows for a large variety of combinations of substitutability between goods ( $\theta$ ) and mark up ( $\mu$ ), which in turn depends on the mode of competition, but we will limit the discussion to a few explanatory cases leaving further analysis of related situations in the companion paper (Colciago and Etro, 2007).

#### 3.1 Supply shocks

In this section we show the qualitative reactions of the economy to a standard shock to the technology parameter following the first order autoregressive process  $\hat{A}_{t+1} = \rho_A \hat{A}_t + \varepsilon_{A_t}$ , where  $\rho_A \in (0, 1)$  is the autocorrelation coefficient and  $\varepsilon_{A_t}$  is a white noise disturbance, with zero expected value and standard deviation  $\sigma_A$ . Figures 4-6 depict percentage deviations from the steady state of key variables in response to a one percent technology shock with persistency  $\rho_A = 0.9$  in case of alternative market structures; time on the horizontal axis is in quarters.

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<sup>16</sup>We provide a sensitivity analysis of our result with respect to  $\eta$  for given  $A$  in Colciago and Etro (2007). When the steady state number of firms increases, the sensitivity of the mark ups to entry diminishes but it applies to a larger number of goods. Therefore the fundamental moments exhibit minor changes.

In Figures 4 and 5 we report the impulse response functions for different values of  $\theta$  under respectively competition in quantities and in prices. To evaluate the results, let us consider the standard case of low substitutability between goods with  $\theta = 6$ , which is in line with the typical calibration for monopolistic competition.<sup>17</sup> Under competition in prices and in quantities the market structure is generated endogenously and the steady state mark ups are respectively 22 % and 35 %, both belonging to the empirically reasonable range. As well known, when firms compete in prices the equilibrium mark ups are lower, which in turn allows for a lower number of firms to be active in the market: this implies that the model is characterized by a lower number of goods compared to the model with competition in quantities. Since this requires a smaller number of new firms to be created in steady state, lower mark ups are associated with a lower savings rate as well. In spite of these substantial differences in the steady state features of the economy, Figures 4 and 5 show that the quantitative reactions of the main aggregate variables to the shock are surprisingly similar in these two models with low substitutability.

Under both frameworks, the temporary shock increases individual output and profits on impact, which creates large profit opportunities. This attracts entry of new firms, which in turn strengthens competition and reduces the equilibrium mark ups. Therefore, our model manages to generate individual and aggregate profits that are procyclical despite mark ups being countercyclical, in line with the empirical evidence on business cycles. Notice that the dampening effect of competition on the mark ups is stronger under competition in quantities, where entry erodes profits margins faster than under competition in prices:<sup>18</sup> this justifies higher entry and lower mark ups under competition in prices. The number of firms and the stock market value of the representative firm remain above their steady state levels along all the transition path. While the shock vanishes and entry strengthens competition, output and profits of the firms drop and the incentives to enter disappear. At some point net exit from the market occurs and the mark ups start increasing toward the initial level.

The impact of these reactions on the real variables resembles that of a basic RBC model, even if it derives from largely different mechanisms. Aggregate output jumps up and gradually reverts to the steady state level, being initially fueled by the reduction in the mark ups associated with entry and by the increase in labor supply associated with higher wages. Part of the increase in income (from higher wages and profits) is saved because the interest rate is increased by the sudden improvement of the profit opportunities. Savings are invested in firm creation, which in turn pushes output up and the interest rate down: the feedback effect on consumption generates its hump shaped path. However, contrary to standard models, here the impact of the shock on consumption is strengthened by a new competition effect. Entry of new firms strengthens competition and temporarily reduces the mark ups, which in turn boosts consumption.

To sum up, the productivity shock reduces not only the marginal cost (as already happens in the RBC model), but also the equilibrium mark up (which is zero in the RBC model and constant in the models with monopolistic competition), therefore the intertemporal substitution toward current consumption is stronger when the market structure is endogenous. In other words, the impact of a temporary shock on consumption is magnified in the presence of endogenous market structures.<sup>19</sup>

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<sup>17</sup>The qualitative behavior of the impulse response functions is similar in case of  $\theta = 3$ , which delivers larger steady state mark ups (63% under competition in quantities and 40 % under competition in prices).

<sup>18</sup>Recall that the mark up elasticity to the number of firms is larger under competition in quantities, as pointed out in the previous section.

<sup>19</sup>As well known, this effect is limited by the logarithmic preferences in consumption, which imply a unitary elasticity of intertemporal substitution. With an isoelastic utility function, the competition effect would be

This analysis makes clear that endogenous market structures with low substitutability between products can provide reasonable qualitative responses to technology shocks and can also reproduce the dynamic behavior of profits and mark ups which is substantially ignored within the standard RBC framework. As noticed earlier, our general model should be interpreted as a model of a representative sector with a potentially high degree of substitutability between goods. When we increase the degree of substitutability ( $\theta$ ) the same qualitative results hold, at least under competition in quantities. In particular, consider the extreme case of homogenous goods ( $\theta \rightarrow \infty$ ), that corresponds to the typical assumption of the RBC literature: in such a case, our model with competition in quantities is compatible with positive (Cournot) mark ups and, as we can see in Figure 4, it is able to reproduce a similar propagation mechanism to the one we have just seen. On the contrary, under competition in prices and homogenous (or highly substitutable) goods, the model collapses to one where mark ups vanish and entry does not take place because of the positive fixed costs of production (therefore we did not display this case in Figure 5). For this reason, and contrary to a long standing literature, we consider the model with competition in quantities as a better tool for macroeconomic analysis of the business cycles in the presence of realistic (and endogenous) market structures.

The above comparison between two models featuring the same structural parameters but different modes of competition can be interesting in its own, but its interpretation is limited by the fact that in different markets different forms of competition take place - and most of the times we are not even able to screen between them. An alternative comparison which can be useful to understand the implications of endogenous market structures emerges when models with equal steady state mark ups are studied. In such a case all the aggregate ratios are the same as well, and different responses to a shock reveal fundamental differences of alternative modes of competition. To study a comparison of this second type, let us consider the model with competition in prices and  $\theta = 6$  (Figure 5). This model is characterized by a steady state mark up of 22 %. Under our parametrization, the same mark up emerges endogenously in a model of competition in quantities when the goods are homogenous, that is with  $\theta \rightarrow \infty$  (Figure 4).

Eyeball comparison between the impulse response functions of these two cases with a mark up of 22% (and therefore with equal steady state values) shows that the effect of competition on the markup is stronger in the case where firms compete in quantities and goods are homogenous. This affects the impact response of consumption, which is clearly stronger under homogenous goods and competition in quantities rather than under low substitutability and competition in prices.<sup>20</sup> Strategic interaction between firms selling homogeneous goods brings about a substantially stronger competition effect on consumption and it contributes to solve the low variability of consumption puzzle identified in standard RBC models.

Finally, with the purpose of illustrating the potentiality of our approach to study the relation between market structures and the business cycle, in Figure 6 we present the impulse response functions for different models of competition in quantities with homogenous goods: the symmetric Cournot case (already present in Figure 4), a model with conjectural variations with  $\lambda = 0.15$ , that leads to imperfect collusion, and a model of Stackelberg competition. The endogenous mark ups are respectively 22 % for Cournot case, 35% for the conjectural variations and 15 % for the Stackelberg case - in which output, profits and stock market value of the leader are larger than those of the followers. The impulse response functions

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stronger when the elasticity of substitution is larger than unity.

<sup>20</sup>The same holds compared to low substitutability and competition in quantities, as we can see from Figures 3 and 4 jointly.



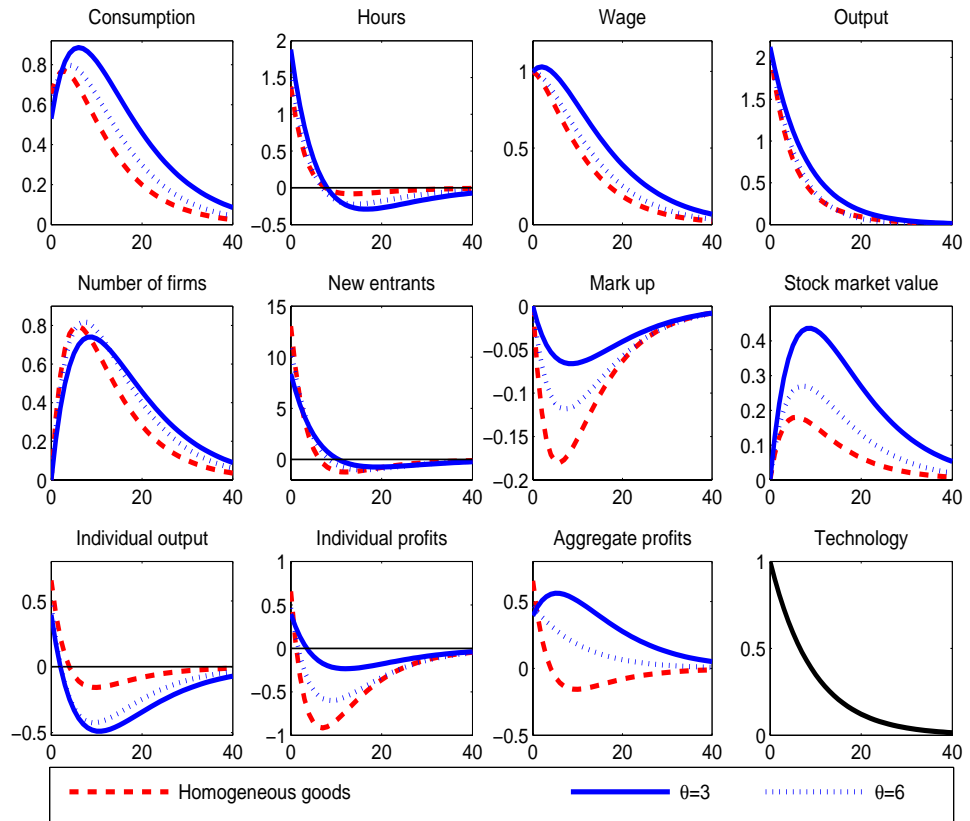


Figure 4: Impulse response to a persistent technology shock. Competition in Quantities.

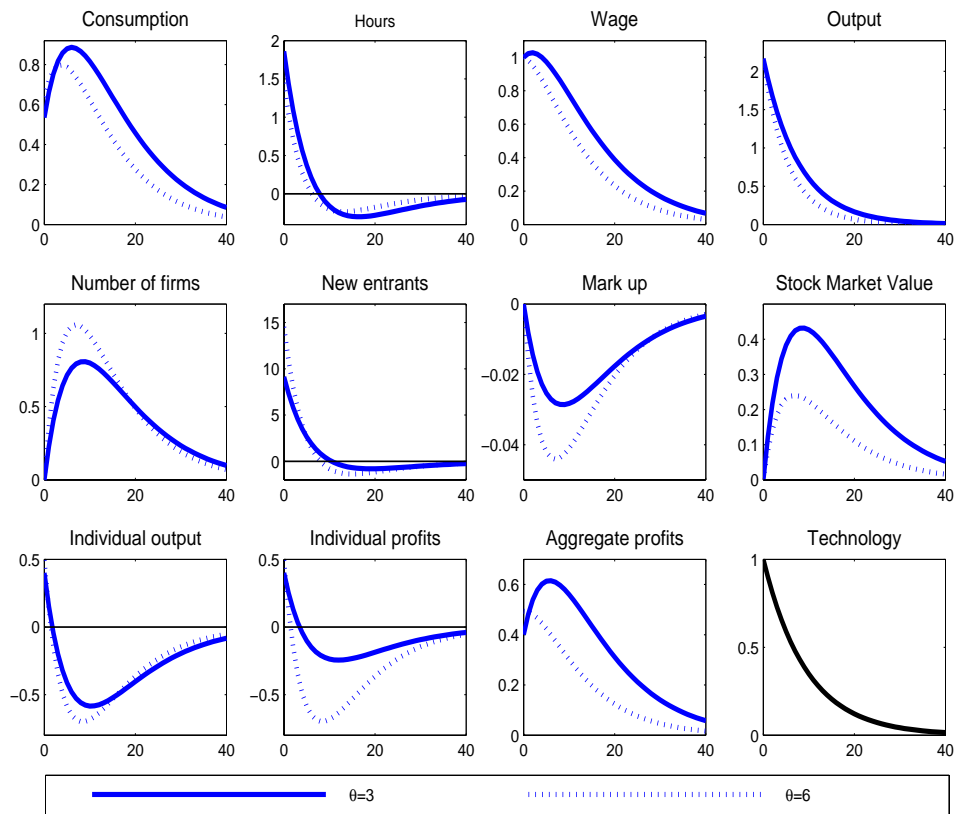


Figure 5: Impulse response to a persistent technology shock. Competition in Prices.

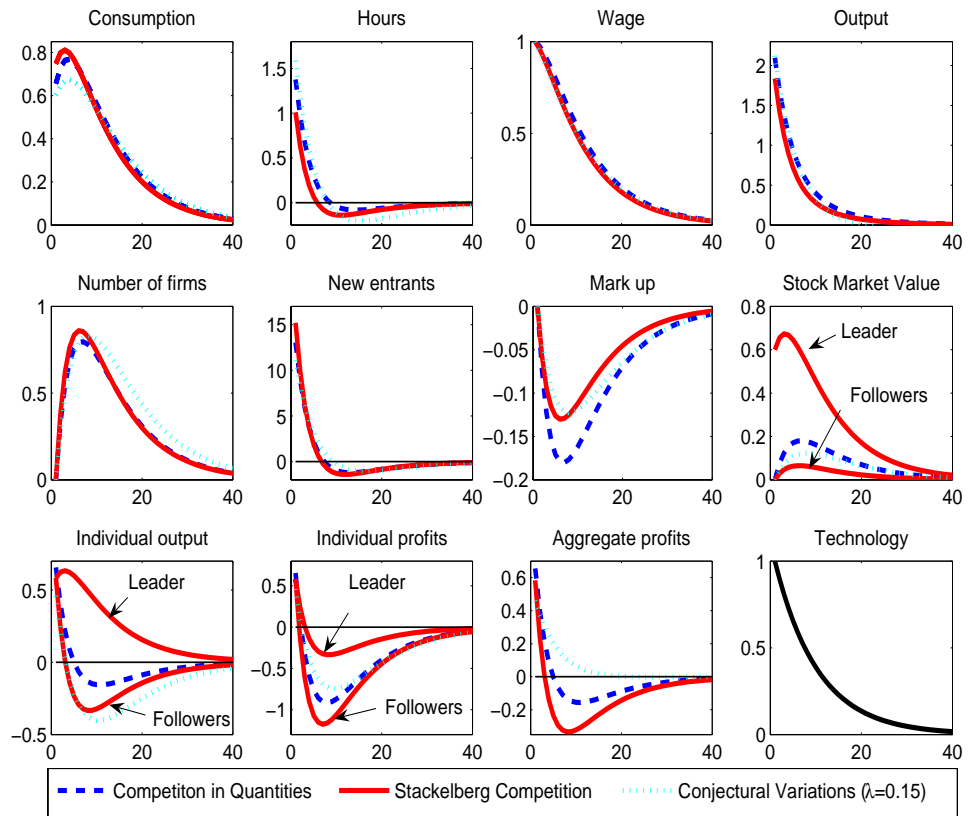


Figure 6: Impulse response to a persistent technology shock. Homogenous goods.

follow similar paths from a qualitative point of view, but there are substantial quantitative differences. For instance, compared to the Cournot case, consumption smoothing is more relevant when the markets are characterized by imperfect collusion and higher mark ups, and less relevant when they are characterized by a market leader whose overproduction reduces the mark ups.<sup>21</sup>

A deeper evaluation of these models requires second moments analysis, which will be presented later. Before that, we need to evaluate qualitatively the response of the models to a different kind of shock: an aggregate demand shock.

### 3.2 Demand Shocks

We now consider the impact of a demand shock associated, as standard in the theory of business cycles, with a change in government spending. We assume that government spending follows the first order autoregressive process  $\hat{G}_{t+1} = \rho_G \hat{G}_t + \varepsilon_{Gt}$ , where  $\rho_G \in (0, 1)$  is the autocorrelation coefficient and  $\varepsilon_{Gt}$  is a white noise disturbance, with zero expected value and standard deviation  $\sigma_G$ .

Figure 7 depicts the response of key variables to a one percent government spending shock with persistency  $\rho_G = 0.9$ . We report the case of competition in quantities under alternative parameterizations for the elasticity of substitution between goods. Solid lines depict the case where  $\theta = 3$  which delivers a steady state markup equal to 63 %, dashed lines represent the case case with  $\theta = 6$  and a markup of 35 %, and finally dotted lines are relative to the case with homogeneous goods ( $\theta \rightarrow \infty$ ) and a 22% markup.

As in the standard neoclassical model (Barro, 1981), the temporary shock to government spending creates a boom because the initial reduction in private consumption is more than compensated by the increase in public spending. As a consequence, labor demand for production increases. Consumers feel poorer and increase their labor supply. In the RBC framework the net effect would be given by a reduction of the wage rate and by a reduction of consumption, with both remaining below the steady state level along the entire transition path; meanwhile, the interest rate would jump up and gradually decrease toward its initial level. In our model, however, there are new mechanisms that substantially change the impact of the demand shock.

First of all, the shock increases individual output and profits on impact. This attracts entry of new firms, which has two consequences. The first one is that the demand of labor for the creation of new firms goes up, which leads to a stronger increase in total labor demand and ultimately to an increase in the wage rate (the opposite compared to the RBC framework), which promotes consumption. The second (and possibly more important) consequence is that entry strengthens competition and endogenously reduces the equilibrium mark ups. Again, this competition effect makes current consumption more attractive for the consumers.<sup>22</sup>

The impact of these two mechanisms is to counterbalance the initial drop in consumption. When substitutability between goods is low, consumption goes above the steady state level after a few quarters and gradually returns toward its long run level from above, which is in sharp contrast with the dynamic response of consumption delivered by the standard RBC model (where converge of consumption to steady state is monotonic from below the steady

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<sup>21</sup>See Colciago and Etro (2007) for further analysis of the temporary and permanent shocks under alternative market structures with homogenous goods.

<sup>22</sup>Therefore the model is consistent with the suggested requirement of Rotemberg and Woodford (1992) of a real wage increasing after a positive demand shock. Nevertheless the reaction of the real wage is limited, which can help to explain the substantial acyclicity of wages in the presence of multiple shocks.

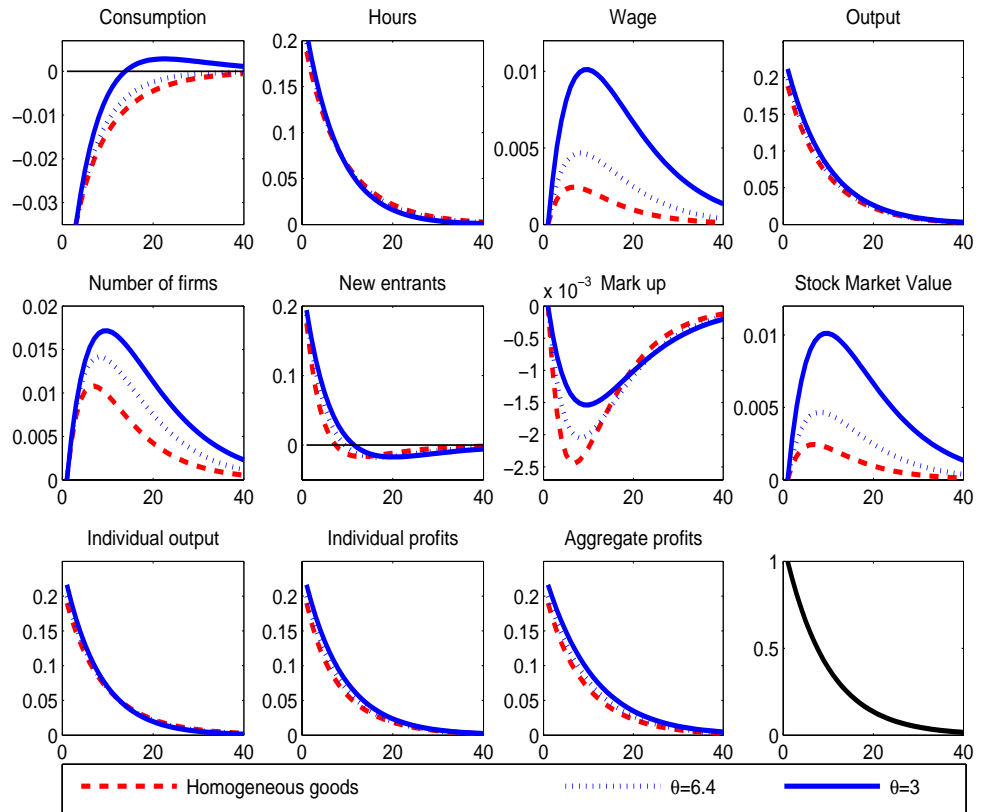


Figure 7: Impulse response to a persistent government spending shock.

<i>Variable</i>	$\sigma(X)$	$\sigma(X)/\sigma(Y)$	$E(X_t, X_{t-1})$	$Corr(X, Y)$
<i>Y</i>	1.66, 1.39	1	0.84, 0.72	1
<i>C</i>	1.19, 0.60	0.75, 0.43	0.78, 0.78	0.76, 0.94
<i>I</i>	4.97, 4.09	2,99 2.59	0.87, 0.70	0.79, 0.98
<i>L</i>	1.82, 0.67	1.10, 0.48	0.90, 0.70	0.88, 0.97
$\Pi$	8.08, <i>n.a.</i>	4.87, <i>n.a.</i>	0.76, <i>n.a.</i>	0.67, <i>n.a.</i>
$\mu$	0.99, <i>n.a.</i>	0.60, <i>n.a.</i>	0.79, <i>n.a.</i>	-0.28, <i>n.a.</i>

Table 1: Second moments. Left: US data. Right: RBC model

state level) and not too far from the available evidence.<sup>23</sup> Overall, these dynamic paths are radically different from the standard RBC models and they are potentially more in line with the mixed empirical evidence on the impact of demand shocks - in particular with the procyclicality of profits and countercyclicality of markups.

### 3.3 Second Moments

To further assess the implications of endogenous market structures for the business cycle, we compute second moments of the key macroeconomic variables. In this exercise we follow the RBC literature and assume that the only source of random fluctuations are technology shocks. We calibrate the productivity process as in King and Rebelo (2000), with persistence  $\rho_A = 0.979$  and standard deviation  $\sigma_A = 0.0072$ . For future reference we report in Table 1 the performance of the standard RBC model<sup>24</sup> with respect to the statistics on US data (1947:1 / 2007:3) for output  $Y$ , consumption  $C$ , investment  $I$ , labor force  $L$ , aggregate profits  $\Pi$  and the mark up  $\mu$ .<sup>25</sup> We computed two alternative measures of the price markup. Since our model features a sunk cost in term of units of labor, both of them allow for overhead labor costs. The measure reported in Table 1 is the labor-share based measure considered by Rotemberg and Woodford (1999). A second one is a model based measure and leads to similar qualitative results but is substantially more volatile and displays stronger countercyclicality.<sup>26</sup>

As well known, the main problems of the RBC model are the limited variability of output and especially consumption and labor force, and the lack of explanations for the cyclical movement of profits and mark ups. As we will see, our model allows to improve the performance of the standard RBC model in all these dimensions.

Table 2 reports second moments of  $Y$ ,  $C$ ,  $I \equiv N^e V$ ,  $L$ ,  $\Pi$ , and mark up  $\mu$  for our

<sup>23</sup>See Galì *et al.* (2007,b) for a recent reference.

<sup>24</sup>The benchmark RBC model we consider is that by King and Rebelo (2000). Our utility function differs from theirs in the subutility from labour supply, but the second moments are equivalent under the same calibration.

<sup>25</sup>Variables have been logged. We report theoretical moments of HP filtered variables with a smoothing parameter equal to 1600. Profits include both the remuneration of capital and the extra-profits due to market power: while we could not distinguish between the two, future research may try to do it.

<sup>26</sup>The model based measure of the price mark up takes into account that in our model the mark ups can be expressed as  $\mu_t = C_t/w_t (L_t - L_t^e)$ , i.e. as the inverse of the share of labor in consumption beyond the sunk quantity used to set up new firms (see Appendix B). Accordingly, we obtain  $\sigma(\mu) = 1.62$ ,  $E(\mu_t, \mu_{t-1}) = 0.81$  and  $Corr(\mu, Y) = -0.63$ . The measure of the labor share used in our computation is given by the ratio of the compensation of employees in the nonfarm business sector to GDP. None of the cyclical properties we report are substantially altered using (GDP-PROPRIETORS' INCOME) instead of GDP. For both the markup measures we consider, the ratio of the overhead quantity of labor to the steady state aggregate labor input is assumed to be 0.2. This is within the range of values endogenously delivered at the steady state by our model under both competitive frameworks.

<i>Variable</i>	$\sigma(X)$		$\sigma(X)/\sigma(Y)$		$E(X_t, X_{t-1})$		$Corr(X, Y)$	
<i>Y</i>	1.52,	1.51	1		0.68,	0.68	1	
<i>C</i>	0.78,	0.78	0.51,	0.52	0.77,	0.76	0.94,	0.95
<i>I</i>	5.89,	7.56	3.87,	5.00	0.65,	0.64	0.97,	0.97
<i>L</i>	0.85,	0.77	0.56,	0.50	0.65,	0.64	0.96,	0.96
$\Pi$	0.70,	0.74	0.46,	0.49	0.71,	0.72	0.99,	0.98
$\mu$	0.15,	0.13	0.10,	0.08	0.95,	0.94	-0.17,	-0.17

Table 2: Second moments under low substitutability. Left: Competition in quantities; Right: Competition in prices

model with competition in quantities and with competition in prices under the common parameterization with low substitutability between goods ( $\theta = 6$ ), corresponding to the impulse response functions of Figures 4 and 5.<sup>27</sup> Both the competitive frameworks provide a similar performance at reproducing some key features of the U.S. business cycle. Imperfect competition, strategic interaction and endogenous entry allow to outperform the standard RBC framework in a number of aspects.

Endogenous mark up fluctuations together with endogenous entry deliver a substantially higher output volatility with respect to the RBC model (1.51/1.52 against 1.39), almost matching the one emerging from US data. As emphasized above, we can capture procyclical profits and entry together with countercyclical mark ups as in the data. This is obtained through the direct effect that entry has on the degree of competition rather than by resorting to an *ad hoc* functional form specification for preferences as in Bilbiie *et al.* (2007a,b) or Bergin and Corsetti (2005). Our model provides a good match for the correlation of profits and mark ups with output, but it underestimates their variability, emphasizing the need for further work on the microfoundation of the endogenous market structures to better explain the high volatility of both profits and mark ups. Moreover, mark up countercyclicality allows to strengthen the propagation of the shock on aggregate demand through the *competition effect*. Both models display an absolute and relative (with respect to output) variability of consumption larger than that delivered by the RBC model. Since low variability of consumption is a well known shortcoming of the RBC theory, the competition effect delivered by strategic interaction and endogenous entry appears to be a relevant channel to overcome it. Finally, notice that, compared to the RBC framework, our model with endogenous market structures slightly improves the performance in terms of variability of the labor force.<sup>28</sup>

Even if we do not report a sensitivity analysis here, the variability of output increases further (but that of consumption goes down) when lower degrees of substitutability between goods are taken in consideration, while it decreases (and the variability of consumption goes up) for higher degrees of substitutability, under both forms of competition.

Table 3 reports second moments for the model with competition in quantities in the case of homogeneous goods, corresponding to the case presented in Figure 4. The relevance of this extreme model relies on the fact that it assumes perfect substitutability between goods exactly as in the standard RBC framework, therefore the difference in performance derives from the endogeneity of the market structures.

The figures suggest that high elasticity of substitution coupled with market concentra-

<sup>27</sup> As in Bilbiie *et al.* (2007b) we report moments of data consistent variables, i.e. deflated using the average price index rather than the consumption based price index.

<sup>28</sup> As in the RBC framework, introducing indivisible-labor a la Hansen (1985) and Rogerson (1988) may improve further the performance of the model.

<i>Variable</i>	$\sigma(X)$	$\sigma(X)/\sigma(Y)$	$E(X_t, X_{t-1})$	$Corr(X, Y)$
<i>Y</i>	1.36	1	0.67	1
<i>C</i>	0.87	0.64	0.78	0.94
<i>I</i>	5.86	4.31	0.63	0.92
<i>L</i>	0.57	0.42	0.60	0.93
$\Pi$	0.70	0.51	0.63	0.99
$\mu$	0.10	0.07	0.93	-0.29

Table 3: Second moments. Competition in quantities with homogeneous goods

tion enhances consumption volatility with respect to the case where goods are imperfectly substitutable. Also the contemporaneous correlation of the markup with output matches closely that assumed by the labor share-based measure of the markup reported above. This is however obtained at the cost of volatility of aggregate output and labor supply which are lower than in the cases considered above - but still in line with the results from the standard RBC model. In conclusion, the model with homogeneous goods and competition in quantities (Cournot competition) is able to perform quite well in matching the cyclical properties of profits and mark ups, on which the neoclassical model is completely silent, and it provides a better approximation of the variability of consumption in front of real shocks.

## 4 Conclusions

In this article we have studied a dynamic stochastic general equilibrium model with flexible prices where the structure of the markets is endogenous and accounts for strategic interactions of different kinds. The model belongs to the emerging literature on endogenous market structures in the macroeconomy and it provides some improvements in the explanation of the business cycle compared to the standard RBC framework. Our characterization of the market structure allows to explain the procyclical variability of the profits together with the countercyclical variability of the mark ups. Nevertheless, we have emphasized a mark up and profit volatility puzzle: further examinations of alternative market structures should be aimed at matching the high levels of volatility that emerge from the empirical investigation of US mark ups and profits.

Many other extensions could be studied. The model could be expanded to an international context (see Ghironi and Melitz, 2005, for a related attempt, in which strategic interactions were not taken in consideration) to study international business cycle issues and optimal policy coordination in an open economy context.<sup>29</sup> The model could be also extended to sticky prices as in Bilbiie *et al.* (2007a), to sticky quantities introducing rigidities in the strategy choice within the model with competition in quantities, and to sticky entry assuming that entry takes time: all these extensions could be fruitful to investigate the relation between endogenous market structures and monetary shocks.

We want to end this work with a limited but hopefully fertile conclusion: endogenous market structures do matter for macroeconomic issues. While most of the recent approach to the study of business cycles has been based either on perfect competition, constant returns to scale and zero mark ups or on monopolistic competition, increasing returns to scale and positive and constant mark ups, we have shown that strategic interactions leading to a link

<sup>29</sup>See Obstfeld and Rogoff (1996) for a standard reference on the topic, and more recently, Colciago *et al.* (2007).



between entry, mark ups and prices can substantially affect the way an economy reacts to shocks.

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## Appendix A: analytical details

The representative agent maximizes intertemporal utility (1) choosing how much to invest in bonds and risky stocks out of labor and capital income. Without loss of generality, bonds and stocks are denominated in terms of good 1. The budget constraint expressed in nominal terms is:

$$\begin{aligned} P_{1t}B_{t+1} + \sum_{k=1}^M P_{1t}V_{kt}(N_{kt} + N_{kt}^e)s_{kt+1} + \sum_{k=1}^M P_{kt}C_{kt} &= \\ = W_tL_t + (1 + r_t)P_{1t}B_t + \sum_{k=1}^M P_{1t}[\pi_{kt}(\theta, N_t) + V_{kt}]N_{kt}s_{kt} - P_{1t}T_t &\quad (32) \end{aligned}$$

where  $B_t$  is net bond holdings with interest rate  $r_t$ ,  $V_{kt}$  is the value of a firm from sector  $k$ ,  $N_{kt}$  and  $N_{kt}^e$  are the active firms in sector  $k$  and the new firms founded in this sector at the end of the period,  $s_{kt}$  is the share of the stock market value of the firms of sector  $k$  that are owned by the agent, and  $T_t$  are lump sum taxes, which equate public spending under budget balance.

After solving the budget constraint for consumption of good 1 and substituting in the utility function, the optimality conditions with respect to  $C_{kt}$  and  $s_{kt+1}$  for each sector, and with respect to  $B_{t+1}$  and  $L_t$  are:

$$P_{1t}C_{1t} = P_{2t}C_{2t} = \dots = P_{Mt}C_{Mt} \quad (33)$$

$$\frac{V_{kt}(N_{kt} + N_{kt}^E)P_{kt}}{P_{1t}C_{kt}} = \beta E \left\{ \frac{[\pi_{kt+1}(\theta, N_{kt+1}) + V_{kt+1}]N_{kt+1}P_{kt+1}}{P_{1t+1}C_{kt+1}} \right\} \quad (34)$$

$$C_{1t}^{-1} = \beta(1 + r_{t+1})E[C_{1t+1}^{-1}] \quad (35)$$

$$\left( \frac{W_t}{P_{kt}} \right) C_{kt}^{-1} = vL_t^{\frac{1}{\varphi}} \quad (36)$$

For each sector  $k$ , demand for the single goods is allocated according to (6) in the text. Each good  $i = 1, 2, \dots, N_{kt}$  in sector  $k = 1, 2, \dots, M$  is produced by a single firm using labor according to (5). Uniperiodal nominal profits are given by  $\Pi_t[x_t(i)]$  or  $\Pi_t[p_t(i)]$  in the text according to whether competition in quantities or in prices takes place, and each firm chooses its strategy  $x_t(i)$  or  $p_t(i)$  to maximize the sum of the current profits and the value of the firm  $V_{kt}(i)$  taking as given the strategies of the other firms. Notice that, in the absence of credible commitments to a sequence of future strategies, the optimal strategy is the one that maximizes current profits because this does not affect the future value of the firm. Endogenous market structures for each sector as described in the text generate a number of firms  $N_{kt}$ , mark ups  $\mu(\theta, N_{kt})$ , and nominal profits  $\Pi_{kt} = [1 - 1/\mu(\theta, N_{kt})]P_{kt}C_{kt}$  for each firm.

Following Bilbiie *et al.* (2007a,b), we adopt a probability  $\delta \in [0, 1]$  with which any firm can exit from the market for exogenous reasons in each period. The dynamic equation determining the number of firms in each sector is then:

$$N_{kt+1} = (1 - \delta)(N_{kt} + N_{kt}^e) \quad \forall k \quad (37)$$

which provides the dynamic path for the average number of firms:

$$\begin{aligned} N_{t+1} &= (1 - \delta) \left( \frac{1}{M} \right) \sum_{k=1}^M (N_{kt} + N_{kt}^e) = \\ &= (1 - \delta) (N_t + N_t^e) \end{aligned} \quad (38)$$

where, of course, we have  $N_t \equiv (1/M) \sum_{k=1}^M N_{kt}$  and  $N_t^e \equiv (1/M) \sum_{k=1}^M N_{kt}^e$ .

Market clearing in the asset markets requires  $B_t = 0$  for any  $t$  in the bond market, and  $s_{kt} = 1$  for any sector  $k$  in the stock market. In a symmetric equilibrium, the number of firms, the mark up and the profits are the same in every sector, which leads to the following equilibrium relations:

$$P_{kt} = P_t \quad C_{kt} = C_t \quad \forall k \quad (39)$$

$$V_t(N_t + N_t^e)C_t^{-1} = \beta E \{ [\pi_{t+1}(\theta, N_{t+1}) + V_{t+1}] N_{t+1} C_{t+1}^{-1} \} \quad (40)$$

$$C_t^{-1} = \beta(1 + r_{t+1})E(C_{t+1}^{-1}) \quad (41)$$

$$L_t = \left( \frac{w_t}{vC_t} \right)^\varphi \quad (42)$$

The equation of motion for the average number of firms allows to rewrite the second relation as:

$$V_t = \beta E_t \left\{ (1 - \delta) \left( \frac{C_{t+1}}{C_t} \right)^{-1} [\pi_{t+1}(\theta, N_{t+1}) + V_{t+1}] \right\} \quad (43)$$

whose forward iteration provides the asset pricing equation:

$$V_t = E \left\{ \sum_{s=t+1}^{\infty} [\beta(1 - \delta)]^{s-t} \left( \frac{C_s}{C_t} \right)^{-1} \pi_s(\theta, N_s) \right\} \quad (44)$$

Given the real marginal cost of production  $w_t/A_t$ , the equilibrium price in units of consumption is  $p_t/P_t = \mu(\theta, N_t)w_t/A_t$ . Since in the symmetric equilibrium  $P_t = p_t N_t^{-1/(\theta-1)}$ , we have  $p_t/P_t = N_t^{1/(\theta-1)}$  and therefore the equilibrium wage:

$$w_t = \frac{A_t N_t^{1/(\theta-1)}}{\mu(\theta, N_t)} \quad (45)$$

As customary, assume that public spending is allocated in the same way as private spending, so that total expenditure per sector is  $E_t = P_t (C_t + G_t)$ . Since  $E_t = N_t y_t p_t$ , we must have  $C_t + G_t = N_t y_t (p_t/P_t) = y_t N_t^{\theta/(\theta-1)}$ .

Individual profits are:

$$\pi_t(\theta, N_t) = \frac{(\mu(\theta, N_t) - 1)(C_t + G_t)}{\mu(\theta, N_t)N_t}$$

To endogenize the number of firms, we assume that entry requires a fixed cost of entry which is proportional to the costs of production.<sup>30</sup> In particular, entry requires an amount of labor force  $\eta/A_t$  with  $\eta > 0$ , for a total cost  $F_t = \eta w_t/A_t$ . The endogeneity of the market structure requires that this value equals the fixed cost of entry at each period,  $V_t = F_t$  for any  $t$ , or:

$$V_t = \frac{\eta w_t}{A_t} = \frac{\eta N_t^{1/(\theta-1)}}{\mu(\theta, N_t)} \quad (46)$$

Labor demand must be the sum of labor in the production of goods, which is equal to  $L_t^c = M(C_t + G_t)/AN_t^{1/(\theta-1)}$  (since  $C_t + G_t = y_t N_t^{\theta/(\theta-1)} = A(L_t^c/M)N_t^{1/(\theta-1)}$ ) and in the creation of new firms, which must be equal to  $L_t^e = MN_t^e \eta/A$ . By Walras' law, market clearing in the labor market is guaranteed.

Since the resource constraint of the economy can be rewritten in real terms as:

$$M(C_t + G_t + N_t^e V_t) = MN_t \pi_t(\theta, N_t) + w_t L_t \quad (47)$$

we can solve for the average number of new firms:

$$N_t^e = \frac{1}{\eta} \left[ A_t^{1+\varphi} \left( \frac{N_t^{1/(\theta-1)}}{v\mu(\theta, N_t)C_t} \right)^\varphi - (C_t + G_t) N_t^{1/(1-\theta)} \right]$$

The above equations fully characterize the equilibrium, and they can be reduced to a system of two equations representing the dynamics of  $N_t$  and  $C_t$ , namely:

$$N_{t+1} = (1 - \delta) \left[ N_t + \frac{A_t^{1+\varphi}}{\eta} \left( \frac{N_t^{1/(\theta-1)}}{v\mu(\theta, N_t)C_t} \right)^\varphi - \frac{C_t + G_t}{\eta N_t^{1/(\theta-1)}} \right] \quad (48)$$

$$\begin{aligned} E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-1} \left[ \frac{\eta N_{t+1}^{1/(\theta-1)}}{\mu(\theta, N_{t+1})} + \frac{(\mu(\theta, N_{t+1}) - 1)(C_t + G_t)}{\mu(\theta, N_{t+1})N_{t+1}} \right] \right\} = \\ = \frac{\eta N_t^{1/(\theta-1)}}{\beta(1 - \delta)\mu(\theta, N_t)} \end{aligned} \quad (49)$$

which crucially depend on the mark up functions, and therefore on the form of competition.

Finally we present the log-linearizations of the model. Assume inelastic labor supply for simplicity ( $\varphi = 0$ ). Log-linearizing the general equilibrium system around its steady state we obtain the system for the local dynamics. Under competition in quantities we have:

$$\begin{aligned} \hat{N}_{t+1} = & \left( 1 - \delta + \frac{(r + \delta)(N^* - 1)}{N^* + \theta - 1} \right) \hat{N}_t + \\ & - \frac{(r + \delta)(\theta - 1)(N^* - 1)}{N^* + \theta - 1} \hat{C}_t + \left[ \delta + \frac{(r + \delta)(\theta - 1)(N^* - 1)}{(N^* + \theta - 1)} \right] \hat{A}_t \end{aligned}$$

<sup>30</sup> Similar fixed costs of entry are used in Bilbiie *et al.* (2007b) and also in Etro (2004, 2008a) to endogenize entry in dynamic general equilibrium models.

and:

$$\begin{aligned}\hat{C}_{t+1} &= \left(\frac{1+r}{1-\delta}\right)\hat{C}_t + \left(\frac{1+r}{1-\delta}\right)\left(\frac{1}{\theta-1} + \frac{1}{N^*-1}\right)\hat{N}_t + \\ &+ \left[\frac{1}{\theta-1} + \frac{1}{N^*-1} - \left(\frac{r+\delta}{1-\delta}\right)\frac{N^*+2(\theta-1)}{N^*+\theta-1}\right]\hat{N}_{t+1}\end{aligned}$$

This system can be explicitly solved for the two future variables in function of their current values. Under competition in prices we have:

$$\begin{aligned}\hat{N}_{t+1} &= \left(1-\delta + \frac{(r+\delta)(N^*-1)}{N^*}\right)\hat{N}_t + \\ &- \frac{(r+\delta)(\theta-1)(N^*-1)}{N^*}\hat{C}_t + \left[\delta + \frac{(r+\delta)(\theta-1)(N^*-1)}{N^*}\right]\hat{A}_t\end{aligned}$$

and:

$$\begin{aligned}\hat{C}_{t+1} &= \left(\frac{1+r}{1-\delta}\right)\hat{C}_t + \left(\frac{1+r}{1-\delta}\right)\left[\frac{1}{\theta-1} + \frac{N^*}{[1+\theta(N^*-1)](N^*-1)}\right]\hat{N}_t + \\ &+ \left[\frac{1}{\theta-1} + \frac{N^*}{[1+\theta(N^*-1)](N^*-1)} - \frac{(r+\delta)\theta N^*}{(1-\delta)[1+\theta(N^*-1)]}\right]\hat{N}_{t+1}\end{aligned}$$

which can be also solved for the two future variables in function of their current values. Stability of the system can be shown as in Bilbiie et al. (2007b) with standard methods.

## Appendix B: data sources

The data derive from FRED, the Federal Reserve Economic Database of the Federal Reserve Bank of St. Louis. Below, we report in brackets the mnemonics of each series.

Compensation of Employees (COE): Billions of Dollars, Quarterly, Seasonally Adjusted Annual Rate (saar), 1947-01-01 2007-07-01.

Gross Domestic Product (GDP): Billions of Dollars, Quarterly, saar, 1947-01-01 2007-07-01.

Proprietors' Income with inventory valuation adjustment (IVA) and capital consumption adjustment (PROPINC): Billions of Dollars, Quarterly, saar, 1947-01-01 2007-07-01.

Personal Consumption Expenditure (PCEC): Billions of Dollars, saar, 1947-01-01 2007-07-01.

Corporate Profits with inventory Valuation Adjustment (IVA) and Capital Consumption Adjustment (CPROFIT): Billions of Dollars, Quarterly, saar, 1947-01-01 2007-04-01.

Gross Domestic Product Implicit Price Deflator (PCEC): Index 2000=100, Quarterly, Seasonally Adjusted (sa), 1947-01-01 2007-07-01.

Hours of all Persons, nonfarm business sector (HOANBS): Index 1992=100, Quarterly, sa, 1947-01-01 2007-07-01.

Fixed Private Investment (FPI): Billions of Dollars, Quarterly, saar, 1947-01-01 2007-07-01.

To derive the empirical measure of the mark up we use (9) to obtain:

$$\mu_t = \frac{w_t}{A_t}$$

Rotemberg and Woodford (1999) assume the existence of overhead labor so that effective labor for the production of consumption goods is  $L_t^c = L_t - L_t^o$  and:

$$\mu_t = \frac{w_t L_t}{A_t (L_t - L_t^o)} \frac{L_t - L_t^o}{L_t}$$

whose log-linearization is:

$$\hat{\mu}_t = -\frac{l^o}{1-l^o}\hat{L}_t - \hat{s}_t$$

where  $l^o \equiv L_t^o/L_t$  represents the average share of overhead labor over total labor input (assumed to be equal to 0.2),  $s_t \equiv w_t L_t/A_t(L_t - L_t^o)$  is the labor share of income, and hatted variables indicate percentage deviations from the HP trend. Second moments derived from this measure of the mark ups are reported in Table 1. We also calculated a second measure of the mark up based on the existence of labor employed to create new firms in our model and on the fact that  $C_t = A_t(L_t - L_t^e)$ . Setting  $s_t^e \equiv w_t L_t/A_t(L_t - L_t^e)$  and  $l^e \equiv L_t^e/L_t$ , we have:

$$\hat{\mu}_t = -\frac{l^e}{1-l^e}\hat{L}_t - \hat{s}_t^e$$

Since  $l^e$  is between 15% and 25% in our calibrated economy, we used again a baseline value of 0.2.