Università
Ca' Foscari
Venezia
Facoltà
di Economia

Corso di Laurea Magistrale
in Economia

Prova finale di Laurea

Titolo
TAXATION IN BUSINESS CYCLE MODELS WITH ENDOGENOUS MARKET STRUCTURES

Relatore
Pr. Federico Etro

Laureanda
Elena Stepanova
Matricola 834430

Anno Accademico
2010 / 2011

Content

Introduction

Real business cycle (RBC) models started with the work of Kydland and Prescott (1982). A broad literature following their approach is based on the assumption of perfect competition in the market between producers of homogenous goods. This assumption leads to marginal cost pricing, an undefined number of firms in the market and no strategic interactions between them.

A new approach to modeling business cycles that starts with Blanchard and Kiyotaki (1987) (we will call it the new Keynesian framework) assumes monopolistic competition in the market between an exogenous number of producers. This approach leads to pricing goods with a constant mark up on the marginal cost, an exogenous number of agents and undefined strategic interactions between them.

Another more recent approach that will be the baseline approach of this work started with Ghironi and Melitz (2005), Bilbiie, Ghironi and Melitz (BGM, 2007) and Etro (2009a) and is characterized by endogenous number of producers (different expressions can stand for this – endogenous entry, endogenous product variety, etc.) – we will call it the BGM model. These models are still based on the assumption of monopolistic competition and so feature constant mark ups in pricing goods and undefined strategic interactions between producers on the market.

In this literature we observe an evolution of the models in the direction of introducing microeconomic aspects into dynamic, stochastic, general equilibrium, macroeconomic models (DSGE models) and an attempt to link firms'behavior at the sectorial level with the general equilibrium properties of the economy, in particular with its business cycle properties. The next step in this direction is the introduction of imperfect competition in the markets, as in Etro and Colciago (EC, 2010) and Colciago and Etro (2010): competition a la Cournot – firms choose their production levels - and a la Bertrand – firms choose prices. Moreover these models also depart from the assumption of homogenous goods and consider goods that can be imperfectly substitutable.

The Etro-Colciago model characterizes the endogenous market structure (EMS) of a market through the form of market competition, the equilibrium strategy of each firm and the endogenous number of firms in the market. This provides a number of important implications for the business cycle literature.

First of all, the endogenous creation of new products is an important mechanism for business cycle propagation and amplification of shocks. It allows the model to perform sufficiently better in comparison with traditional Real Business Cycle (RBC) models – it explains procyclical behavior of entry and profits, it does at least as well as RBC benchmark model in replicating real data[1] second moment properties of variables.

Second, a wide industrial organization literature provides theoretical and empirical support for the relevance of the competition effect that in model with EMS works as an additional propagation mechanism. At the theoretical level, there is a crucial difference between models of monopolistic behavior a` la Dixit and Stiglitz (1977), recently employed by BGM (2007) for business cycle analysis, and models with strategic interactions as in EC(2010). In the first class of models, the mark up and the production of each firm are constant, while the number of firms increases linearly with the size of the market. In the second class of models, positive shocks to the size of the market attract entry and strengthen competition in such a way that the mark up decreases, the production of each firm increases (to cover the fixed costs) and the number of firms increases less than proportionally. Early works of the New Empirical Industrial Organization literature starting with Bresnahan and Reiss (1987) and more recent works by Manuszak (2002), Campbell and Hopenhayn (2005), Manuszak and Moul (2008) or Etro (2009a) have provided convincing evidence in support of the second class of models and of the competition effect on mark ups, firms' production and number of firms.

The main purpose of this thesis is to introduce taxation in this class of models and evaluate its implications. Limited literature already exists on this topic. In BGM (2008) it is shown that competitive equilibrium of the BGM model is not a social planner optimal one (see sections 1.6, 1.7 of this thesis) and the authors come up with fiscal policies that ensure implementation of the Pareto optimum as a competitive equilibrium when efficiency of the market solution fails (section 1.9). Also Etro (2009a) analyzes the role of optimal fiscal policy within the Etro-Colciago model with endogenous market structures, obtaining related results on the optimal policies. These policies are countercyclical, induce markup synchronization across time and states, and align the consumer surplus and profit destruction effects of firm entry.

In contrast with the large body of literature that studied fiscal policy in the presence of monopolistic competition (see Auerbach and Hines, 2002, 2003), BGM argue that monopoly power with prices being above marginal cost is not a source of distortion and that any markup distortion

[1] Data of US economy gathered in King and Rebelo (1999)

must be eliminated (for example, in order to make the steady state of the model efficient, before addressing stabilization around this steady state). They prove that monopoly profits should in fact be preserved whenever entry is endogenously determined and that the distortion is not due to the presence of a markup, but rather to the nonsynchronization of them across goods, time and states. This generates an optimal taxation which is countercyclical and promotes entry in recession while limiting it during booms.

This work pursues several purposes:
- to provide an overview of the models proposed by BGM (2007) and EC (2010);
- to study the propagation of transitory shocks in these models and in particular to compare traditional productivity shocks with new shocks to the fixed entry cost (rarely considered in the previous literature; see also Etro, 2009,b);
- to address issues of optimal fiscal policies that can be applied in these models;
- to extend these models with distortionary taxes and study the propagation of transitory shocks in a modified model setup.

The thesis is organized as follows:

Chapter 1 presents the basic framework - agents behavior (households (sections 1.1, 1.5, 1.7), firms (sections 1.2, 1.3, 1.4)) - and provides equilibrium conditions (section 1.6), characterizes the steady state (section 1.8) and reviews fiscal policies that will be optimal in the framework of this model (section 1.9);

Chapter 2 illustrates dynamic properties of the model for transmission of economic fluctuations by means of numerical examples and computation of impulse response functions. We study shock to the cost of entry to the market under original model setup (section 2.1). We modify model setup by incorporation of distortion taxations (section 2.2) and study temporary government spending (subsection 2.2.1) and productivity shocks (subsection 2.2.2) under new setup. We also provide comparison of new setup model performance against the original one.

Chapter 3 will provide some conclusions.

Chapter 1 Model Setup

1.1 Household Preferences

The number of households in the economy is normalized to unity. Lets assume that contracts and prices are indicated in nominal terms with prices being flexible. Thus, it is sufficient to solve model only for real variables. Money doesn't have any role in the economy, it is introduced only as convenient unit of account for contracts. Composition of the consumption basket changes over time due to firm entry affecting the definition of the consumption-based price index.

The representative household supplies L units of labor inelastically in each period at the nominal wage rate W_t. The household maximizes expected intertemporal utility from consumption (C):

$$E_t\left(\sum_{s=t}^{\infty}\beta^{s-t}U(C_s)\right),$$

where $\beta \in (0,1)$ is the subjective discount factor and $U(C)$ is a period utility function with the standard properties. At time t, the household consumes the basket of goods C_t, defined over a continuum of goods Ω. At any given time t, only a subset of goods $\Omega_t \subset \Omega$ is available.

Let $p_t(\omega)$ denote the nominal price of a good $\omega \in \Omega_t$.

For any symmetric homothetic preferences, there exists a well defined consumption index C_t and an associated welfare-based price index P_t.

The demand for an individual variety, $c_t(\omega)$, is then defined as

$$c_t(\omega)d\omega = C_t \frac{\partial P_t}{\partial p_t(\omega)},$$

where, by the conventional notation, quantities with a continuum of goods are flow values.

The relative price ρ describes the benefit of additional product variety:

$$\rho_t(\omega) = \rho(N_t) \equiv \frac{p_t(\omega)}{P_t}, \text{ for any symmetric variety } \omega, \tag{1.1}$$

or, in elasticity form it is expresses as:

$$\varepsilon(N_t) \equiv \frac{\rho'(N_t)}{\rho(N_t)}N_t,$$

where N_t is the number of producers.

Model considers C.E.S. preferences (constant elasticity of substitution between goods) as initially proposed in Dixit and Stiglitz (1977). Therefore the consumption aggregator is

$$C_t = \left(\int_{\omega \in \Omega} c_t(\omega)^{\theta - 1/\theta} d\omega \right)^{\frac{\theta}{\theta - 1}}$$

where $\theta > 1$ is the symmetric elasticity of substitution across goods or we will also call it the degree of substitutability between goods.

The consumption-based price index is then

$$P_t = \left(\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}} \tag{1.2}$$

and the household's demand for each individual good ω is (for the proof see Appendix)

$$c_t(\omega) = C_t \left(\frac{p_t(\omega)}{P_t} \right)^{-\theta}. \tag{1.3}$$

1.2 Firms

The economy is populated by a continuum of firms, each producing a different variety/good $\omega \in \Omega$. For simplicity, model equates a producer with a production line for an individual variety/good (while empirically, a firm may comprise more than one production lines). Model does not address the determination of product variety within firms. So process of producer entry and exit should be seen in broad sense, i.e. as also incorporating product creation and destruction by existing firms within them.

Production depends on only one factor, which is labor. Aggregate labor productivity is indexed by A_t, which represents the effectiveness of one unit of labor. A_t is exogenous variable of the model. Output supplied by firm ω is

$$y_t(\omega) = A_t l_t(\omega),$$

where $l_t(\omega)$ denotes the firm's labor demand for production purpose. The unit cost of production, in units of the consumption good C_t, is $\frac{w_t}{A_t}$, where $w_t \equiv \frac{W_t}{P_t}$ is the real wage.

Prior to entry, firms face a sunk entry cost of $\eta_{E,t}$ effective labor units, equal to $\eta_{E,t} \frac{w_t}{A_t}$ units of the consumption basket. $\eta_{E,t}$ is exogenous variable of the model. Given model assumption that each firm can be seen as a production line for a good, the entry cost can, in turn, be seen as the development and setup cost associated with a good (potentially influenced by market regulation). Producer doesn't face any fixed costs.

All firms that enter the economy produce in every period, until they are hit with a "death" shock, which occurs with probability $\delta \in (0,1)$ in every period. The exogenous "death" shock also takes place at the individual variety level.

Firms set prices in a flexible fashion as markups over marginal costs. In units of consumption, firm ω's price is

$$\rho_t(\omega) = \mu_t \frac{w_t}{A_t},$$

where μ_t stands for the markup. The firm's profit in units of consumption is

$$d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{Y_t^C}{N_t}, \tag{1.4}$$

where Y_t^C is total output of the consumption basket and will in equilibrium be equal to total consumption demand C_t.

We denote firm's profits with d_t having in mind that all firm's profits are paid out as dividends.

1.3 Symmetric Firm Equilibrium

All firms face the same marginal cost. Hence, equilibrium prices, quantities, and firm profits and values are identical across firms: $p_t(\omega) = p_t$, $\rho_t(\omega) = \rho_t$, $l_t(\omega) = l_t$, $y_t(\omega) = y_t$, $d_t(\omega) = d_t$, $\upsilon_t(\omega) = \upsilon_t$.

In turn, equality of prices across firms implies that the consumption-based price index P_t and the firm-level price p_t are such that the following is fulfiled $\frac{p_t}{P_t} \equiv \rho_t = \rho(N_t)$.

Therefore benefit of additional product variety is described by:

$$\rho(N_t) \equiv \frac{p_t}{P_t} = \frac{p_t}{\left(\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega\right)^{\frac{1}{1-\theta}}} = \frac{p_t}{N^{\frac{1}{1-\theta}}\left(p_t^{1-\theta}\right)^{\frac{1}{1-\theta}}} = N^{\frac{1}{\theta-1}}$$

An increase in the number of firms necessarily implies that the relative price of each individual good increases because $\rho'(N_t) > 0$. When there are more firms, households derive more welfare from spending a given nominal amount, i.e., ceteris paribus, the price index decreases. It follows that the relative price of each individual good must rise.

The aggregate consumption output of the economy is

$$Y_t^C = N_t \rho_t y_t = C_t$$

Importantly, in the symmetric firm equilibrium, the value of waiting to enter is zero, despite the entry decision being subject to sunk costs and exit risk; i.e., there are no option-value considerations pertaining to the entry decision. This happens because all uncertainty in the model (including the "death" shock) is aggregate.

1.3.1 Equilibrium under Monopolistic competition

Given household's demand for each individual good $c_t(\omega)$ (1.3) profits of a firm at time t are:

$$d_t(\omega) = (p_t(\omega) - cost_t)c_t(\omega) = (p_t(\omega) - cost_t)C_t\left(\frac{p_t(\omega)}{P_t}\right)^{-\theta} \tag{1.5}$$

where $cost_t$ is the (nominal) marginal cost of production.

Lets now assume that there is an infinity of monopolistic firms, each one acts independently in the choice of its price in every period, and has no impact on the price index or the consumption index. Accordingly, from the first order conditions the profit maximizing price is

$$p_t = \frac{\theta}{\theta - 1} cost_t$$

for each firm, which corresponds to a common and constant markup for all goods:

$$\mu(N_t) = \mu = \frac{\theta}{\theta - 1}$$

1.3.2 Equilibrium under Bertrand competition

Lets denote expenditure in each sector of economy as $EXP_t = C_t P_t$, then household's demand for each individual good $c_t(\omega)$ (1.3) can be re-written as $c_t(\omega) = EXP_t \frac{p_t(\omega)^{-\theta}}{P_t^{1-\theta}}$. Using expression for price index P_t (1.2) we get that profit of a firm (1.5) is:

$$d_t(\omega) = (p_t(\omega) - cost_t)c_t(\omega) = (p_t(\omega) - cost_t)EXP_t \frac{p_t(\omega)^{-\theta}}{\int\limits_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega}$$

Under competition in prices we derive Bertrand equilibrium price as price that maximizes firms' profit taking as given the prices of the other firms and expenditure in each sector. First order conditions of the profit maximization problem are:

$$\left\{p_t(\omega)^{-\theta} - \theta(p_t(\omega) - cost_t)p_t(\omega)^{-\theta-1}\right\} = \frac{(1-\theta)p_t(\omega)^{-\theta}(p_t(\omega) - cost_t)p_t(\omega)^{-\theta}}{\int\limits_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega}$$

Using the fact that equilibrium is symmetric we can replace $\int\limits_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega = N_t p_t^{1-\theta}$. And solving for p_t we get:

$$p_t = \frac{\theta(N_t - 1) + 1}{(N_t - 1)(\theta - 1)} cost_t \text{ for each firm,}$$

which corresponds to markup of:

$$\mu(N_t) = \frac{\theta(N_t - 1) + 1}{(N_t - 1)(\theta - 1)}$$

1.3.3 Equilibrium under Cournot competition

Given household's demand for each individual good $c_t(\omega)$ (1.3) and using that in equilibrium demand equals supply - $y_t(\omega)$ inverse demand function will be:

$$p_t(\omega) = \frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int\limits_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega} EXP_t,$$

where expenditure in each sector of economy are $EXP_t = C_t P_t$ .we get that profit of a firm (1.5):

$$d_t(\omega) = (p_t(\omega) - cost_t) y_t(\omega) = \left(\frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int\limits_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega} EXP_t - cost_t \right) y_t(\omega)$$

Under competition in quantities each firm chooses $y_t(\omega)$ that maximizes profits taking as given supply of other firms. First order conditions of the profit maximization problem are:

$$\left(\frac{\theta-1}{\theta}\right) \frac{y_t(\omega)^{-\frac{1}{\theta}}}{\int\limits_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega} EXP_t - \left(\frac{\theta-1}{\theta}\right) \frac{y_t(\omega)^{\frac{\theta-2}{\theta}}}{\left(\int\limits_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega\right)^2} EXP_t = cost_t$$

Using the fact that equilibrium is symmetric we can replace $\int\limits_{\omega\in\Omega_t} y_t(\omega)^{\frac{\theta-1}{\theta}} d\omega = N_t y_t^{\frac{\theta-1}{\theta}}$. And solving for y_t we obtain: $y_t = \frac{(\theta-1)(N_t-1)}{\theta N_t^2 cost_t} EXP_t$. Substituting back into inverse demand function, we get the equilibrium price:

$$p_t = \frac{\theta N_t}{(\theta-1)(N_t-1)} cost_t \text{ for each firm,}$$

which corresponds to markup for all goods:

$$\mu(N_t) = \frac{\theta N_t}{(N_t-1)(\theta-1)}$$

1.4 Firm Entry and Exit

In each period there are N_t firms in economy and unlimited number of potential new entrants. Potential new entrants are forward looking, and foresee their excepted profits $d_s(\omega)$ in every future period $s \geq t+1$ as well as the probability δ (in every period) of incurring the exogenous "death" shock. Entrants at time t only start producing at time $t+1$, which introduces a one-period time-to-build lag in the model. The exogenous exit shock occurs at the very end of the time period (after production and entry). A proportion δ of new entrants will therefore never produce. Prospective entrants in period t compute their expected post-entry value ($\upsilon_t(\omega)$) given by the present discounted value of their expected stream of profits $\{d_s(\omega)\}_{s=t+1}^{\infty}$:

$$\upsilon_t(\omega) = E_t\left(\sum_{s=t+1}^{\infty}[\beta(1-\delta)]^{s-t}\frac{U'(C_s)}{U'(C_t)}d_s(\omega)\right) \tag{1.6}$$

This also represents the value of incumbent firms after production has occurred (since both new entrants and incumbents then face the same probability $1-\delta$ of survival and production in the subsequent period). Entry occurs until firm value is equalized with the entry cost, leading to the free entry condition

$$\upsilon_t(\omega) = w_t\frac{\eta_{E,t}}{A_t}. \tag{1.7}$$

The condition holds as long as the number $N_{E,t}$ of new entrants is positive. It is assumed that macroeconomic shocks are small enough for this condition to hold in every period.

Finally, the timing of entry and production assumptions imply that the number of producing firms in period t is given by

$$N_t = (1-\delta)(N_{t-1} + N_{E,t-1}). \tag{1.8}$$

The number of producing firms represents the capital stock of the economy. It is an <u>endogenous state variable</u> that behaves much like physical capital in the benchmark RBC model.

1.5 Household Budget Constraint and Intertemporal Decisions

Without loss of generality lets assume that households hold only shares in a mutual fund of firms.

Let x_t be the share in the mutual fund of firms held by the representative household entering period t. The mutual fund pays a total profit in each period (in units of currency) equal to the total profit of all firms that produce in that period, $P_t N_t d_t$. During period t, the representative household buys x_{t+1} shares in a mutual fund of $N_{H,t} \equiv N_t + N_{E,t}$ firms (those already operating at time t and the new entrants). Only $N_{t+1} = (1-\delta) N_{H,t}$ firms will produce and pay dividends at time $t+1$. Since the household does not know which firms will be hit by the exogenous exit shock δ at the very end of period t, it finances the continuing operation of all pre-existing firms and all new entrants during period t. The date t price (in units of currency) of a claim to the future profit stream of the mutual fund of $N_{H,t}$ firms is equal to the nominal price of claims to future firm profits, $P_t \upsilon_t$.

The household enters period t holding x_t of mutual fund shares, it receives dividend income, the value of selling its initial share position, and income from supplying labor. The household allocates these resources between purchases of x_{t+1} shares to be carried into next period, consumption C_t. So in each period household budget constraint (in units of consumption) is of the form:

$$\upsilon_t N_{H,t} x_{t+1} + C_t = (d_t + \upsilon_t) N_t x_t + w_t L \qquad (1.9)$$

The household maximizes its expected intertemporal utility subject to (1.9). The Euler equation for share holdings is:

$$\upsilon_t = \beta (1-\delta) E_t \left(\frac{U'(C_{t+1})}{U'(C_t)} (d_{t+1} + \upsilon_{t+1}) \right) \qquad (1.10)$$

As expected, forward iteration of this equation and absence of speculative bubbles yield the asset price solution in equation (1.6).

1.6 Aggregate Accounting and Equilibrium

Summing up individual budget constraints of households (1.9) across all the economy and imposing the equilibrium condition $x_{t+1} = x_t = 1 \ \forall t$ we obtain the aggregate accounting identity that should be fulfilled in each period:

$$C_t + N_{E,t}\upsilon_t = w_t L + N_t d_t : \qquad (1.11)$$

Total consumption plus investment (in new entrants) must be equal to total income (part of which is coming from supplying labor and the other – from return on investments in the form of dividends).

As opposed to RBC model, in the current model we need to distinguish between labor that is used in production of consumption goods and labor employed in setting-up new firms (increasing capital stock of the economy). So current model can be viewed as a two-sector economy. While in the benchmark RBC model, capital stock is accumulated by using as investment part of the output of the same good used for consumption and all labor is allocated only to the productive sector of the economy.

The total output of the economy, Y_t, is equal to total income, $w_t L + N_t d_t$. On the other side, Y_t is also given by consumption output, $Y_t^C (= C_t)$, plus investment output, $N_{E,t}\upsilon_t$. We also note that, firm value υ_t can be viewed as the relative price of the investment "good" in terms of consumption.

Equilibrium on the labor market requires that the sum of amount of labor used in production of consumption goods L_t^C and amount of labor employed in setting-up the new entrants' plants L_t^E must equal aggregate labor supply:

$$L_t^C + L_t^E = L,$$

where the amount of labor used in production of consumption can be expressed as $L_t^C = N_t l_t$, and the amount of labor used to build new firms can be expressed as $L_t^E = N_{E,t} \frac{\eta_{E,t}}{A_t}$.

When labor supply is fixed, there are no labor market dynamics in the model, other than the determination of the equilibrium wage along a vertical supply curve. In our model, even when labor supply is fixed, labor market dynamics arise in the allocation of labor between production of consumption and creation of new firms. The allocation is determined jointly by the entry decision of prospective entrants and the portfolio decision of households who finance that entry. The value of firms, or as we also call it the relative price of investment in terms of consumption υ_t, plays a crucial role in determining this allocation. (When labor supply is elastic, labor market dynamics operate along two margins as the interaction of household and firm decisions determines jointly the total amount of labor and its allocation to the two sectors of the economy. We study this case in the section 1.7)

1.6.1 The Competitive Equilibrium

The model is summarized in Table 1

Table 1. Model Summary

Pricing	$\rho_t = \mu_t \frac{w_t}{A_t}$
Variety effect	$\frac{p_t}{P_t} \equiv \rho_t = \rho(N_t)$
Markup	$\mu_t = \mu(N_t)$
Profits	$d_t = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{C_t}{N_t}$
Free entry	$\upsilon_t = w_t \frac{\eta_{E,t}}{A_t}$
Number of firms	$N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$
Euler equation (shares)	$\upsilon_t = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}(\upsilon_{t+1} + d_{t+1})\right)$
Aggregate accounting equation	$C_t + N_{E,t}\upsilon_t = w_t L + N_t d_t$

It can be shown that the system in Table 1 can be reduced to a system of two equations in two variables, number of firms and consumption.

To see this, write firm value as a function of the endogenous state N_t and the exogenous state $\eta_{E,t}$ by combining free entry, pricing, variety, and markup equations:

$$\upsilon_t = \eta_{E,t}\frac{\rho(N_t)}{\mu(N_t)} \tag{1.12}$$

After substitution of (1.12) and equation for profits into the Euler equation for shares we get:

$$\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \frac{C_{t+1}}{N_{t+1}}\mu(N_t)\left(1 - \frac{1}{\mu(N_{t+1})}\right)\right]\right) \tag{1.13}$$

The number of new entrants as a function of consumption and number of firms is

$$N_{E,t} = A_t \frac{L}{\eta_{E,t}} - \frac{C_t}{\eta_{E,t}\rho(N_t)}.$$

Substituting this into the law of motion for N_t (scrolled forward one period) yields:

$$N_{t+1} = (1-\delta)\left(N_t + A_t \frac{L}{\eta_{E,t}} - \frac{C_t}{\eta_{E,t}\rho(N_t)}\right) \tag{1.14}$$

Competitive equilibrium of the economy (use of this term assume no intervention of the policy-maker in the economy and has no reference to perfect competition) is defined as follows:

<u>Definition 1(BGM (2008)): </u>*A Competitive Equilibrium (CE) consists of a 2-tuple* $\{C_t, N_{t+1}\}$*satisfying (1.13) and (1.14) for a given initial value* N_0 *and a transversality condition for investment in shares.*

The system of stochastic difference equations (1.13) and (1.14) has a unique stationary equilibrium under the following conditions. A steady-state CE satisfies:

$$\eta_E \rho(N) = \beta(1-\delta)\left[\eta_E \rho(N) + \frac{C}{N}(\mu(N)-1)\right],$$

$$C = A\rho(N)L - \rho(N)\eta_E \frac{\delta}{1-\delta} N .$$

After eliminating C, this system reduces to:

$$H^{CE}(N) \equiv \frac{AL(1-\delta)}{\eta_E\left(\frac{r+\delta}{\mu(N)-1} + \delta\right)} = N$$

where $r \equiv \frac{1-\beta}{\beta}$. Allowing households to hold bonds in the current model would simply pin down the real interest rate as a function of the expected path of consumption determined by the system in Table 1. In steady state, the real interest rate would be such that $\beta(1+r) = 1$. For notational convenience, the expression $(1-\beta)/\beta$ is replaced with r when the equations in Table 1 imply the presence of this term.

The steady-state number of firms in the CE, N^{CE}, is a fixed point of $H^{CE}(N)$

1.6.2 The Planning (Pareto) Optimum

Given the model described above, we now study a hypothetical scenario in which a social planner maximizes lifetime utility of the representative household by choosing quantities directly (including the number of goods produced).

The "production function" for aggregate consumption output is $C_t = A_t \rho(N_t) L_t^C$. Therefore, the problem solved by the social planner is the following:

$$\max_{\{N_{s+1}\}_{s=t}^{\infty}} E_t\left(\sum_{s=t}^{\infty} \beta^{s-t} U\left[A_s \rho(N_s)\left(L - \frac{1}{1-\delta}\frac{\eta_{E,s}}{A_s} N_{s+1} + \frac{\eta_{E,s}}{A_s} N_s\right)\right]\right) \tag{1.15}$$

The first order condition for this maximization problem can be written as:

$$U'(C_t)\rho(N_t)\eta_{E,t} = \beta(1-\delta)E_t\left(U'(C_{t+1})\left[\eta_{E,t+1}\rho(N_{t+1}) + \frac{C_{t+1}}{N_{t+1}}\varepsilon(N_{t+1})\right]\right) \tag{1.16}$$

This equation, together with the dynamic constraint (1.14) – law of motion for the number of firms (which is the same under the competitive and social planner equilibria), leads to the following definition.

<u>Definition 2 (BGM (2008))</u>: *A Planning Equilibrium (PE) consists of a 2-tuple $\{C_t, N_{t+1}\}$ satisfying (1.14) and (1.16) or a given initial value N_0*

The conditions for uniqueness of the stationary PE are similar to those for the CE found in the previous section. The steady-state number of firms N^{PE} is the fixed point of a function similar to $H^{PE}(N)$; where the variety effect $\varepsilon(N)$replaces the net markup:

$$H^{PE}(N) \equiv \frac{AL(1-\delta)}{\eta_E\left(\frac{r+\delta}{\varepsilon(N)} + \delta\right)} = N .$$

Below we formulate a welfare theorem that is proved in (BGM (2008)) and provides the conditions under which the competitive (CE) and social planner (PE) equilibria coincide with strictly positive entry costs

***A Welfare Theorem**:*

The Competitive and Planner equilibria are equivalent - i.e., $CE \Leftrightarrow PE$ - if and only if the following two conditions are jointly satisfied:

(i) $\mu(N_t) = \mu(N_{t+1}) = \mu$ *and*

(ii) the elasticity of product variety and the markup functions are such that $\varepsilon(x) = \mu(x) - 1$.

Major consequences of the welfare theorem that we will be discussing in the next sections:

- as competitions in quantities and in prices generate markups varying in time with the number of firms competitive equilibrium doesn't coincide with the social planner optimal one;
- as under endogenous labor supply markups are not synchronized between consumption goods and such good as leisure competitive equilibrium doesn't coincide with the social planner optimal one (section 1.7);
- fiscal policies can be introduced to bring two equilibriums together (section 1.9).

1.7 Inefficiency under Endogenous Labor Supply

Making labor supply being endogenous inside the model results in lack of markup synchronization across goods. As consequence it brings inefficiency to the competitive equilibrium that can be reached in the model. This is implied by differences in markups across the items that bring utility to households (under assumption that labor market is perfectly competitive).

From now on we assume that representative household is able to choose in the beginning of every period how much labor efforts to supply. This results in utility function being enlarged with an additional term measuring the disutility of hours worked.

Lets specify a general, nonseparable utility function over consumption and effort, $U(C_t, L_t)$, under standard assumptions ensuring that the marginal utility of consumption is positive, $U_C > 0$, the marginal utility of effort is negative, $U_L < 0$, and utility is concave: $U_{CC} < 0$, $U_{LL} < 0$ and $U_{CC}U_{LL} - (U_{CL})^2 \geq 0$

Two changes are required to the Table 1: L labor is now indexed with time period index t - L_t; and utility from now on depends not only consumption but also on number of hours worked and will be denoted as $U(C_t, L_t)$. Equation to determine labor supply in period t is obtained from the intratemporal first-order condition of the household governing the choice of labor effort:

$$-U_L(C_t, L_t) = w_t U_C(C_t, L_t) \tag{1.17}$$

Joining this with the wage schedule

$$w_t = A_t \frac{\rho(N_t)}{\mu(N_t)}, \tag{1.18}$$

which remains valid also with endogenous labor supply, yields the condition governing intratemporal substitution between consumption and leisure in case of competitive equilibrium:

$$-\frac{U_L(C_t, L_t)}{U_C(C_t, L_t)} = A_t \frac{\rho(N_t)}{\mu(N_t)} \tag{1.19}$$

Further applying other equilibrium conditions from Table 1, (1.19) can be solved to obtain hours worked as a function of consumption, the number of firms, and productivity.

The social planner optimum when labor supply is endogenous is found by solving following maximization problem:

$$\max_{\{L_s, N_{s+1}\}_{s=t}^{\infty}} E_t\left(\sum_{s=t}^{\infty}\beta^{s-t}U\left[A_s\rho(N_s)\left(L_s - \frac{1}{1-\delta}\frac{\eta_{E,s}}{A_s}N_{s+1} + \frac{\eta_{E,s}}{A_s}N_s\right), L_s\right]\right)$$

The Euler equation for the social planner's optimal choice of N_{t+1} and the law of motion for the number of firms are identical to the case of fixed labor supply, up to the addition of a time index for labor and to recognizing the dependence of household utility function on consumption and the level of effort.

The additional intratemporal condition for the planning optimum is:

$$-\frac{U_L(C_t, L_t)}{U_C(C_t, L_t)} = A_t\rho(N_t) \tag{1.20}$$

The only difference (with respect to the fixed-labor case) between the competitive market equilibrium and the social planning optimum concerns the equations governing intratemporal substitution between consumption and leisure - equations (1.19) and (1.20). Comparing these two equations shows that the two equilibria differ as follows: At the Pareto optimum, the marginal rate of substitution between consumption and leisure ($-\frac{U_L(C_t, L_t)}{U_C(C_t, L_t)}$) is equal to the marginal rate at which hours and the consumption good can be transformed into each other ($A_t\rho(N_t)$). In the competitive equilibrium this is no longer the case. There is a wedge between these two objects equal to the reciprocal of the gross price markup, $\frac{1}{\mu(N_t)}$. Since consumption goods are priced at a markup while leisure is not, demand for the latter is suboptimally high (hence, hours worked and consumption are suboptimally low).

This kind of distortion would still exist even markups across consumption goods would be synchronized and competitive equilibrium would still be inefficient. The wedge of $\frac{1}{\mu(N_t)}$ between the marginal rate of substitution between consumption and leisure in CE and PE should be dealt separately and as will be shown in section 1.9.3 taxing leisure at a rate equal to the net markup in the pricing of goods removes this distortion by ensuring effective markup synchronization.

1.8 Stability and uniqueness of the model steady state

In this section we introduce precise form of utility function and using it we solve for the steady state. We assume that utility function is of the form:

$$U(C_t, L_t) = lnC_t - \chi \frac{(L_t)^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}, \tag{1.21}$$

where $\chi > 0$ and $\varphi > 0$ is Frish elasticity of labor supply to wages, and intertemporal elasticity or substitution in labor supply. As explained in BGM (2007) the choice of utility function of this particular form was guided by results in King, Plosser, and Rebelo (1988): Given separable preferences, log utility from consumption ensures that income and substitution effects of real wage variation on effort cancel out in steady state; this is necessary to have constant steady-state effort and balanced growth if there is productivity growth.

In this case intertemporal first-order condition for allocation of labor efforts (1.17) is:

$$\chi (L_t)^{\frac{1}{\varphi}} = \frac{w_t}{C_t}$$

In this case (and also using (1.18)) equations (1.13) and (1.14) become

$$\frac{\eta_{E,t}\rho(N_t)}{\beta(1-\delta)\mu(N_t)} = E_t\left(\left(\frac{C_{t+1}}{C_t}\right)^{-1}\left[\frac{\eta_{E,t+1}\rho(N_{t+1})}{\mu(N_{t+1})} + \frac{C_{t+1}}{N_{t+1}}\left(1-\frac{1}{\mu(N_{t+1})}\right)\right]\right)$$

$$N_{t+1} = (1-\delta)\left(N_t + \frac{A_t^{1+\varphi}}{\eta_{E,t}}\left(\frac{\rho(N_t)}{\mu(N_t)\chi C_t}\right)^{\varphi} - \frac{C_t}{\eta_{E,t}\rho(N_t)}\right) \tag{1.22}$$

Equations allow us to solve for the steady-state number of firms and consumption (and therefore all other variables) by solving the system of equations (1.23,1.24):

$$N = [\chi(r+\delta)]^{-\varphi}\left[(1-\delta)\frac{A}{\eta_E}\right]^{1+\varphi}\frac{\left(\frac{\mu(N)-1}{N\mu(N)}\right)^{\varphi}}{\delta + \frac{r+\delta}{\mu(N)-1}} \tag{1.23}$$

$$C = \frac{(r+\delta)\rho(N)}{(1-\delta)(\mu(N)-1)}N\eta_E \tag{1.24}$$

Under assumptions of log-normality and homoskedasticity log-linearization around the steady state provides:

$$\hat{N}_{t+1} = \left[1-\delta+\frac{r+\delta}{\mu-1}\varepsilon+\left(\frac{r+\delta}{\mu-1}+\delta\right)\varphi(\varepsilon-k)\right]\hat{N}_t - \left[\varphi\left(\frac{r+\delta}{\mu-1}+\delta\right)+\frac{r+\delta}{\mu-1}\right]\hat{C}_t + (1+\varphi)\left(\frac{r+\delta}{\mu-1}+\delta\right)\hat{A}_t - \delta\eta_{E,t} \tag{1.25}$$

$$\hat{C}_t = \frac{1-\delta}{1+r}E_t\left(\hat{C}_{t+1}\right) - \left[\frac{1-\delta}{1+r}(\varepsilon-k) - \frac{r+\delta}{1+r}\left(1-\frac{k}{\mu-1}\right)\right]\hat{N}_{t+1} + (\varepsilon-k)\hat{N}_t - \frac{1-\delta}{1+r}E_t\left(\hat{\eta}_{E,t+1}\right) + \hat{\eta}_{E,t} \tag{1.26}$$

where $k \equiv \mu(N)' \dfrac{N}{\mu(N)}$ is the elasticity of the markup function with respect to the number of firms and hat above the variable means percent deviation from the steady state level for this variable. Equation (1.25) states that the number of firms producing at $t+1$ increases if consumption at time t is lower (households prefer more investment in the new firms to consumption), if the sunk entry cost is below the initial level, or if productivity is higher. Equation (1.26) states positive relation between consumption at time t and expected future consumption, number of firms in the economy in the current period, sunk entry cost in current period; negative relation with expected sunk entry cost in future period; undetermined relation with number of firms in the future period. This means that the higher expected future consumption and the larger the number of firms producing at time t higher is consumption at time t. Current deregulation lowers current consumption, because households save more to finance faster firm entry. However, expected future deregulation boosts current consumption as households anticipate the availability of more varieties in the future. The effect of N_{t+1} depends on parameter values. From empirical evidence we normally can assume that $\varepsilon - k > \dfrac{r+\delta}{1-\delta}$: and this implies that an increase in the number of firms producing at $t+1$ is associated with lower consumption at t.

The system (1.25)-(1.26) has a unique, non-explosive solution for any possible parametrization. Under assumption that productivity follows first order autoregressive process $\hat{A}_t = \phi_A \hat{A}_{t-1} + \varepsilon_{A,t}$ where $\varepsilon_{A,t}$ is an i.i.d., normal innovation with zero mean and variance $\sigma^2_{\varepsilon_A}$, we can solve the system. Differently from productivity, $\eta_{E,t}$ is not treated as a stochastic process subject to random innovations at business cycle frequency, because it is rational to assume that market regulation is controlled by a policymaker, who can change it in more or less persistent fashion, so that $\eta_{E,t} = \phi_{\eta_E}\eta_{E,t-1}$ in all periods after an initial change.

Proof of non-explosiveness (BGM (2007)):

$$\begin{bmatrix} C_{t+1} \\ N_{t+1} \end{bmatrix} = M \begin{bmatrix} C_t \\ N_t \end{bmatrix} \text{ where } M \equiv \begin{bmatrix} \frac{1+r}{1-\delta} - \Theta \frac{r+\delta}{\mu-1} & \Theta\Phi - \frac{1+r}{1-\delta}(\varepsilon - k) \\ -\frac{r+\delta}{\mu-1} & \Phi \end{bmatrix},$$

$$\Theta \equiv \varepsilon - k - \frac{r+\delta}{1-\delta}\left(1 - \frac{k}{\mu-1}\right), \ \Phi \equiv 1 - \delta + \frac{r+\delta}{\mu-1}\varepsilon$$

Existence of a unique, non-explosive, rational expectations equilibrium requires that one eigenvalue of M be inside and one outside the unit circle. The characteristic polynomial of M takes the form

$$J(\lambda) = \lambda^2 - \lambda \cdot trace(M) + det(M), \text{ where}$$

$$trace(M) = 1 - \delta + \frac{1+r}{1-\delta} + k\frac{r+\delta}{\mu-1}\left[1 - \frac{r+\delta}{(1-\delta)(\mu-1)}\right] + \frac{r+\delta}{1-\delta}\frac{r+\delta}{\mu-1}$$

$$\det(M) = 1 + r + \frac{r+\delta}{1-\delta}\frac{r+\delta}{\mu-1}k$$

The condition for existence of a unique, non-explosive rational expectations equilibrium is $J(-1)J(1) < 0$, where $J(1) = -\frac{r+\delta}{1-\delta}\left(\delta + \frac{r+\delta}{\mu-1}\right) + k\frac{(r+\delta)^2}{1-\delta}\frac{\mu}{(\mu-1)^2} < 0$ if and only if

$$k < \frac{\mu-1}{\mu}\frac{r+\delta\mu}{r+\delta}$$

Since $k \leq 0$ and the right-hand side of the latter inequality is always positive, this condition is always satisfied. Moreover, $J(-1) = 4 + 2r - J(1) > 0$ J whenever $J(1) < 0$ so there exists a unique, stable, rational expectations equilibrium for any possible parametrization.

1.8.1 Steady state under different forms of competition

We call (1.23) equation of motion of the number of firms. It can be numerically solved for consumption and is hump shaped function of the number of firms. We will depict it with solid line on phase diagrams (N,C) (see as example Figure 1 - Phase diagram of (N,C) in case of monopolistic competition and parameter values as $\varphi = 1$, $\theta = 4$, $A = 0.5$, $\eta = 0.025$)

One can also study the impact of the elasticity of labor supply φ on the steady state endogenous market structures. When it is large, agents tend to work more, which tends to allow entry of a larger number of firms and strengthens competition. At least for low values of φ, its increase is associated with an increase in the steady state consumption level, and with a reduction of the markups.

We call (1.24) – steady state consumption equation. We will depict it with dotted line on phase diagrams (N,C) (see as example Figure 1). Steady state consumption equation represents a positive and convex relation between the number of firms and the consumption index, as can be seen in Figure 1. Two effects operate in the same direction: on one side more firms produce more in total and create larger gains from variety, on the other side they are more competitive and each one of them produces more of its variety. Notice that when the discount factor β increases, this relation is shifted downward: more patient agents invest more and are able to consume less in steady state.

In particular equation (1.24) in case of competition in quantities (Cournot) becomes:

$$C = \eta_E N^{\frac{\theta}{\theta-1}} \frac{(1-\beta(1-\delta))}{\beta(1-\delta)} \frac{(\theta-1)(N-1)}{(\theta+N-1)};$$

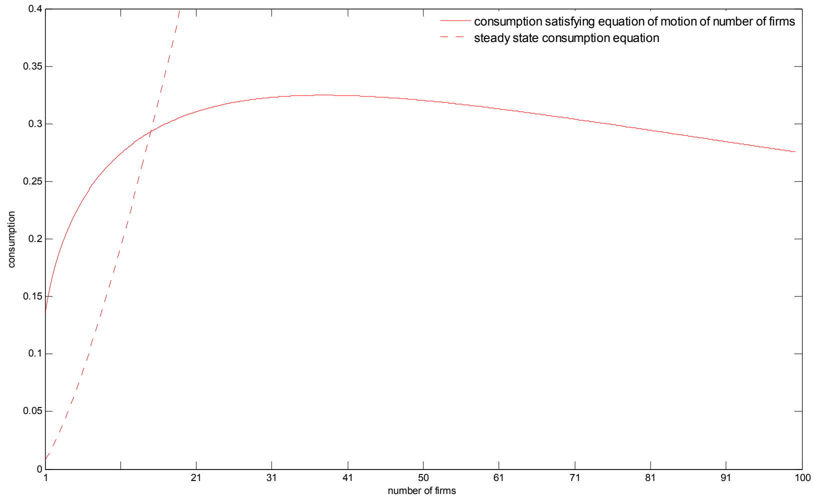
in case of competition in prices (Bertrand) becomes:

$$C = \eta_E N^{\frac{1}{\theta-1}} \frac{(1-\beta(1-\delta))}{\beta(1-\delta)} (\theta-1)(N-1);$$

in case of monopolistic competition becomes:

$$C = \eta_E N^{\frac{\theta}{\theta-1}} \frac{(1-\beta(1-\delta))}{\beta(1-\delta)} (\theta-1)$$

Figure 1 Phase diagram of (N,C) under monopolistic competition
(in case of $\varphi = 1$, $\theta = 4$, $A = 0.5$, $\eta = 0.025$)



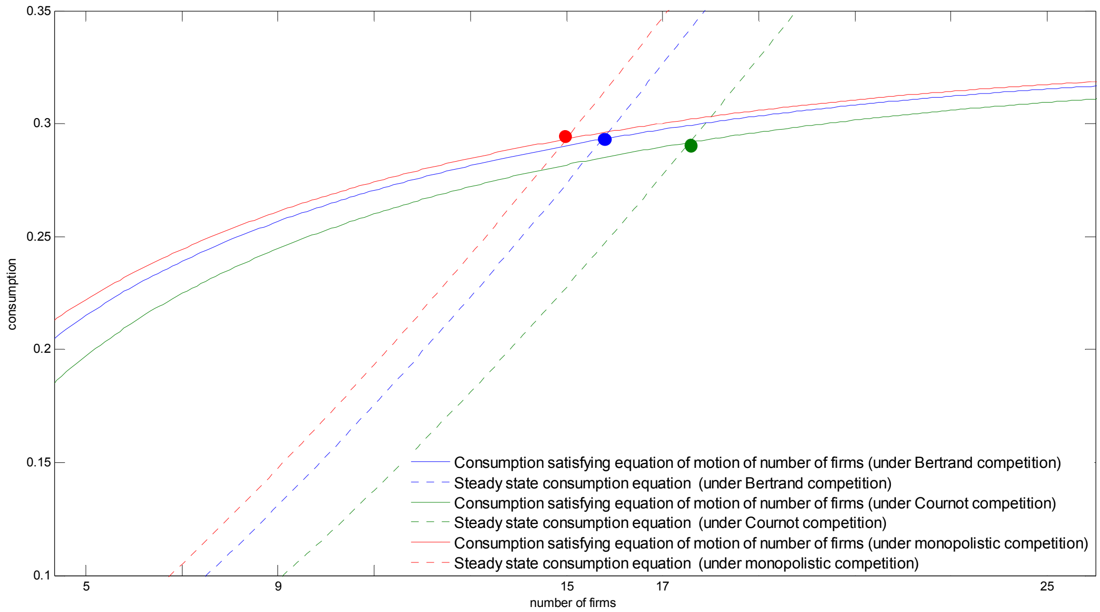
We now study relation between steady states under different forms of competition. On Figure 2 we depict phase diagrams (N,C): for Cournot competition - in green, for Bertrand competition - in blue, for monopolistic competition - in red, together. From this diagram we see that

1) given the same structural parameters, the endogenous market structure in steady state with competition in quantities (Cournot) imply a larger number of firms compared to the case of competition in prices (Bertrand). Even if Cournot competition generates higher mark ups, endogenous entry attracts more firms and strengthens competition;

2) both forms of competition – in prices and in quantities imply larger number of firms than monopolistic competition;

3) both forms of competition have levels of consumption being less than in case of monopolistic competition.

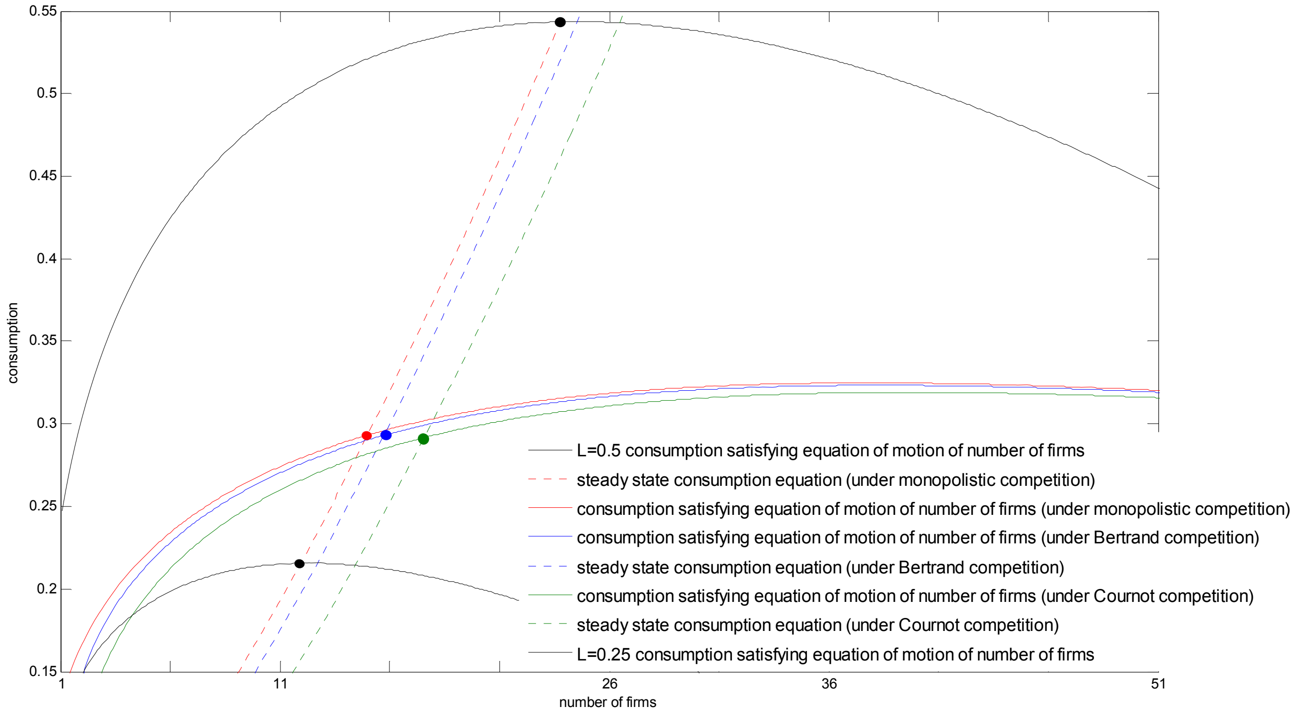
Figure 2 Phase diagram of (N,C) under different forms of competition
(in case of $\varphi = 1$, $\theta = 4$, $A = 0.5$, $\eta = 0.025$)



We are interested how far all steady states depart from Pareto optimal steady state specified by (1.14) and (1.16).

On Figure 3 we depict optimal steady states with black dots, one corresponds to exogenous labor of 0.5, another – of 0.25. Black solid lines depict equation (1.14) of motion of firms under exogenous labor condition for exogenous labor of 0.5, another – of 0.25. Intersections with (1.16) steady state consumption equation (in our case it coincides with steady state consumption equation under monopolistic competition) are marked with black dots and correspond to optimal steady states.

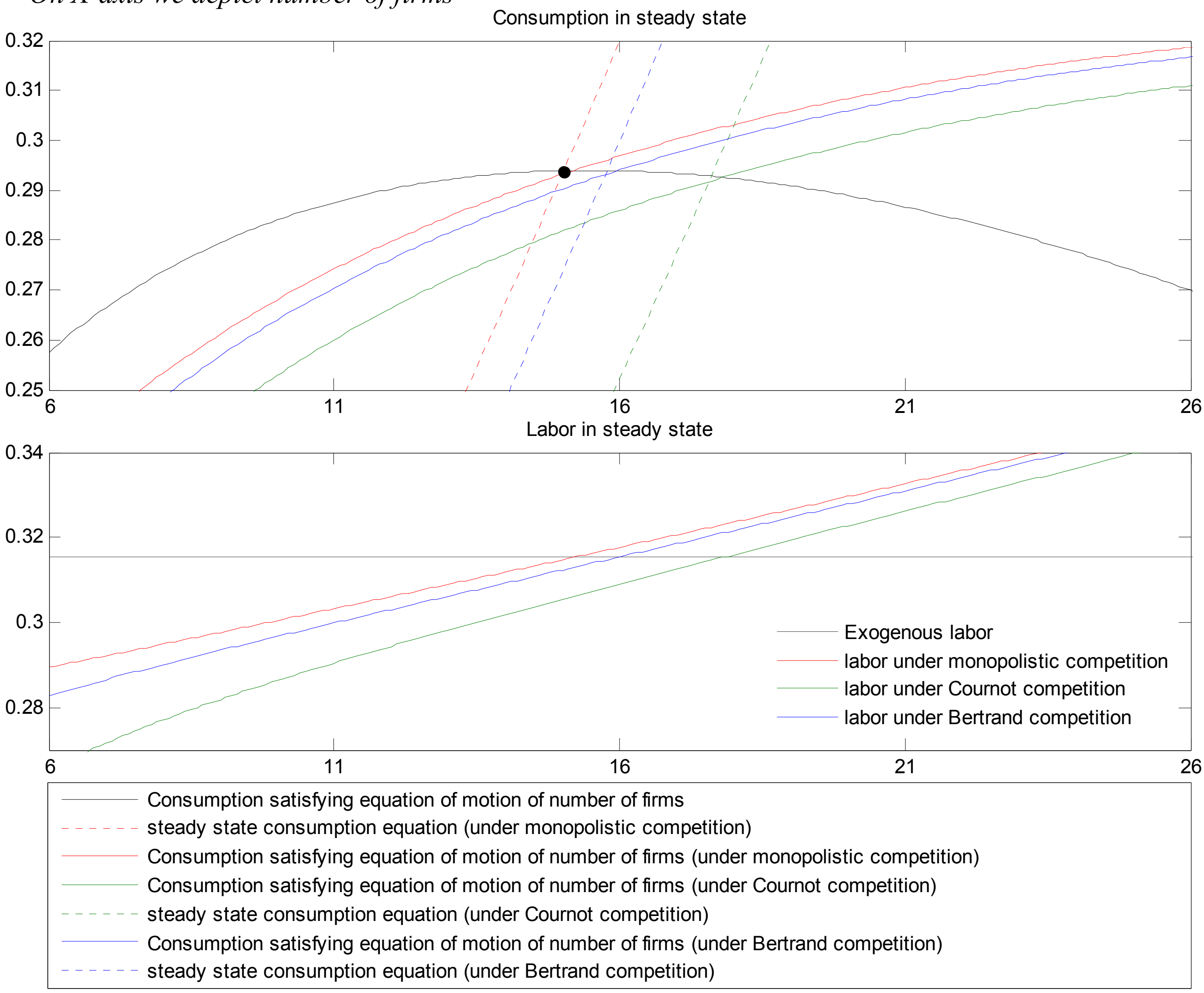
Figure 3 Phase diagram of (N, C) under different forms of competition and under exogenous labor supply condition (in case of $\varphi = 1$, $\theta = 4$, $A = 0.5$, $\eta = 0.025$)



We set level of exogenous labor on the level to make competitive equilibrium steady state under monopolistic competition to be optimal steady state, in this case we get Figure 5 (Black solid line depict equation (1.14) of motion of firms under exogenous labor condition. Intersection with (1.16) steady state consumption equation (in our case it coincides with steady state consumption equation under monopolistic competition) is marked with black dot and corresponds to optimal steady states).

We can conclude that monopolistic competition steady state is the closest from the optimal one. We just need to correct for inefficiency created by exogeneity of labor. Bertrand steady state is the next closet one: in particular, after correction for the exogenous labor inefficiency and taking into account integer constraint for the number of firms we see that Bertrand steady state departs from optimal one at most for 1 firm. And as was noted before the endogenous market structure in the steady state with competition in quantities (Cournot) implies a larger number of firms compared to the case of competition in prices (Bertrand), so Cournot steady state is the most distant from optimal steady state.

Figure 5 Phase diagram of (N,C) under different forms of competition, exogenous labor level is set to equate monopolistic steady state to the Pareto optimal one.
(in case of $\varphi = 1$, $\theta = 4$, $A = 0.5$, $\eta = 0.025$)
On X-axis we depict number of firms



1.9 Optimal fiscal policies

Table 2 summarizes remedies proposed in BGM (2008) needed to reach first best allocation.

Here we consider the general case when both conditions of welfare theorem are not fulfilled and correction is needed under inelastic labor supply and the case of elastic labor supply as additional source of inefficiency.

For us in particular will matter sales subsidy and entry subsidy as proposed optimal tax path can be applied also to the model of competition in prices and quantities. And, of course, labor supply subsidy will matter for us as source of correction of inefficiency arising from having endogenous labor supply model setup.

Table 2 Fiscal policies implying first best allocation

Case:	**inelastic labor supply**	**elastic labor supply**
Source of inefficiency	Markups are not synchronized in time $\mu(N_t) \neq \mu(N_{t+1}) \neq \mu$ Elasticity of product variety and the markup functions are such that $\varepsilon(x) \neq \mu(x) - 1$.	Heterogeneity in markups across consumption and leisure (leisure good that is not subject to a markup, priced at marginal cost in a competitive labor market)
Remedies	sales subsidy financed by lump-sum taxes on consumers	Subsidizing/taxing labor supply at a rate equal to the net markup in consumption goods prices, even if goods remain priced above marginal cost. Applying a lump-sum tax/transfer to the households
	proportional to entry cost subsidy financed by lump-sum taxes on firm profits	

1.9.1 Subsidy to firm entry

We start by studying a policy that subsidizes firm entry at rate τ_t^{entry}: Therefore, entrants pay only $\left(1 - \tau_t^{entry}\right) w_t \frac{\eta_{E,t}}{A_t}$ entry cost in units of consumption, and this subsidy is fully financed by lump-sum taxes on consumers T_t. The only equations in Table 1 that are chnaged are the free entry condition, which becomes

$$\upsilon_t = \left(1 - \tau_t^{entry}\right) w_t \frac{\eta_{E,t}}{A_t}$$

and the aggregate resource constraint, which becomes

$$C_t + N_{E,t} \frac{\upsilon_t}{\left(1 - \tau_t^{entry}\right)} = w_t L + N_t d_t$$

after substituting the government balanced budget constraint is

$$T_t = \tau_t^{entry} w_t \frac{\eta_{E,t}}{A_t} N_{E,t}$$

Proposition: A subsidy to firm entry restores efficiency of the competitive equilibrium if:

$$1 - \tau_t^{entry^*} = \frac{\mu(N_t) - 1}{\varepsilon(N_t)},$$

$$1 - \tau_{t+1}^{entry^*} = \frac{\mu(N_{t+1})}{\mu(N_t)} \left(1 - \tau_t^{entry^*}\right)$$

Proof: The Proposition is readily proven once one observes that under the entry subsidy τ_t^{entry} the state equation for the number of firms (1.14) remains unchanged and the Euler equation for shares holding in the competitive economy (1.13) becomes

$$\left(1 - \tau_t^{entry}\right)\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\left(1 - \tau_{t+1}^{entry}\right)\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \frac{C_{t+1}}{N_{t+1}}\mu(N_t)\left(1 - \frac{1}{\mu(N_{t+1})}\right)\right]\right)$$

Comparing this with the planning optimum and using the conditions from The Welfare Theorem, we arrive the optimal path of entry subsidies $\tau_t^{entry^*}$ as indicated in Proposition.

1.9.2 Sales subsidy

Another possibility to restore efficiency of competitive equilibrium is a subsidy to firm sales because it influence the pricing decisions of firms (this method was studied by many papers since Robinson (1933) that were addressing the possible distortions associated with monopoly).

Proposition: A subsidy to firm sales τ_t^{sales} *financed by lump-sum taxes on firm profits* T_t^{profit} *restores efficiency of the competitive equilibrium if the optimal path of is:*

$$\frac{1 + \tau_{t+1}^{sales^*}}{1 + \tau_t^{sales^*}} = \frac{\mu(N_{t+1})}{\mu(N_t)}$$

$$\frac{\mu(N_t)}{1 + \tau_t^{sales^*}}\left(1 - \frac{1 + \tau_{t+1}^{sales^*}}{\mu(N_{t+1})}\right) = \varepsilon(N_{t+1})$$

Proof: Profit function can be obtained from (1.11) and becomes

$$d_t = \left(1 + \tau_t^{sales}\right)\rho_t y_t - w_t l_t - T_t^{profit}$$

Optimal pricing is changed in the following way:

$$\rho_t = \frac{\mu(N_t)}{1 + \tau_t^{sales}} \frac{w_t}{A_t}$$

So profit function becomes $d_t = \left(1 + \tau_t^{sales}\right)\rho_t y_t - \frac{\left(1 + \tau_t^{sales}\right)\rho_t}{\mu(N_t)} y_t - T_t^{profit}$

Assuming zero lump-sum taxation, balanced budget implies:

$$T_t^{profit} = \tau_t^{sales} \rho_t y_t$$

So profits are finally given by

$$d_t = \left(1 - \frac{1 + \tau_t^{sales}}{\mu(N_t)} \right) \rho_t y_t = \left(1 - \frac{1 + \tau_t^{sales}}{\mu(N_t)} \right) \frac{C_t}{N_t}$$

The value of the firm is given by

$$\upsilon_t = w_t \frac{\eta_{E,t}}{A_t} = \rho_t \frac{1 + \tau_t^{sales}}{\mu(N_t)} \eta_{E,t}$$

Euler equation for the shares yields:

$$\frac{1 + \tau_t^{sales}}{\mu(N_t)} \eta_{E,t} \rho(N_t) = \beta(1 - \delta) E_t \left(\frac{U'(C_{t+1})}{U'(C_t)} \left[\frac{1 + \tau_{t+1}^{sales}}{\mu(N_{t+1})} \eta_{E,t+1} \rho(N_{t+1}) + \frac{C_{t+1}}{N_{t+1}} \left(1 - \frac{1 + \tau_{t+1}^{sales}}{\mu(N_{t+1})} \right) \right] \right)$$

Comparing this with the planning optimum and using the conditions from The Welfare Theorem, we find the optimal path of sales subsidy $\tau_t^{sales^*}$ as indicated in Proposition.

1.9.3 Labor subsidy

When labor supply is elastic, there is one more distortion to correct for. Efficiency can clearly be restored by subsidizing labor supply (or taxing leisure) at a rate equal to the net markup in the pricing of consumption goods and applying a lump-sum tax/transfer to the households. Assume that the government subsidizes labor at the rate τ_t^{labor},financing this policy with lump-sum taxes on household income.

The first-order condition for the household's optimal choice of labor supply (1.17) is the only equilibrium condition that is affected by the labor subsidy:

$$-U_L(C_t, L_t) = \left(1 + \tau_t^{labor}\right) w_t U_C(C_t, L_t)$$

Combining this with the wage schedule (1.18) yields

$$-\frac{U_L(C_t, L_t)}{U_C(C_t, L_t)} = \left(1 + \tau_t^{labor}\right) A_t \frac{\rho(N_t)}{\mu(N_t)},$$

Comparing this equation to (1.20) shows that a rate of taxation of leisure equal to the net markup of price over marginal cost,

$$1 + \tau_t^{labor^*} = \mu(N_t)$$

restores efficiency of the market equilibrium. This policy ensures synchronization of markups across consumption goods and leisure.

Chapter 2 Model Dynamics – Propagation of Shocks

2.1 Shock to sunk entry cost

In this section we want to identify the extent to which the endogenous market structures influence the propagation of shocks throughout the economy. The EMSs approach allows us to study different forms of supply shocks. We do this on the example a shock to sunk entry cost. We compare it to the impact of a productivity shock.

Our model allows for a large variety of combinations of substitutability between goods (θ) and markup (μ), which in turn depends on the form of competition. We consider cases of Cournot, Bertrand and monopolistic competition discussed in section 1.3.

Calibration of structural parameters is standard and follows King and Rebelo (1999). The time unit is a quarter. The discount factor, β, is 0.99, while the rate of business destruction, δ, equals 0.025 implying an annual rate of 10 %. The Frish elasticity of labor supply is φ, and we fix it at 4 as in King and Rebelo (1999).

Government spending is financed by lump sum tax and is 20% of total output of the economy, replicating reality the real world economy.

Differences in response to a productivity shock and a sunk entry cost shock

A shock of 1% increase in productivity decreases marginal cost of production and respectively causes markups decrease. A shock of 1% increase in sunk entry costs augments up-front investments and respectively causes markups increase. High entry cost compared to the size of the market leads to a smaller number of competitors and thus to higher markups. As consequence of markups moving in contrary directions for these two types of shocks, all other variables also respond contrary. We may say that productivity shock is a positive one, while sunk entry cost shock is a negative one. To correct for this and keep the same direction of variable responses for both shocks we will consider a shock of 1% decrease in sunk entry costs, and will compare it to a shock of 1% increase in productivity.

In case of the productivity shock we set the steady state productivity value to $A = 1$ and the baseline value for the entry cost is set to $\eta = 1$. Shock to the model technology parameter follows the first order autoregressive process: $\hat{A}_t = \phi_A \hat{A}_{t-1} + \varepsilon_{A,t}$ where hat above the variable means percent deviation from steady state level for this variable, $\phi_A \in (0,1)$ is the autocorrelation coefficient and $\varepsilon_{A,t}$ is a white noise disturbance, with zero expected value and standard deviation $\sigma^2_{\varepsilon_A}$.

In case of the sunk entry cost shock we set the steady state entry cost value to $\eta = 1$ and the baseline value for productivity to $A = 1$. Shock to the sunk entry cost parameter follows the first order autoregressive process: $\left(\frac{1}{\hat{\eta}}\right)_t = \phi_\eta \left(\frac{1}{\hat{\eta}}\right)_{t-1} + \varepsilon_{\eta,t}$ where hat above the variable means percent deviation from steady state level for this variable, $\phi_\eta \in (0,1)$ is the autocorrelation coefficient and $\varepsilon_{\eta,t}$ is a white noise disturbance, with zero expected value and standard deviation $\sigma^2_{\varepsilon_\eta}$.

Figure 6 depicts percentage deviations from the steady state of key variables in response to a 1 % productivity shock and sunk entry cost shock with persistency $\phi_A = \phi_\eta = 0,9$. We simulate for the case of Cournot competition and the degree of substitutability is 6 ($\theta = 6$). Time on the horizontal axis is in quarters.

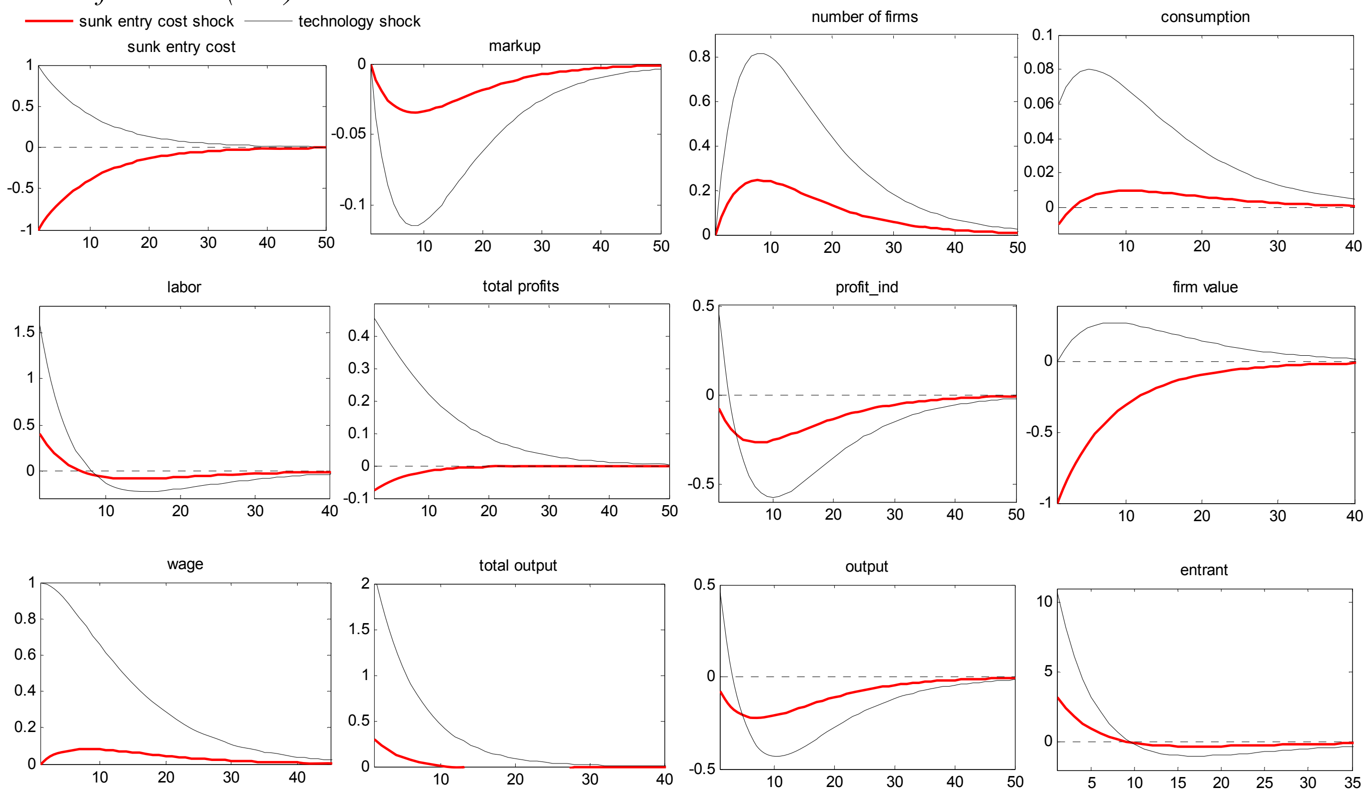
We see that the productivity shock has a stronger effect in terms of deviation from the steady state. Response of the markup and the number of firms to the productivity shock is more than double in comparison with the sunk entry cost shock. Explanation of this is the fact that the productivity shock initially impacts a bigger number of firms (i.e., all firms that are on the market at the moment of the shock) while decrease in the entry cost initially impacts a smaller number of firms – only "new entrant firms". So the propagation of a productivity shock happens with a higher strength.

We further proceed with the comparison of variables response to both shocks. In advance we need to say that even if directions of convergence back to the steady state are the same, the incentives to this behavior are different.

First, we explain our intuition for the variables response to the sunk entry cost shock. The number of entrants increases, it strengthens market competition and reduces the markups. A reduction in the markup means a reduction in profits and consequently in the firms value as it is discounted sum of future profits. The consumption initially decreases as households decide to postpone it in favor of investments and the entrance to the market by investing into creation of new firms. The firm value is very cheap. At the same time households feel poorer due to a reduction in profits as it is a source of their income and no changes in their wages as another source of their income, so they increase labor supply.

An increase in the total number of firms leads to an increase in labor demand from the firms side and this pushes up wages. Thus households reduce labor supply. At the same time as the total profits and the firms value grow households feel richer and increase their consumption. They start decreasing investments as creation of new firms becomes more expensive due to the wages increase.

Figure 6 Decrease in sunk cost of entry shock vs production shock ($\theta = 6$) – impulse response functions (IRF)



At some point the variable "the number of new entrants" crosses its steady state level. It happens at the same time for the both shocks. At this point the total number of firms reaches their maximum and the markup their minimum level. From this moment net exit from the market starts. This makes the markup start increasing towards the steady state level. Individual profits as well as individual output start increasing. Wages start decreasing with decreasing labor demand from the firms side. Labor supply increases in response.

As shocks vanish variables converge to initial steady state levels.

The table below summarizes main differences in the variables behavior for both shocks.

Table 3 Differences in response to a productivity shock and a sunk entry cost shock

Variable	*Initial response*		*Behavior along the transition path*	
	A shock	*η shock*	*A shock*	*η shock*
consumption	+	–		
individual profit	+	–	Decreases	Increases
wage	+	No reaction	Decreases	Hump shaped that starts from increase
output	+	–		
firm value	No reaction	–	Hump shaped that starts from increase	Increases

The explanation for these differences is the dissimilar incentives driving the variables reaction. Contrary to a sunk entry cost shock productivity shock increases individual output and profits on impact. There is a big demand for labor as production is profitable, that is why wages are initially pushed up. As there are more profits in the economy and also wages are high households feel rich – so they have a higher consumption level than in the steady state. The firms' value being equal to the cost of entry $\upsilon_t(\omega) = w_t \frac{\eta_{E,t}}{A_t}$ doesn't change as two effects – increase in labor productivity and increase in labor cost – cancel each other out.

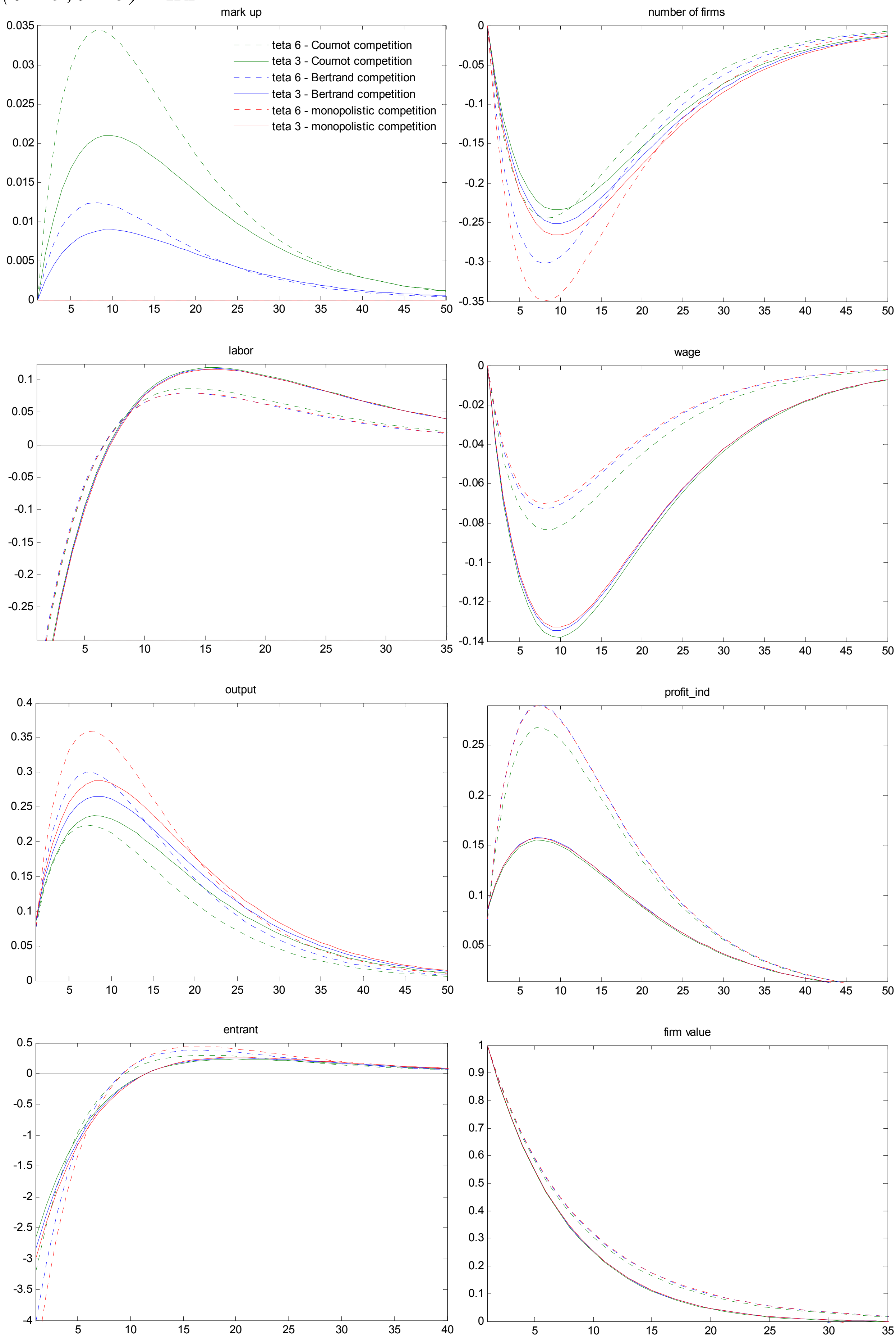
Response to a shock under different types of competition

It is important to outline the difference between variables responses in case of different markup types, i.e. different forms of competition. On Figure 7 we report impulse response functions for a temporary shock of 1% increase in sunk entry cost. We consider degree of substitutability θ of 6 and 3 ($\theta = 6$, $\theta = 3$) and we consider three forms of competition (in quantities – in green, in prices – in blue and monopolistic – in red).

First we report difference in the variables steady state values. Under competition in prices and in quantities (for $\theta = 6$) the market structure is generated endogenously and the steady state markups are respectively 23,7 % and 36,8 %, both belonging to the empirically reasonable range, for the monopolistic competition markup is 20% and is constant. As was shown in steady state analysis, when firms compete in prices the equilibrium markups 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 the steady state, lower markups are associated with a lower saving rate as well.

In spite of these substantial differences in the steady state of the economy, Figure 7 shows that the quantitative reaction of the main aggregate variables to the *shock are similar under all forms of competition*. The impact of the shock is strengthened by competition effect. Along the transition path we see how new firms entry starts reduction of markups by strengthening market competition. But we cannot unambiguously conclude which type of competition creates stronger response to the shock as it differs from variable to variable and also with degree of substitutability.

Figure 7 Increase in sunk cost of entry shock – comparison of different forms of competition ($\theta = 6$, $\theta = 3$) – IRF



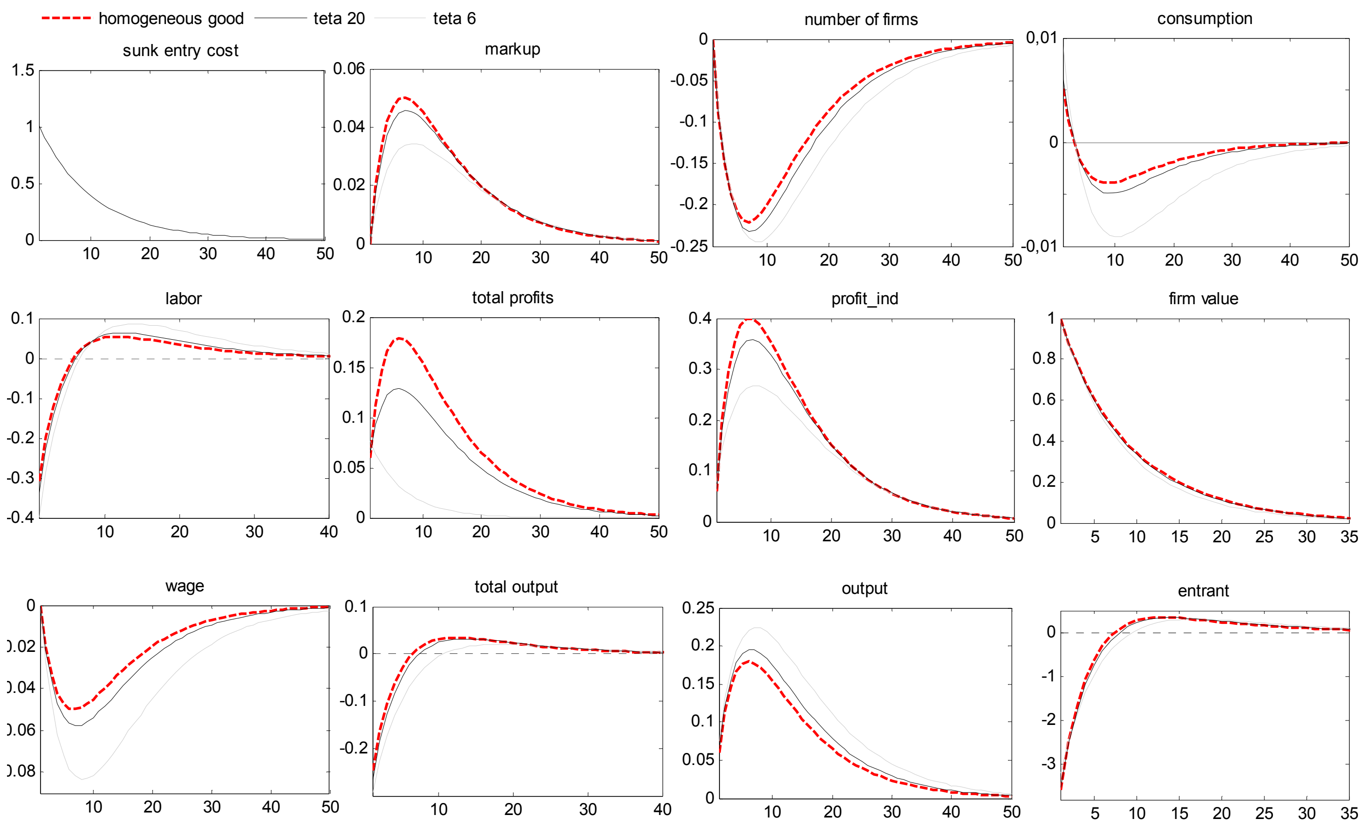
Response to a shock under different degree of substitutability

When we increase the degree of substitutability (for example as we pass from $\theta = 6$ to $\theta = 20$ and $\theta = \infty$ – case of homogeneous good) the same qualitative results hold but the impact of the shock on competition and mark ups becomes stronger.

We depict this situation on Figure 8 for the case of Cournot competition.

The noticeable difference is total profits decrease along all transition path in case of low degree of substitutability, while total profits are hump-shaped in case of high degree of substitutability. This can be explained by significant decrease in the number of firms in case of low substitutability so that individual profits generated by firms are not enough to make total profits grow.

Figure 8 Increase in sunk cost of entry shock – Cournot competition, $\theta = 6$, $\theta = 20$, $\theta = \infty$ – IRF



2.2 Model modification – incorporation of taxes

Lump sum tax

We start with incorporating taxes in the original model with lump sum tax as the most easy example in terms of changes needed to the system of model equations (Table 1). The only equation that is touched by the change is Aggregate accounting equation (1.11)

$$C_t + N_{E,t}\upsilon_t + T_t = w_t L_t + N_t d_t \tag{2.1}$$

In each period households receive 2 types of income: first is income from labor $w_t L_t$ and second is return in form of dividends from holding stock $N_t d_t$. They use their income to consume C_t, to invest in creation of new firms $N_{E,t}\upsilon_t$ and pay out taxes T_t.

We also introduce government budget constraint saying that taxes gathered in period t, T_t should cover government spending in this period, G_t: $G_t = T_t$

We also modify equation of profits (1.5) as follows

$$d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{Y_t^{C+G}}{N_t} \text{ or in equilibrium } d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{C_t + G_t}{N_t} \tag{2.1}$$

because having government spending means that consumption output of the economy becomes consumption and government spending output of the economy and should be in equilibrium the sum of consumption demand C_t and government spending G_t.

Consequently two main equations derived from the model system of equations (Table 1) – equations needed to calculate consumption (1.13) and number of firms (1.14) in $t+1$ are changed to include lump sum tax and government spending (See derivation in Appendix1)

$$\begin{cases} \eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \frac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1 - \frac{1}{\mu(N_{t+1})}\right)\right]\right) \\ N_{t+1} = (1-\delta)\left(N_t + A_t\frac{L}{\eta_{E,t}} - \frac{C_t + G_t}{\eta_{E,t}\rho(N_t)}\right) \\ G_t = T_t \end{cases}$$

(2.3)

For the case of endogenous labor supply equation for the number of firms (modified equation (1.22)) that we will be using becomes

$$N_{t+1} = (1-\delta)\left(N_t + \frac{A_t^{1+\varphi}}{\eta_{E,t}}\left(\frac{\rho(N_t)}{\mu(N_t)\chi C_t}\right)^{\varphi} - \frac{C_t + G_t}{\eta_{E,t}\rho(N_t)}\right)$$

Distortionary taxation – Labor tax

As in the case of lump sum tax Aggregate accounting equation (1.11) has to be modified. We have the following

$$C_t + N_{E,t}\upsilon_t + \tau_t^L w_t L_t = w_t L_t + N_t d_t$$

Households use their total income $w_t L_t + N_t d_t$ to consume, to invest in creation of new firms and pay out taxes $\tau_t^L w_t L_t$, where labor income $w_t L_t$ is taxed at the rate of τ_t^L.

We can re-write our modified Aggregate accounting equation as:

$$C_t + N_{E,t}\upsilon_t = \left(1 - \tau_t^L\right) w_t L_t + N_t d_t$$

in order to show that in comparison with original model (1.11) here we have households getting less income from labor as part of it is taken by the government in the form of labor tax τ_t^L.

Government budget constraint is

$$G_t = \tau_t^L w_t L_t \qquad (2.4)$$

Taxes gathered from labor income in period t – $\tau_t^L w_t L_t$ should cover government spending in this period - G_t.

If in the model we have endogenous labor supply then we need to modify also intertemporal first-order condition for allocation of labor efforts (1.17) which in case of using utility function of the form (1.21) becomes:

$$\chi \left(L_t\right)^{\frac{1}{\varphi}} = \frac{\left(1 - \tau_t^L\right) w_t}{C_t}$$

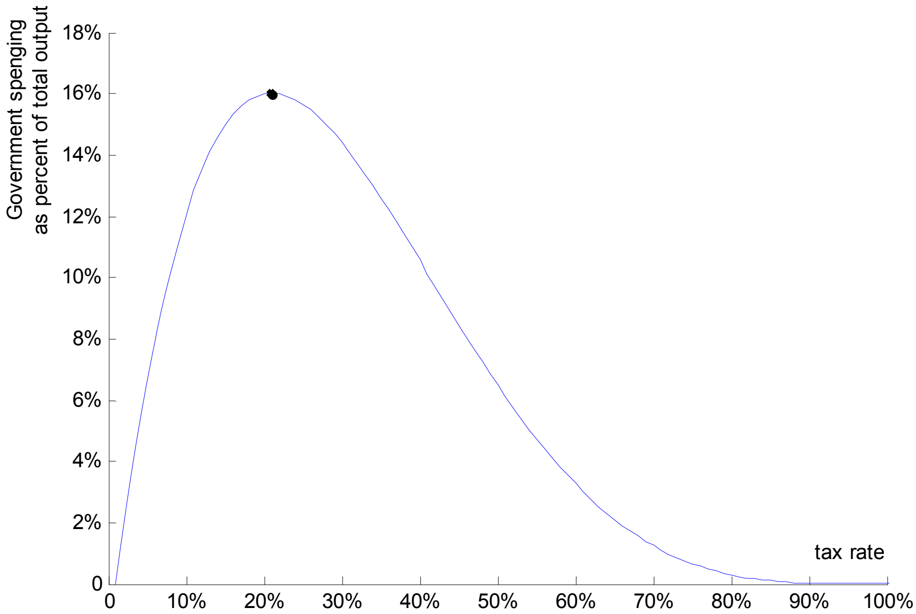
From it labor supply will be defined as

$$L_t = \left(\frac{\left(1 - \tau_t^L\right) w_t}{\chi C_t} \right)^{\varphi} \qquad (2.5)$$

We should keep in mind that in comparison with the previous case where lump sum tax was limited to the total income, here we are limited to the total income from labor (which is obviously something less than the total income) in each period and we need to be accurate with the figure of government spending we can afford. Numerical calculation show that we can't anymore support government spending on the level of 20% of total output as was in the setup of original model.

Maximum that we can have in the steady state keeping all other model parameters the same is 16%. It is shown on the Figure 9 where we depict government spending as a function of tax rate (combining (2.4) and (2.5) we derived $\frac{G}{Y} = \frac{\tau^L (1-\tau^L)^{\varphi} w^{\varphi+1}}{\chi^{\varphi} C^{\varphi}} \Big/ Y$)

Figure 9 Government spending as function of tax rate



Consequently system of equations for derivation of consumption and number of firms in period $t+1$ under the case of endogenous labor supply (2.3) and existence of labor tax becomes:

$$\begin{cases} \eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \frac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1-\frac{1}{\mu(N_{t+1})}\right)\right]\right) \\ N_{t+1} = (1-\delta)\left(N_t + \frac{A_t^{1+\varphi}}{\eta_{E,t}}\left(\frac{\rho(N_t)(1-\tau_t^L)}{\mu(N_t)\chi C_t}\right)^{\varphi} - \frac{C_t+G_t}{\eta_{E,t}\rho(N_t)}\right) \\ G_t = \tau_t^L w_t L_t \end{cases}$$

(2.6)

Distortionary taxation – Profit tax

As in the case of lump sum tax Aggregate accounting equation (1.11) has to be modified. We have the following

$$C_t + N_{E,t}\upsilon_t + \tau_t^d N_t d_t = w_t L_t + N_t d_t$$

Households use their total income $w_t L_t + N_t d_t$ to consume, to invest in creation of new firms and pay out taxes $\tau_t^d N_t d_t$, where profit income $N_t d_t$ is taxed at the rate of τ_t^d.

We can re-write our modified Aggregate accounting equation as:

$$C_t + N_{E,t}\upsilon_t = w_t L_t + \left(1-\tau_t^d\right)N_t d_t$$

in order to show that in comparison with original model (1.11) here we have households getting less income from investments as part of it is taken by the government in the form of profit tax τ_t^d.

Government budget constraint is

$$G_t = \tau_t^d N_t d_t \qquad (2.7)$$

Taxes gathered from investment income in period t – $\tau_t^d N_t d_t$ should cover government spending in this period – G_t.

Please refer to Appendix where we show that system of equations for derivation of consumption and number of firms in period $t+1$ under the case of endogenous labor supply (2.3) and existence of profit tax is:

$$\begin{cases} \eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\dfrac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\dfrac{\mu(N_t)}{\mu(N_{t+1})} + \left(1-\tau_t^d\right)\dfrac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1-\dfrac{1}{\mu(N_{t+1})}\right)\right]\right) \\ N_{t+1} = (1-\delta)\left(N_t + A_t\dfrac{L}{\eta_{E,t}} - \dfrac{C_t+G_t}{\eta_{E,t}\rho(N_t)}\right) \\ G_t = \tau_t^d N_t d_t \end{cases}$$

(2.8)

2.2.1 Government spending shock in the model with labor tax, profit tax, lump sum tax

Intensity of response to a shock

We now consider the impact of a demand shock traditionally associated in the business cycles literature, with an increase in government spending. We assume that government spending follows the first order autoregressive process: $\hat{G}_{t+1} = \rho_G \hat{G}_t + \varepsilon_{G,t}$ where hat above the variable means percent deviation from steady state level for this variable, $\rho_G \in (0,1)$ is the autocorrelation coefficient and $\varepsilon_{G,t}$ is a white noise disturbance, with zero expected value and standard deviation σ_G.

Figure 10 depicts the response of key variables to a shock of temporary 1% increase in government spending with persistency $\rho_G = 0.9$ (in the steady state government spending are 16% of total output). We report the case of competition in quantities under the elasticity of substitution between goods $\theta = 6$.

We also want to outline that strength of reply is the most strong in case of labor tax presence, then in case of profit tax presence. Lump sum tax is the least in terms of impact of government spending shock on variable deviation from the steady state levels.
In the table below we list all differences between government shock propagation in the economy with these 3 forms of taxation.

We start with explanation for initial reaction of variables.
As was intuition of neoclassical model by Barro and King (Barro, 1981; Barro and King, 1984) transitive shock to government spending will create a boom in production. Even reduction in consumption will not prevent growth in output, because this growth will be mainly driven by increase in demand from the public sector side. This remains true under lump sum taxation.
Under labor tax it is still true, but an increase in total output is less than in case of lump-sum tax.
Under profit tax it is no longer true because government spending doesn't cover decrease in the investment activity cause by introduction of profit tax.
Profits increase under lump sum tax and profits tax. But in first case it attracts new entrance to the market, while in the second case when profits are taxed government in fact drives off new entrants. Shock to government spending means direct impact on profit tax rate and makes entrance unattractive. Government pumps out from economy excessive profits that were generated due to government spending shock. Due to this reason we have negative impact on number of

firms on the market and labor demand from the firms side. Consumption is temporary increased because there is no incentives for households to postpone it in favor of investments.
Under lump sum tax due to the favorable profits effect entrance is positive and it increases demand for labor from the firms side.
Under labor tax we have negative profits, that mean no entrance incentives, decrease in total number of firms on the market and labor demand.

Table 4 Difference in responses to government spending shock

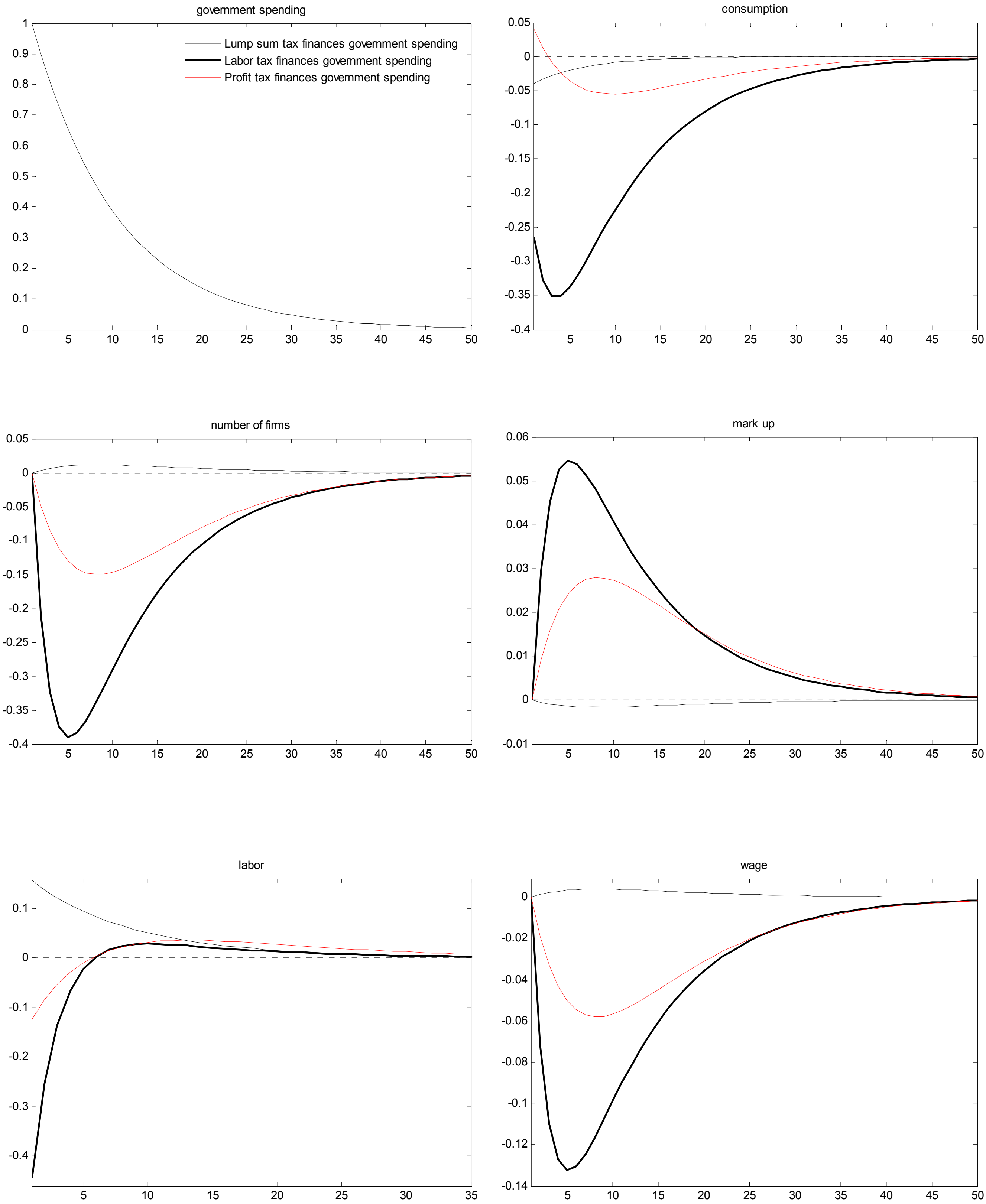
Variable	*Initial response*		
	Lump sum tax	*Labor tax*	*Profit tax*
Consumption	–	–	+
New entrants	+	–	–
Labor	+	–	–
Profits	+	–	+
Output	+	–	+

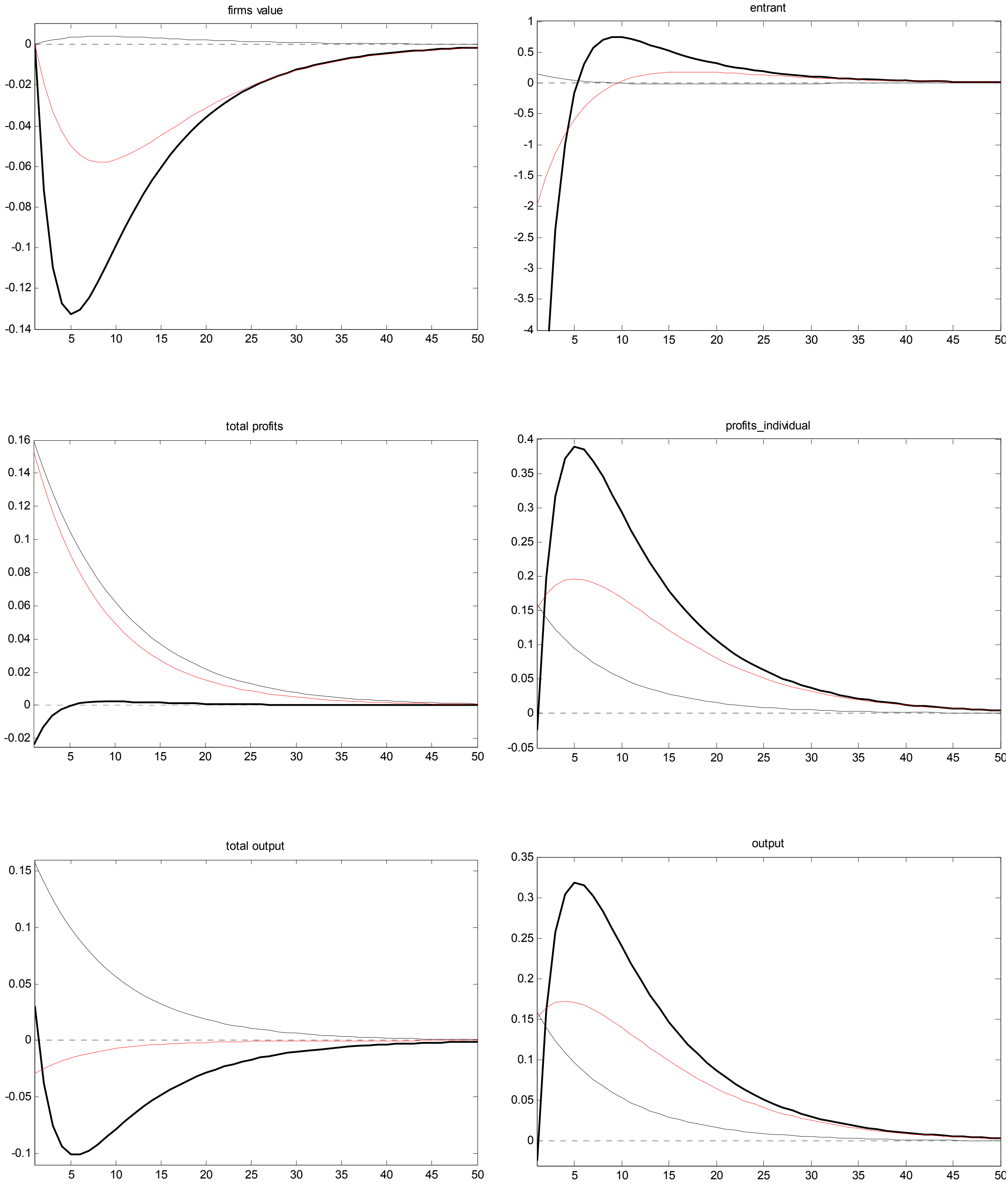
We proceed with the explanation of variables movement along the transition path.
Under lump sum tax demand for labor increases wages and this in turn promotes consumption. Such reaction is in contrast with RBC model which argues that net effect would be given by reduction of wages and consumption, with both remaining below the steady state levels along the entire transition path (while, interest rate would jump up and gradually decrease toward its initial level).

We see that having government spending being tied to labor income brings us back to the Real Business Cycle (RBC) model reaction to the government spending shock. We see reduction in wages and reduction in consumption. While model with lump sum tax responds in the contrary way and is very much different from RBC.
At the same time under lump sum tax case entry promotes competition, reduce markups, increasing number of firms on the market reduces profits and incentives to invest – so households see current consumption as more attractive.
We see opposite behavior in case when government spending are tied directly to one of the forms of income taxes. Profits on impact start growing, promoting entrance and reduction in consumption what is explained by incentives of households to postponed it in favor of investments.

Most of variables have hump-shaped path that means that when at some point net exit from the market is reached, markups pass its minimal level and start increasing towards initial steady state values.

Figure 10 Government spending shock – different forms of taxation – Cournot competition, $\theta = 6$ – IRF




firms value
entrant
total profits
profits_individual
total output
output

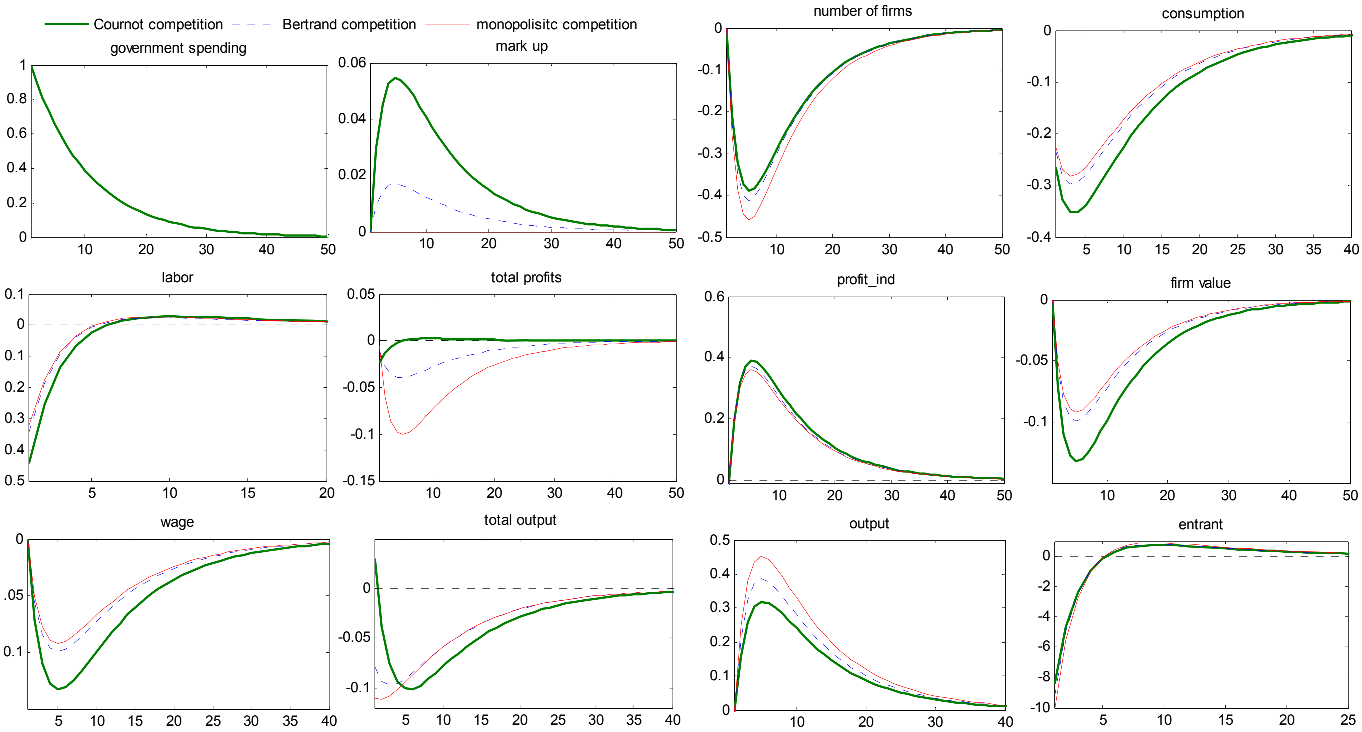
Comparison of different markup types

It is also important to outline difference between variables responses in case of different types of markups applied. In Figure 11 we report the impulse response functions to 1% government spending shock for $\theta = 6$ under respectively three forms of competition (in quantities – in green, in prices – in blue and monopolistic – in red). First we report difference in steady state variables values. Firms on the market are 4.875; 5.75; 8.125 respectively for monopolistic, Bertrand and Cournot competitions. That again confirms our hypothesis that taking into account integer constraint on number of firms Bertrand steady state number of firms departs from monopolistic case not more than on 1 firm. Labor tax is 18,8%; 19%; 20,67% respectively.

In spite of differences in the steady state values of the economy, Figure 11 shows that the quantitative reactions of the main aggregate variables to the shock are similar under all forms of competition. The impact of the shock is strengthened by competition effect. We see how entry of new firms strengthens competition and starts reduction the markups process along the transition path. But we cannot unambiguously conclude which type of competition creates stronger response to shock as it differs from variable to variable and also with degree of substitutability.

We see one substantial difference in total profits behavior along the transition path for Cournot competition against Bertrand and monopolistic – they start growing while second two – start from decreasing. We explain this fact with considerable increase in the markup $\mu(N_t)$ under Cournot competition, while total profits being $\left(1 - \frac{1}{\mu(N_t)}\right) N_t y_t$.

Figure 11 Government spending shock – labor tax – comparison of different forms of competition, $\theta = 6$ – IRF



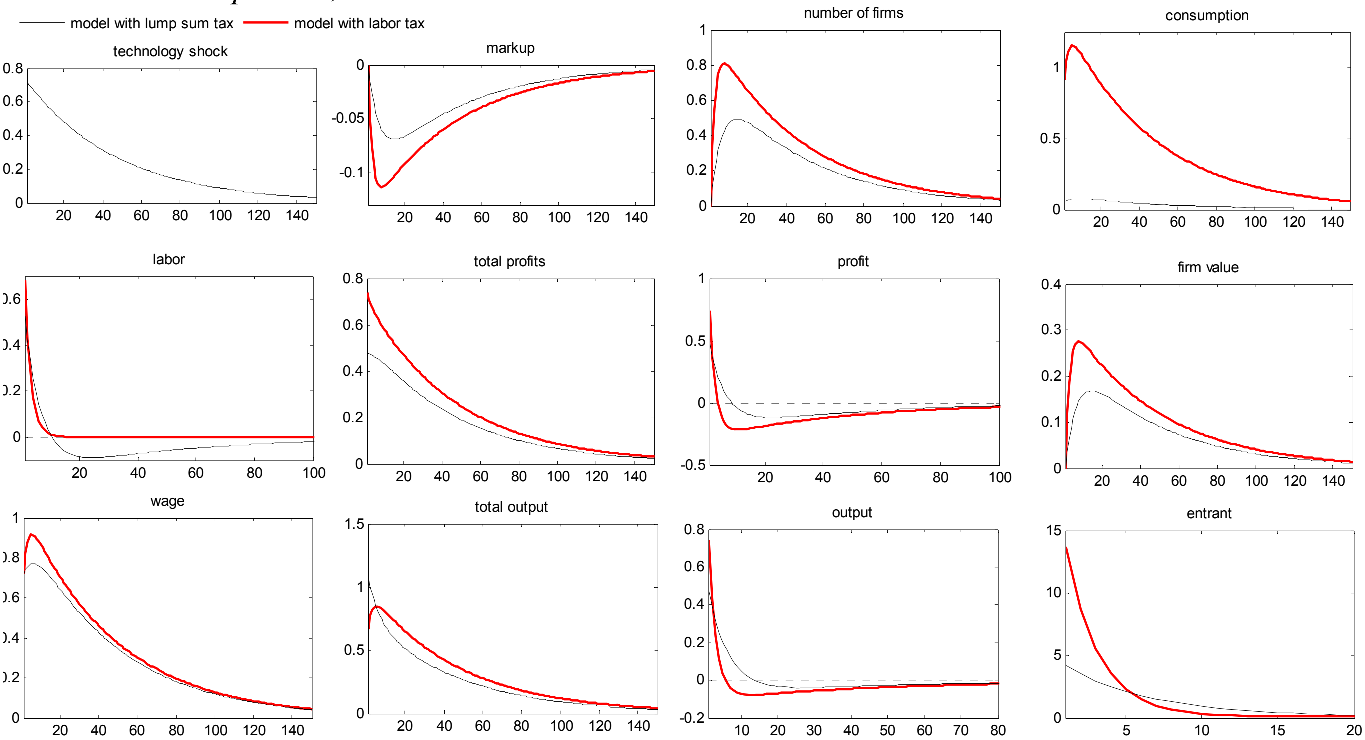
2.2.2 Productivity shock in case of lump sum tax and distortionary tax

This experiment is designed to see whether there is considerable difference between a response to productivity shock in the model where labor tax finances government spending and in the model where it is financed by lump sum tax. We calibrate the productivity process to suit King, Rebelo (1999) in order to compare variables second moments with real data reported in King, Rebelo (1999). Persistence is set as $\rho_A = 0.979$ and standard deviation $\sigma_{\varepsilon_A} = 0{,}0072$

We report no substantial differences neither in initial changes in response to a shock, nor along the transition path. We report here also second moments statistic to show that in case of incorporation of labor tax model starts generating higher volatility in consumption, labor, profits which is good if being compared to real data statistics given in King, Rebelo (1999), but this has major drawbacks as volatility of total output decreased and this is not reproducing nor real data statistics in King, Rebelo (1999), nor outcome of standard RBC model, original model was doing better in this parameter (it was not close to real data, but very close to RBC model outcome), also we see huge increase in investments volatility which also doesn't suit real data, original model comes closer to real data in this parameter. Nevertheless we are still catching main features of the model which are: procyclicality of entry, profits and counter-cyclicality of markups.

However we can conclude that incorporation of labor tax brings ambiguous improvement to the original model in the way it replicates real data.

Figure 12 Productivity shock in the model with labor tax and original model with lump sum tax – Cournot competition, $\theta = 6$ – IRF



Second moments for	σ_X		σ_X/σ_Y	
	Original model	Model with labor tax	Original model	Model with labor tax
total output (Y)	1,35	1,05	1	1
consumption	0,87	1,44	0,64	1,37
labor	0,67	0,74	0,5	0,71
total profits	0,63	0,94	0,47	0,9
investments	5,16	14,93	3,82	14,2
markup	0,06	0,13	0,04	0,12

Chapter3 Conclusion

A new approach in business cycle theory, called endogenous market structures (EMS) approach, stresses that the form of market competition and the number of competitors matter for understanding how the economy reacts to a shock. In the EMS approach the number of firms is endogenous and depends on the form of market competition, markups in turn depend on the number of firms on the market, in contrast to the mainstream business cycle literature.

To illustrate the importance of strategic interactions in the market, we study the propagation of a transitory shock to fixed entry costs. We find that competition affects the strength of the model economy's response to the shock. We are also interested in comparing a transitory shock to fixed entry costs with a productivity shock traditionally considered in the business cycle literature. To our knowledge, this was never done before. We find that a productivity shock has a stronger impact on the economy in terms of variable deviations from steady state values. We see that variables responses are similar, i.e. the direction of the transition path is the same, but we argue that the incentives generating such behavior are of different origin.

In this thesis, we consider taxation in the model with EMS. We start by specifying optimal fiscal policies for such type of models. We conclude that when entry is endogenous in the model and there is imperfect competition, optimal fiscal policies should not eliminate firm profits. Profits are needed to provide the right incentives for the product creation. This result belongs to BGM 2008. This contradicts the usual economic argument prescribing the elimination of monopoly profits, since imperfect competition brings inefficiency and fiscal policies should eliminate this inefficiency by equalizing prices to marginal costs. BGM 2008 states that this is no longer true when firm entry is endogenous in the model.

Our next step was to enlarge the benchmark model with distortionary taxation and to analyze the resulting changes in the model economy's response. Thus, we introduce labor and profit taxes in the system and compare the reaction to a demand shock in both the modified and original systems. We use a temporary shock to government spending as the demand shock. Government spending is financed by lump sum tax in the original model while it is financed by taxation of labor income or investment income in the modified model.

Presence of distortionary taxes in the model causes larger deviations from the steady state level in response to the shock. Contrary to the lump sum tax, a distortionary tax decreases the number of firms, i.e. market competition and augments markups. It lowers labor demand and consequently wages. This is similar to the qualitative results in an RBC model. Analyzing the second moments, however, gives ambiguous results. Distortionary taxes improve the model economy's performance in matching real data statistics for variables such as consumption, labor and profits but cannot do so for output and investment data.

As a future extension of the topic, we propose adding public debt instruments to the model economy. Combination of taxes and government bonds is a more realistic assumption on government fiscal policy, so it will further improve the model.

Literature

1. Auerbach, A. J. and Hines, J. R. (2002): "Taxation and Economic Effciency", Auerbach, A., and M. Feldstein, eds., Handbook of Public Economics, vol. 3, 1347–1421, Elsevier, Amsterdam.
2. Auerbach, A. J. and Hines, J. R. (2003): "Perfect Taxation with Imperfect Competition", Cnossen, S., and H.-W. Sinn, eds., Public Finance and Public Policy in the New Century, 127–153, MIT Press, Cambridge, MA.
3. Bilbiie F.O., Ghironi F. and Melitz M.J. (2007): "Endogenous Entry, Product Variety, and Business Cycles", National Bureau of Economic Research, Working Paper 13646.
4. Bilbiie F.O., Ghironi F. and Melitz M.J. (2008): "Monopoly Power and Endogenous Product Variety: Distortions and Remedies", National Bureau of Economic Research, Working Paper 14383.
5. Blanchard, O. and Kiyotaki, N. (1987): "Monopolistic Competition and the Effects of Aggregate Demand", American Economic Review, vol. 77 (4), 647–666.
6. Bresnahan, T. and Reiss, P. (1987): "Do Entry Conditions Vary Across Markets?", Brookings Papers on Economic Activity, vol. 3, 833–881.
7. Campbell, J. and Hopenhayn, H. (2005): "Market Size Matters", Journal of Industrial Economics, vol. 53 (1), 1–25.
8. Campbell, J. Y. (1994): "Inspecting the Mechanism: An Analytical Approach to the Stochastic Growth Model", Journal of Monetary Economics, vol. 33, 463–506.
9. Colciago, A. and Etro, F. (2010): "Real Business Cycles with Cournot Competition and Endogenous Entry", Journal of Macroeconomics, Elsevier, vol. 32 (4), 1101–1117.
10. Dixit, A.K. and Stiglitz, J.E. (1977): "Monopolistic Competition and Optimum Product Diversity", American Economic Review, vol. 67, 297–308.
11. Etro, F. (2009a): "Endogenous Market Structures and the Macroeconomy", Springer, New York and Berlin.
12. Etro, F. (2009b): "The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe", Review of Business and Economics, vol. 54 (2), 179–208.
13. Etro, F. and Colciago, A. (2010): "Endogenous Market Structures and the Business Cycle", The Economic Journal, vol. 120 (549), 1201–1234.
14. Ghironi, F. and Melitz, M. (2005): "International Trade and Macroeconomic Dynamics with Heterogenous Firms", Quarterly Journal of Economics, vol. CXX, 865–915.
15. King, R. G. and Rebelo, S. T. (1999): "Resuscitating Real Business Cycles", Taylor, J. B., and M.Woodford, eds., Handbook of Macroeconomics, vol. 1B, 927–1007, Elsevier, Amsterdam.
16. Kydland, F. and Prescott, Ed. (1982): "Time to Build and Aggregate Fluctuations", Econometrica, vol. s50 (6), 1345–1370.
17. Manuszak, M. and Moul, Ch. (2008): "Prices and Endogenous Market Structure in Office Supply Superstores", Journal of Industrial Economics, vol. 56, 94–112.
18. Manuszak, M. (2002): "Endogenous Market Structure and Competition in the 19th Century American Brewing Industry", International Journal of Industrial Organization, vol. 20, 673–932.

19. Robinson, J. (1933): “The Economics of Imperfect Competition”, Cambridge University Press, Cambridge, UK.

APPENDIX

Proof of 1.3

Lets denote expenditure in each sector of economy as $EXP_t = C_t P_t$

In each time period the households maximize consumption in this time period by choosing bundle of goods ω under the time period budget constraint. Demand for each individual good is delivered by solution of the following optimization problem:

$$\begin{cases} \max\limits_{\{c_t(\omega)\}} \quad C_t \\ \text{subject to } \int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega = EXP_t \end{cases}$$

Lagrangian for this problem is: $L = \left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta - 1/\theta} d\omega \right)^{\frac{\theta}{\theta-1}} - \lambda \left(\int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega - EXP_t \right)$

First order conditions with respect to $c_t(\omega)$: $\frac{\theta}{\theta-1}\left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta - 1/\theta} d\omega \right)^{\frac{1}{\theta-1}} \frac{\theta-1}{\theta} c_t(\omega)^{\frac{-1}{\theta}} = \lambda p_t(\omega)$

$$c_t(\omega)^{\frac{-1}{\theta}} = \lambda p_t(\omega)\left(\int\limits_{\omega\in\Omega} c_t(\omega)^{\theta - 1/\theta} d\omega \right)^{\frac{-1}{\theta-1}}$$

$$c_t(\omega) = \lambda^{-\theta} p_t(\omega)^{-\theta} C_t \tag{A.1}$$

First order conditions with respect to λ: $\int\limits_{\omega\in\Omega} p_t(\omega)c_t(\omega)d\omega = EXP_t$, where we plug (A.1) and get

$\int\limits_{\omega\in\Omega} p_t(\omega)\lambda^{-\theta} p_t(\omega)^{-\theta} C_t d\omega = EXP_t$, then we used formula for expenditure and get

$\lambda^{-\theta} C_t \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = P_t C_t$; or after simplification $\lambda^{-\theta} \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = P_t$

here we use formula of the price index (1.2) $P_t = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}$ and we get that:

$$\lambda^{-\theta} \int\limits_{\omega\in\Omega} p_t(\omega)^{1-\theta} d\omega = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}$$

$$\lambda = \left(\int\limits_{\omega\in\Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{\frac{-1}{1-\theta}} = \frac{1}{P_t}$$

Pluging λ back to (A.1) we get the result $c_t(\omega) = C_t \left(\frac{p_t(\omega)}{P_t} \right)^{-\theta}$

Proof of 2.3

We will show that

$$
\begin{cases}
\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\dfrac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\dfrac{\mu(N_t)}{\mu(N_{t+1})} + \dfrac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1-\dfrac{1}{\mu(N_{t+1})}\right)\right]\right) \\
N_{t+1} = (1-\delta)\left(N_t + A_t\dfrac{L}{\eta_{E,t}} - \dfrac{C_t+G_t}{\eta_{E,t}\rho(N_t)}\right) \\
G_t = T_t
\end{cases}
$$

First equation of the system is derived from the Euler equation for household share holdings (1.10)

$$\upsilon_t = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}(\upsilon_{t+1}+d_{t+1})\right)$$

after substitution for free entry equation $\upsilon_t = w_t\dfrac{\eta_{E,t}}{A_t}$

$$w_t\frac{\eta_{E,t}}{Z_t} = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left(w_{t+1}\frac{\eta_{E,t+1}}{A_{t+1}} + d_{t+1}\right)\right)$$

after substituting for wage got from pricing equations - $\rho_t = \mu_t\dfrac{w_t}{A_t}$ and $\rho_t = \rho(N_t)$

$$\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left(\eta_{E,t+1}\rho(N_{t+1})\frac{\mu_t}{\mu_{t+1}} + \mu_t d_{t+1}\right)\right) \tag{A.2}$$

after substitution for profits $d_t(\omega) = \left(1-\dfrac{1}{\mu(N_t)}\right)\dfrac{C_t+G_t}{N_t}$ (2.2) we get the result

Second equation of the system is derived from Number of firms equation (1.8) expressed for period $t+1$: $N_{t+1} = (1-\delta)(N_t + N_{E,t})$.

where number of new firms is delivered by aggregate accounting equation (2.1) $C_t + N_{E,t}\upsilon_t + T_t = w_t L_t + N_t d_t$ or replacing for $G_t = T_t$ we get

$$N_{E,t} = \frac{w_t L_t}{\upsilon_t} + \frac{N_t d_t}{\upsilon_t} - \frac{C_t + G_t}{\upsilon_t}$$

using free entry condition (1.7): $\upsilon_t = w_t \frac{\eta_{E,t}}{A_t}$, profits(2.2):

$$d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{C_t + G_t}{N_t}$$

$$N_{E,t} = A_t \frac{L_t}{\eta_{E,t}} - \frac{C_t + G_t}{w_t \frac{\eta_{E,t}}{A_t} \mu(N_t)}$$

after substituting for wage got from pricing equations - $\rho_t = \mu_t \frac{w_t}{A_t}$ and $\rho_t = \rho(N_t)$

$$N_{E,t} = A_t \frac{L_t}{\eta_{E,t}} - \frac{C_t + G_t}{\eta_{E,t} \rho(N_t)}$$

Plugging back into the number of firms equation we get the result.

Proof of 2.8

We will show that

$$\begin{cases} \eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \left(1-\tau_t^d\right)\frac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1-\frac{1}{\mu(N_{t+1})}\right)\right]\right) \\ N_{t+1} = (1-\delta)\left(N_t + A_t\frac{L}{\eta_{E,t}} - \frac{C_t+G_t}{\eta_{E,t}\rho(N_t)}\right) \\ G_t = \tau_t^d N_t d_t \end{cases}$$

For the first equation of the system:

Remember that the period budget constraint (in units of consumption) is:

$$\upsilon_t N_{H,t} x_{t+1} + C_t + \tau_t^d d_t N_t x_t = \left(\left(1-\tau_t^d\right)d_t + \upsilon_t\right)N_t x_t + w_t L$$

The household maximizes its expected intertemporal utility subject to this budget constraint. So the Euler equation for share holdings is then:

$$\upsilon_t = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left(\left(1-\tau_{t+1}^d\right)d_{t+1} + \upsilon_{t+1}\right)\right)$$

We further proceed as in the Proof of 2.3 to arrive to analogue of (A.2) equation. We then substitute for the formula of profits (2.2) to obtain the result

After substitution for free entry equation $\upsilon_t = w_t\frac{\eta_{E,t}}{A_t}$

$$w_t\frac{\eta_{E,t}}{A_t} = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left(w_{t+1}\frac{\eta_{E,t+1}}{A_{t+1}} + \left(1-\tau_{t+1}^d\right)d_{t+1}\right)\right)$$

after substituting for wage got from pricing equations - $\rho_t = \mu_t\frac{w_t}{A_t}$ and $\rho_t = \rho(N_t)$

$$\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left(\eta_{E,t+1}\rho(N_{t+1})\frac{\mu_t}{\mu_{t+1}} + \mu_t\left(1-\tau_{t+1}^d\right)d_{t+1}\right)\right)$$

after substitution for profits $d_t(\omega) = \left(1-\frac{1}{\mu(N_t)}\right)\frac{C_t+G_t}{N_t}$ (2.2) we get the result

$$\eta_{E,t}\rho(N_t) = \beta(1-\delta)E_t\left(\frac{U'(C_{t+1})}{U'(C_t)}\left[\eta_{E,t+1}\rho(N_{t+1})\frac{\mu(N_t)}{\mu(N_{t+1})} + \left(1-\tau_t^d\right)\frac{C_{t+1}+G_{t+1}}{N_{t+1}}\mu(N_t)\left(1-\frac{1}{\mu(N_{t+1})}\right)\right]\right)$$

Second equation of the system is derived from Number of firms equation (1.8) expressed for period $t+1$: $N_{t+1} = (1-\delta)(N_t + N_{E,t})$.

where number of new firms is delivered by aggregate accounting equation (2.1) $C_t + N_{E,t}\upsilon_t + T_t = w_t L_t + N_t d_t$ or replacing for $G_t = T_t$ we get

$$N_{E,t} = \frac{w_t L_t}{\upsilon_t} + \frac{N_t d_t}{\upsilon_t} - \frac{C_t + G_t}{\upsilon_t}$$

using free entry condition (1.7): $\upsilon_t = w_t \frac{\eta_{E,t}}{A_t}$, profits(2.2):

$$d_t(\omega) = \left(1 - \frac{1}{\mu(N_t)}\right)\frac{C_t + G_t}{N_t}$$

$$N_{E,t} = A_t \frac{L_t}{\eta_{E,t}} - \frac{C_t + G_t}{w_t \frac{\eta_{E,t}}{A_t}\mu(N_t)}$$

after substituting for wage got from pricing equations - $\rho_t = \mu_t \frac{w_t}{A_t}$ and $\rho_t = \rho(N_t)$

$$N_{E,t} = A_t \frac{L_t}{\eta_{E,t}} - \frac{C_t + G_t}{\eta_{E,t}\rho(N_t)}$$

Plugging back into the number of firms equation we get the result.

MatLab code for steady state number of firms calculations

```
function firms=firms_cournot(n,a_bar,delta,teta,r_bar,phi_l,f,govery);
   rho_n_bar  =n^(1/(teta-1));
   mu=teta*n/((teta-1)*(n-1));
   aa=(mu_n-1)/mu_n;
   wlovery=(delta*(mu-1)+r_bar+delta)/((mu*(r_bar+delta)+delta*(mu-1)));
   tax_bar=govery/wlovery;
   wage_bar        =rho_n_bar/mu_n*a ;
   covery=mu*(r_bar+delta)/(mu*(r_bar+delta)+delta*(mu-1))-govery;
   chi=wlovery/covery;
   entrant_bar     =delta/(1-delta)*n;
   y_agg_bar       =a *rho_n_bar*(1-aa*f*entrant_bar/a );
   c_bar=covery *y_agg_bar;
   g_bar=govery*y_agg_bar;
   firms =delta*n-((1-delta)*a/f*(1/(c_bar*chi)*(rho_n_bar)*(1-
   tax_bar)/(mu_n)*a)^phi_l-(1-delta)*(c_bar+g_bar )/(f*rho_n_bar));
fzero(@(n) firms_cournot(n,1,0.025,6,1.01,4,1,0.16),8)
```

Example of Dynare code - model with labor tax and shock to government spending

```
%-----------------------------------------------------------------
% 1. Defining variables
%-----------------------------------------------------------------
var tax n g c l wage y  y_agg entrant rho_n mu_n pro_ind pro_agg inve v rr ;
varexo e;

%-----------------------------------------------------------------
% 2. Defining parameters
%-----------------------------------------------------------------

parameters bond_bar left_bar a  sunk_labor g_bar tax_bar R_bar delta betta
teta rho f phi_l chi n_bar sigma r_bar eta epsi rho_n_bar mu_n_bar c_bar
pro_agg_r_bar aa aa1 wage_bar y_bar l_bar y_agg_bar den_a num_a aa1 aa en-
trant_bar price_bar v_r_bar c_r_bar inve_r_bar wage_r_bar y_agg_r_bar;

%-----------------------------------------------------------------
% 3. calibration
%-----------------------------------------------------------------
R_bar=1+0.04/4;
betta=1/R_bar;
delta =0.025;        %depreciation rate
rho   =0.9;          %persistence of shock
r_bar =1/betta-1;
a  =1;
phi_l =4;
f     =1;
govery=0.16;
l_bar=1;
bond_bar=0;
teta  =6;
sigma =0.01

%-----------------------------------------------------------------------
n_bar=8.125;
```

```
rho_n_bar  =n_bar^(1/(teta-1));
mu_n_bar   =(teta*n_bar)/((teta-1)*(n_bar-1));

%defining some  auxiliary coefficients

aa=(mu_n_bar-1)/mu_n_bar;
aa1=(mu_n_bar-1);

entrant_bar     =delta/(1-delta)*n_bar;
y_agg_bar       =a *rho_n_bar*(l_bar-aa*f*entrant_bar/a );
wage_bar        =rho_n_bar/mu_n_bar*a ;

wlovery =(wage_bar*l_bar)/y_agg_bar;

tax_bar = govery/wlovery;

covery =mu_n_bar*(r_bar+delta)/(mu_n_bar*(r_bar+delta)+delta*aa1)-govery ;

chi          = wlovery*(1-tax_bar)*(covery )^(-1);
l_bar=(1/chi*wlovery*(1-tax_bar)*(covery)^(-1))^(phi_l/(1+phi_l));
g_bar   = govery *y_agg_bar;
c_bar=covery *y_agg_bar;
y_bar           =(rho_n_bar)^(-teta)*(c_bar+g_bar);
pro_ind_bar     =(1-1/mu_n_bar)*(c_bar+g_bar)/n_bar;
pro_agg_bar     =(1-1/mu_n_bar)*(c_bar+g_bar);
v_bar           =rho_n_bar/mu_n_bar*f;
inve_bar        =v_bar*entrant_bar;
sunk_labor_bar  =entrant_bar*f/a ;

%----------------------------------------------------------------
% 5. model
%----------------------------------------------------------------

model;

rho_n=n(-1)^(1/(teta-1));
mu_n=(teta*n(-1))/((teta-1)*(n(-1)-1));
n=(1-delta)*n(-1)+(1-delta)*a/f*(l)^phi_l-(1-delta)*(c+g )/(f*rho_n);

f*(rho_n)/(mu_n)=betta*(1-delta)*c/c(+1)*f*rho_n(+1)/mu_n(+1)+betta*(1-
delta)*c/c(+1)*(1-1/(mu_n(+1)))*(c(+1)+g(+1) )/n;
tax =g/(wage*l);
chi*l^(1/phi_l)=wage*(1-tax )/c;
wage=rho_n/mu_n*a;
entrant=n/(1-delta)-n(-1);
y_agg=a*(rho_n)*l-a*(rho_n)*(1-1/mu_n)*f/a*entrant;
y=rho_n^(-teta)*(c+g  );
pro_ind=(1-1/mu_n)*(c+g  )/n(-1);
pro_agg=(1-1/mu_n)*(c+g  );
v=f*wage/a;
inve=v*entrant;
1/c=betta*rr*(1/c(+1));
log(g/(g_bar))=rho*log(g(-1)/(g_bar))+e;

end;

%----------------------------------------------------------------
% 6. computations
%----------------------------------------------------------------

initval;
```

```
 c      =c_bar;
 n      =n_bar;
 g      =g_bar;
 l      =l_bar;
 wage   =wage_bar;
 y      =y_bar;
 y_agg  =y_agg_bar;
 rho_n  =rho_n_bar;
 entrant=entrant_bar;
 mu_n   =mu_n_bar;
 pro_ind=pro_ind_bar;
 pro_agg=pro_agg_bar;
 entrant=entrant_bar;
 v      =v_bar;
 inve   =inve_bar;
 tax= tax_bar;


 e = 0;

end;
steady;
check;
shocks;
var e=(sigma)^2;
end;

stoch_simul (noprint,hp_filter=1600,order=1,irf=50);
```