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HETEROGENEOUS CONSUMERS AND MARKET STRUCTURE IN A MONOPOLISTICALLY COMPETITIVE SETTING

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Heterogeneous consumers and market structure in a monopolistically competitive setting

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The present paper extends the traditional Dixit and Stiglitz set-up by introducing consumers'/workers' heterogeneity into a general equilibrium model of monopolistic competition. The model obtains a closed-form solution for a symmetric equilibrium and shows how the market outcome depends on the joint distribution of consumers'/workers' taste and labor productivities. In contrast to the traditional framework, our model predicts that the short-run equilibrium price may vary with the number of firms, demonstrating both anti- and pro-competitive behavior, which is in accordance with economic intuition and empirical evidence. Proposed approach is also capable to explain variability of the long-run equilibrium markups, which is observed empirically. Unlike the standard CES model, where markups are constant, in our setting the equilibrium markups depend on the covariance of tastes and productivity.

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Key words: Heterogeneous consumers, monopolistic competition, preference for variety, labor productivity, markups, inequality distribution.

Contents

1 Introduction

The representative agent approach is one of the cornerstones of modern economics, which has become widely used in the literature after Robert Lucas had published his article on econometric policy evaluation – his famous Lucas critique (Lucas, 1976; Acemoglu, 2009). In accordance with this approach, the choices of the diverse agents can be considered as the choices of the only one utility maximizing individual, whose behavior coincides with the aggregate behavior of the heterogeneous consumers. More precisely, the representative agent models are characterized by an explicitly stated optimization problem of the representative agent, which can be either a consumer or a producer. The derived individual demand or supply curves of the representative agent are used then as the substitutes for the corresponding aggregate demand or supply curves. An assumption of the representative agent allows one to greatly simplify the analysis and obtain transparent analytical results. Nevertheless its justification has never been rigorously proven and still to be the hot area of discussions (Kirman, 1992; Hartley, 1996; Colander *et al*, 2009; Stiglitz, 2011).

As far as the demand-side of the economy is concerned, the representative agent approach allows one to obviate the aggregation problem (Grandmont, 1987, 1992). However, the cost of this is that the properties of the market outcome often turn out to be too simplistic to capture a number of important stylized facts. To model the demand side of the economy, the representative agent approach typically postulates the identical and homothetic preferences across consumers (Acemoglu, 2009; Markusen, 2010). In particular, this assumption is used in the Dixit and Stiglitz model of monopolistic competition (Dixit and Stiglitz, 1977), which has been applied successfully to a wide range of economic fields (Brakman and Heijdra, 2004). Yet, there is a growing discomfort with the assumption of identical consumers having homothetic preferences, persistently stimulating researchers to explore alternative options. Presently, there is an increasing list of publications taking the heterogeneity and non-homotheticity of consumers' preferences into account when explaining market structure and international trade pattern (Fieler, 2011; Markusen, 2010; Simonovska, 2010; Kichko *et al*., 2014; Di Comite *et al*, 2013). Our contribution aims at the same direction.

By using consumer specific CES utility function, depending on individuals' tastes, combined with heterogeneity in consumers'/workers' labor productivities, we provide an extension of the Dixit and Stiglitz model of monopolistic competition, which allows one to generate a richer set of predictions compared to the more conventional setup. The notable difference between our model and the most of the traditional ones is that the aggregate demand curves show more versatile behavior than the individual demand curves (Hart, 1979; Hart, 1985; Perloff and Salop, 1985; Sattinger, 1984). The distinction between individual and market demands and, consequently, between individual and collective consumers' behavior, is the key ingredient of our model, which makes it possible to capture specific aggregate demand-side effects in market outcomes.

One of the most important predictions of our model is the dependence of the short-run equilibrium prices upon the number of firms, which is in accordance with economic intuition and empirical evidence. This dependence is not captured by the more conventional set-up (Dixit and Stiglitz, 1977) and is viewed as the one of its major inconsistencies (Zhelobodko *et al*, 2012). Our set-up eliminates this pitfall by incorporating consumers' heterogeneity into the CES model of monopolistic competition.

Our model also features variable markups, an empirically observed phenomenon, characteristic to both closed and open economy cases (Oliveira Martins *et al*., 1996; Roberts and Supina, 1996; Tamminen and Chang, 2012; Bellone *et al*, 2014; Di Comite *et al*, 2013), which cannot be explained by traditional models of monopolistic competition. Unlike the more conventional models, where markups are assumed to be constant, in our set-up markups may vary along with the moments of the joint tastes-productivity distribution.

It is worth noting that an increase in the taste and productivity dispersions and the average productivities may exert an ambiguous influence upon the markups magnitude depending on the sign of the correlation coefficient between tastes and labor productivities of the consumers/workers. An ambiguity of the markups behavior is a key finding of ours, which is in a full accordance with empirical evidence documented in the literature (Roberts and Supina, 1996; Tamminen and Chang, 2012; Atsuyuki and Naomi, 2014).

In order to sign this correlation coefficient, we make use of the empirical observations of the price elasticities for disaggregated goods, obtained in the literature (Ivanova, 2005), to show that this ambiguity takes place in reality.

The remaining of the paper is organized as follows. Section 2 describes the model. In Sections 3 and 4 we derive a closed-form solution for the short- and long-run equilibrium outcomes. Section 5 focuses on the comparative static analysis of the model. Section 6 discusses the sign of the correlation coefficient estimation. Section 7 concludes.

2 The model

There is a one-sector economy, which involves a monopolistically competitive industry supplying a horizontally differentiated consumption good, and inhabited by heterogeneous individuals. Heterogeneity of individuals is represented by a set of attributes inherent to them as persons. The structure of the proposed model suggests that these attributes could be restricted by the following three types: 1) consumers'/workers' role played in production process, 2) tastes, and 3) labor productivities.

Assuming that consumers and firm employees are the same people, we divide them into two groups, distinguished by the form of professional activity. The first group of employees contains people, fulfilling administrative functions and creating the new products. The payments to this group of the «creative» workers generate the fixed cost of a firm. The second group of employees consists of the people, directly involved into production process. The payments to this group of «production» workers provide the variable costs of a firm. The aforementioned approach is very close to what is used in the literature on economic growth (Nahuis and Smulders, 2002): while unskilled workers produce final goods and services directly for the market, skilled workers produce services for internal use that affect market performance indirectly. They use their skills to improve the firm's production process and product quality, the firm's organization, management, marketing, financial planning, and research and development.

In what follows, we will label the members (and corresponding variables) of the two groups by a subscript *r*, running values F and V, reflecting each group members' association with fixed and variable costs, accordingly. In what follows, L_r will denote the population size of each group, $L \equiv L_F + L_V$ will denote the total population of the economy given exogenously, and $\theta = L_F / L$ will denote the population share of the «creative» staff. The latter is an endogenous parameter, which will be derived in the long-run equilibrium of the model.

Splitting individuals into two different groups of employees enables one to reflect heterogeneity of the labor market structure in the models of monopolistic competition. Notice that the difference between employees fulfilling different functions, provided by the structure of the costs, is a specific feature of any model of monopolistic competition (Brakman and Heijdra, 2004; Combes *et al.*, 2008; Melitz, 2003). Nevertheless, this difference is not ordinarily accounted for, since it requires an appropriate modification of the utility function.

Assume further that consumers in both of the two groups are endowed with different tastes and labor productivities, connected statistically, i.e. assume that the attributes of a consumer ω_r in group r can be represented by a couple $(\sigma_r(\omega_r), h_r(\omega_r))$, where $\sigma_r(\omega_r) > 1$ is the tastes parameter that captures how consumer ω_r in group r perceives the differentiated varieties, and $h_r(\omega_r)$ is the consumer/worker ω_r labor productivity.

An assumption of the different labor productivities is traditionally applied in the monopolistic competition and business cycle literature (Behrens and Murata, 2012; Edmond and Veldkamp, 2009) to reflect consumers' income inequality. Following the logic of this literature, we also use the heterogeneous labor productivity as the source of earnings dispersion in our model. An individual ω_r with labor productivity $h_r(\omega_r)$ in group r supplies inelastically that many units of labor and obtains income $y_r(\omega_r) = h_r(\omega_r)w$, where w stands for the *numeraire* wage in the economy (the more productive is the particular consumer/worker the higher personal income she/he acquires). By associating the numeraire wage with the minimum wage rate in the economy, we may state that $h_r(\omega_r) > 1$, pointing out that no one of the consumers/workers is allowed to get income lower than minimum wage. Without loss of generality it will be set to unity ($w = 1$), unless otherwise specified.

Notice that in accordance with our model specification, individuals having the same labor productivity may exhibit different tastes and vice versa, individuals with identical tastes may have different productivities. The relationship between taste parameters and labor productivities is introduced to reflect statistical correspondence between tastes and personal incomes of the consumers. The existence of such correspondence is suggested by the very structure of our model, incorporating consumers' heterogeneity (see below the expression for the «effective» tastes parameter).

To represent statistical correspondence between tastes and labor productivities, denote by (Ω_r, μ_r) the space of consumers, belonging to the group *r*, and by $L_r \equiv \int_{\Omega_r} d\mu_r$ – the population size of the corresponding group. In this context, the distribution of $\sigma_r(\cdot)$ across (Ω_r, μ_r) may be viewed as the univariate taste distribution, the distribution of $h_r(\cdot)$ across (Ω_r, μ_r) may be viewed as the univariate labor productivity distribution, while the distribution of both attributes may be considered as the joint tastes-labor productivity distribution, given *exogenously*[1]. In what follows, we also assume that attributes belonging to the consumers of the first group do not correlate with the corresponding attributes of consumers in the second.

[1] The joint distribution of the tastes parameters and labor productivities may serve as a substitute for the joint distribution of tastes and incomes as they are distinguished by the numeraire (or minimum) wage. Taking this into account, everywhere below we will make no difference between the two of these distributions and will use them interchangeably.

The utility function of a consumer ω_r in group r is represented by

$$U_r(\omega_r) = \left(\sum_{i=1}^{N} \left(x_{ri}(\omega_r) \right)^{(\sigma_r(\omega_r)-1)/\sigma_r(\omega_r)} \right)^{\sigma_r(\omega_r)/(\sigma_r(\omega_r)-1)}, \qquad (1)$$

where $x_{ri}(\omega_r)$ is the individual consumption of a variety i by a consumer in group r, N is the total number of varieties available, equal to the number of firms in the economy. Contrary to the Dixit and Stiglitz (1977) approach, where all individuals are identical and have the same preferences, the preferences (1) generally differ across consumers within specific group due to differences in tastes parameters: $\sigma_r(\omega_r') \neq \sigma_r(\omega_r'')$ for $\omega_r' \neq \omega_r''$. The same is valid for consumers belonging to different groups, so that $\sigma_r(\omega_r) \neq \sigma_s(\omega_s)$ for $\omega_r \neq \omega_s$, thus reflecting the idea that consumers belonging to different socioeconomic classes may have different preferences over the same good.

To reduce the notational burden, assume that firms do not take into account the individual characteristics (attributes) of the consumers when setting prices and, therefore, do not price discriminate across them. Taking this into account, the budget constraint of a consumer ω_r can be represented by

$$\sum_{i=1}^{N} p_i x_{ri}(\omega_r) = h_r(\omega_r), \qquad (2)$$

where p_i is the price of i-th variety, which doesn't depend upon the particular consumer attributes in group *r*.

Maximization of the utility function (1) taking into account the budget constraint (2) yields the individual demand for i-th variety generated by a consumer in group *r*:

$$x_{ri}(\omega_r) = \frac{p_i^{-\sigma_r(\omega_r)}}{P_r(\omega_r)} h_r(\omega_r), \qquad (3)$$

where $i = 1, 2, ..., N$, and $P_r(\omega_r) = \sum_{j=1}^{N} p_j^{-(\sigma_r(\omega_r)-1)}$ is the price aggregate, common to the consumers sharing the same elasticity of substitution.

Market demand function for i-th variety generated by all consumers belonging to a particular group *r* is found by aggregating individual demand functions (3) and is given by:

$$q_{ri} = \int_{\Omega_r} x_{ri}(\omega_r) d\mu_r = \int_{\Omega_r} \frac{h_r(\omega_r)}{P_r(\omega_r)} p_i^{-\sigma_r(\omega_r)} d\mu_r \, . \tag{4}$$

Unlike the individual demands (3), the market demand (4) is not isoelastic because tastes parameters $\sigma_r(\cdot)$ in our setting may vary across consumers. As a consequence, the market demand faced by every firm depends on the joint tastes and labor productivity distributions. In the limiting case where all consumers share the same preferences ($\sigma_r(\omega_r) = \sigma$) the market demand becomes isoelastic and linear in total income: $q_i = \frac{p_i^{-\sigma}}{P} Y$, where $Y = \int_{\Omega_F} h(\omega_F) d\mu_F + \int_{\Omega_V} h_V(\omega_V) d\mu_V$, so that the way income is distributed across consumers has no impact on the market outcome.

As far as consumers are heterogeneous, we find it reasonable to restrict our analysis to the case of identical firms in order to disentangle effects triggered by the two types of heterogeneity. By doing so, we assume that firms share the same technology and produce under increasing returns with $f > 0$ and $c > 0$ denoting the fixed and the marginal *efficient* labor requirements needed to supply q_i units of variety i. Taking this into account, the profit of a firm i is given by

$$\pi_i = (p_i - c)q_i - f \, , \tag{5}$$

where $q_i \equiv q_{Fi} + q_{Vi}$ stands for the total market demand, faced by firm i, q_{Fi} and q_{Vi} are the components (4) of the total demand, generated by the first and second groups of consumers/workers, correspondingly.

In what follows we divide time into two periods: the first is the «shot-run», defined as the time over which we can take the number of firms as exogenously given, and the second is the «long-run», defined as the time over which the number of firms is endogenous, determined by a free entry and exit condition.

3 Short-run equilibrium

Applying the first-order condition to profits (5) and focusing on the symmetric equilibrium with equal prices across the set of varieties, $p_i = p$ ($i = 1, 2, ..., N$), where N stands for a given number of firms, yields the following short-run equilibrium price (see section A1 in Appendix):

$$p = \frac{\tilde{\sigma}}{\tilde{\sigma} - 1} c. \tag{6}$$

We call the parameter $\tilde{\sigma}$ appearing in (6) an «effective» taste parameter, as it reflects not only consumers' taste distributions, but also the influence of other consumers' attributes upon the consumers' perception of differentiated varieties (see below). Unless all consumers have the same attitude toward product differentiation, the market price depends on the joint taste and labor productivity distribution through the value of this parameter. Calculations show that parameter $\tilde{\sigma}$ in our model is equal to (see A1 in Appendix):

$$\tilde{\sigma} = \alpha \tilde{\sigma}_F + (1 - \alpha) \tilde{\sigma}_V, \tag{7}$$

where $\tilde{\sigma}_F$ and $\tilde{\sigma}_V$ are the «effective» tastes parameters, characterizing preferences for varieties, exhibited by the first and the second group of consumers, $\alpha \equiv Y_F / Y$ is the share of the first group income in the total income of the economy, $1 - \alpha \equiv Y_V / Y$ is the share of the second group income in the total income of the economy[2]. It can be shown (see section A1 in Appendix) that $\tilde{\sigma}_F$ and $\tilde{\sigma}_V$ are given by

$$\tilde{\sigma}_F = \frac{\overline{\sigma_F h_F}}{\bar{h}_F}, \tag{8}$$

and

$$\tilde{\sigma}_V = \frac{\overline{\sigma_V h_V}}{\bar{h}_V}, \tag{9}$$

where $\overline{\sigma_F h_F}$ ($\overline{\sigma_V h_V}$) is the covariance between the tastes parameters and labor productivities of the first (second) group of consumers, $\bar{h}_F$ ($\bar{h}_V$) is the average value of labor productivity of the first (second) group.

In what follows, it will be more convenient to represent the «effective» tastes parameters (8) and (9) in an alternative way, using the following decomposition:

[2] Equivalently we may treat α (1-α) as the share of the first (second) group expenditure on purchasing differentiated varieties.

$$\tilde{\sigma}_r = \bar{\sigma}_r + \rho_r \cdot \frac{\sqrt{\mathbf{Var}(\sigma_r)} \cdot \sqrt{\mathbf{Var}(h_r)}}{\bar{h}_r}, \tag{10}$$

where $\bar{\sigma}_r$ is the average value of the taste parameters of the consumers, $\mathbf{Var}(\sigma_r)$ and $\mathbf{Var}(h_r)$ are the variances of the tastes parameters and labor productivities, $\rho_r \equiv \rho(\sigma_r ; h_r)$ is the correlation coefficient between tastes and labor productivities in group *r*. While the first part of the decomposition (10) reflects the consumers' attitude towards product differentiation whatever other attributes of these consumers are, the second part reflects the potential influence of other attributes of the consumers (and indirectly of the consumers' environment) upon the perception of goods. As long as $-1 \le \rho_r \le 1$, $r = F, V$, we may conclude that the magnitude of the «effective» sigma increases along with increase in the correlation coefficient and varies in the range $(\tilde{\sigma}_{\min}, \tilde{\sigma}_{\max})$, where $\tilde{\sigma}_{r,\min} = \bar{\sigma}_r - \left(\sqrt{\mathbf{Var}(\sigma_r)} \cdot \sqrt{\mathbf{Var}(h_r)}\right)/\bar{h}_r$ and $\tilde{\sigma}_{r,\max} = \bar{\sigma}_r + \left(\sqrt{\mathbf{Var}(\sigma_r)} \cdot \sqrt{\mathbf{Var}(h_r)}\right)/\bar{h}_r$. This shows that the magnitude of the «effective» sigma may be either greater or less than the average value of the taste parameters in the corresponding group.

Taking into account that the income share of the «non-production» workers can be alternatively written as (see section A2 in Appendix)

$$\alpha = \frac{\theta \bar{h}_F}{\theta \bar{h}_F + (1-\theta)\bar{h}_V}, \tag{11}$$

where $\theta \equiv L_F / L = (N l_F)/L$ is a given share of the «white collars» in the economy, l_F is an exogenously given firm employment of the «creative» workers, we may conclude that «effective» preference for variety in (7) is expressed through the set of exogenously given moments of the joint taste-productivity distribution and a given share of the «white collars».

In order to obtain the closed form expression for equilibrium price in (6) and to express the idea that the higher average labor productivity enables firm to produce a symmetric variety at lower marginal cost, we follow Melitz (2003) and assume that the marginal cost of a firm is inversely related to the average labor productivity of the consumers/workers, directly involved into production process: $c = 1/\bar{h}_V$.[3] This assumption makes it possible to rewrite equilibrium price in the following way:

$$p = \frac{\alpha\tilde{\sigma}_F + (1-\alpha)\tilde{\sigma}_V}{\alpha\tilde{\sigma}_F + (1-\alpha)\tilde{\sigma}_V - 1}\frac{1}{\bar{h}_V}, \tag{12}$$

where $\tilde{\sigma}_F \equiv \bar{\sigma}_F + \rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\bar{h}_F}$, $\tilde{\sigma}_V \equiv \bar{\sigma}_V + \rho_V \cdot \frac{\sqrt{\mathbf{Var}(\sigma_V)} \cdot \sqrt{\mathbf{Var}(h_V)}}{\bar{h}_V}$,

$\rho_F \equiv \rho(\sigma_F; h_F)$, $\rho_V \equiv \rho(\sigma_V; h_V)$. It is easily verified that in the limiting case of homogeneous consumers, equilibrium price (12) immediately boils down to the price level $p = [\sigma/(\sigma-1)]c$ appearing in the Dixit and Stiglitz framework.

As is well known, the parameter sigma, which is typically associated with its role as the elasticity of substitution, is a key parameter of any model of monopolistic competition. In our setting this parameter equals to the weighted average of the «effective» sigmas of the two groups of consumers/workers (with weights being the shares of groups' expenditures on purchasing goods) and reflects the way in which consumers in group r perceives the differentiated varieties. Besides, it incorporates the potential correlation between tastes and labor productivities (and, hence, incomes) of consumers/workers, thus making possible to distinguish between the individual and collective choice.

What is important, the «effective» sigma in our model may depend upon the number of firms, making prices to demonstrate both pro- and anti-competitive behavior (Zhelobodko *et al*., 2012). Such a behavior is completely outside the scope of the Dixit and Stiglitz set-up, where prices do not depend upon the number of firms. The independence of short-run prices upon the number of competitive firms in the CES models of monopolistic competition runs against empirical evidence and is viewed as the one of the major inconsistencies of the Dixit-Stiglitz approach (Combes *et al*, 2008; Zhelobodko *et al*, 2012). Our set-up eliminates this pitfall by incorporating a socioeconomic heterogeneity into the CES model of monopolistic competition. The uncovered mechanism of the pro- and anti-competitive behavior of the short-run equilibrium prices in the monopolistically competitive setting with a CES-like utility function is a new result

[3] To reflect the idea of the noticeable contribution of the «creative» workers into production process, it could be also possible to assume alternative scenario with $c = 1/\bar{h}$, where $\bar{h}$ is the average productivity of both groups of consumers. Indeed, while unskilled workers produce final goods and services directly for the market, skilled workers produce services for internal use that indirectly influences firms' total productivity.

of ours. It has an empirical appeal and affects the market outcome through a new channel that, as it seems, has been completely ignored until now.

To see how prices may change along with the firm number, look at the income and population shares α and θ (see (11) and the line below). At fixed L and l_F these two parameters change in the same direction as the number of firms N does: the greater N will automatically ensure the higher values for θ and α (see sections A3-A5 in Appendix). Looking further at the «effective» preference for variety $\tilde{\sigma} = \alpha\tilde{\sigma}_F + (1-\alpha)\tilde{\sigma}_V = \tilde{\sigma}_V + \alpha(\tilde{\sigma}_F - \tilde{\sigma}_V)$, we may conclude that an increase in the income share α will automatically increase the value of the «effective» sigma when $\tilde{\sigma}_F > \tilde{\sigma}_V$ and decrease it when $\tilde{\sigma}_F < \tilde{\sigma}_V$. As a consequence, increasing $\tilde{\sigma}$ will decrease the price level in our economy, thus providing pro-competitive effect, while decreasing $\tilde{\sigma}$ will increase the price level, providing anti-competitive effect.

When the «effective» sigmas in the two groups of consumers coincide with each other ($\tilde{\sigma}_F = \tilde{\sigma}_V$), the effect of price dependency upon the number of firms completely disappears. This suggests that the price competition effect in our model is related with assumed division of consumers/workers into two groups, which «effective» preferences for varieties $\tilde{\sigma}_F$ and $\tilde{\sigma}_V$ may differ. Any change in the number of firms (at fixed L and l_F) in our model is inevitably accompanied by the corresponding transformation in the labor market structure. For example, an increase in the number of firms should automatically increase the proportion of «white-collar» workers at the expense of proportion of «blue-collars». The increased proportion of «creative» workers simultaneously increases its income share appearing in «effective» sigma, triggering corresponding variation in its magnitude and, as a consequence, corresponding variation in equilibrium price level.

4 Long-run equilibrium

Short-run equilibrium of the model derived in the previous section provides the equilibrium price for varieties by taking the number of firms in economy as given. This makes it possible to consider the total number of people consisting «white collars» as known, since it can be expressed through the given number of firms N and an exogenously given firm employment l_F of the «creative» workers: $L_F = Nl_F$. Similar observation is valid for the relative share of this group of employees, as long as $\theta \equiv L_F / L = (Nl_F)/L$. This means that the distribution of employees between the two groups of consumers/workers in the short-run equilibrium is determined by the number of firms in the economy.

Addressing the long-run equilibrium enables one to make the number of firms in the economy (as well as the population and income shares of the «creative staff») the endogenous parameters of the model. The endogenization of θ makes the distribution of consumers/workers between the two groups of employees completely determined by the joint distribution of consumers'/workers' attributes (see below). Any discrepancy between actual (θ) and long-run equilibrium (θ^*) magnitudes of the relative shares of «white collars» (and corresponding values of the relative shares of «production» workers) will provide distortions on the labor market, leading to the excess of one type of employees and the deficit of the others. These distortions will be inevitably eliminated in the long-run perspective due to mobility of the employees between the two groups of consumers. In order to get the long-run equilibrium values of income and population shares of the two groups of employees, we have to obtain the equilibrium number of firms and equilibrium firm employment in our model.

This can be done by assuming free entry and exit on the market. Applying zero profit condition ($\pi = (p-c)q - f = 0$) gives a long-run equilibrium output of a firm (firm size):

$$q^* = (\tilde{\sigma}-1)\bar{h}_V \bar{h}_F l_F . \tag{13}$$

Substituting the marginal ($=1/\bar{h}_V$) and the fixed ($=\bar{h}_F l_F$) costs and equilibrium output (13) into the balance of costs condition $cq + f = \bar{h} l$ yields the equilibrium employment of a firm:

$$l^* = \frac{\bar{h}_F}{\bar{h}} \tilde{\sigma} l_F . \tag{14}$$

Equilibrium employment of the «production» workers can be found as the difference between the total firm employment (l^*) and firm employment of the «non-production» workers (l_F):

$$l_V^* = \left(\frac{\bar{h}_F}{\bar{h}} \tilde{\sigma} - 1 \right) l_F . \tag{15}$$

Aggregating both sides of the budget constrain (2) over all consumers gives the equilibrium number of firms ($N^* = L / l^*$):

$$N^* = \frac{\bar{h}}{\bar{h}_F} \frac{L}{\tilde{\sigma} l_F}. \tag{16}$$

Notice that the «effective» taste parameter $\tilde{\sigma}$ appearing in (12)-(16) still remains an exogenously given, because it depends upon an exogenously given income share α of «creative» workers. To make $\tilde{\sigma}$ an endogenous parameter, we use the definition of the income share $\alpha^* \equiv \theta^* (\bar{h}_F / \bar{h}^*)$, corresponding to the long-run equilibrium of the model. By plugging $\theta^* = l_F / l^* (= L_F / L)$ into this expression, where l^* is taken from (14), we obtain the following «alpha-sigma relation»: $\alpha^* \tilde{\sigma}^* = 1$. By substituting $\tilde{\sigma}^* = \alpha^* \tilde{\sigma}_F + (1-\alpha^*)\tilde{\sigma}_V$ into the latter, we get the following quadratic equation for unknown α^*:

$$(\tilde{\sigma}_V - \tilde{\sigma}_F)(\alpha^*)^2 - \tilde{\sigma}_V \alpha^* + 1 = 0. \tag{17}$$

When $\tilde{\sigma}_V \neq \tilde{\sigma}_F$ it has a unique solution (see section A6 in Appendix):

$$\alpha^* = \frac{\tilde{\sigma}_V - \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2(\tilde{\sigma}_V - \tilde{\sigma}_F)}. \tag{18}$$

Taking into account the definition of income share $\alpha^* \equiv \theta^* (\bar{h}_F / \bar{h}^*)$, where $\bar{h}^* = \theta^* \bar{h}_F + (1-\theta^*)\bar{h}_V$, we get the long-run equilibrium share of «white collars» in the economy:

$$\theta^* = \frac{\alpha^* \bar{h}_V}{\alpha^* (\bar{h}_V - \bar{h}_F) + \bar{h}_F}. \tag{19}$$

The long-run equilibrium value of the «effective» tastes parameter can be found by plugging (18) into $\tilde{\sigma}^* = \alpha^* \tilde{\sigma}_F + (1-\alpha^*)\tilde{\sigma}_V$. This yields

$$\tilde{\sigma}^* = \frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2}. \tag{20}$$

To complete our derivation of the long-run equilibrium outcome of the model, we have to make a substitution $\tilde{\sigma} \to \tilde{\sigma}^*$ into formulas (12)-(16) above. As a result (see A7 in Appendix), we get the following set of equilibrium variables which are very suitable for a comparative static analysis:

$$p^* = \frac{\tilde{\sigma}^*}{\tilde{\sigma}^* - 1} \frac{1}{\bar{h}_V}, \tag{21}$$

$$q^* = (\tilde{\sigma}^* - 1)\bar{h}_V \bar{h}_F l_F, \tag{22}$$

$$l^* = \left(1 + (\tilde{\sigma}^* - 1)\frac{\bar{h}_F}{\bar{h}_V}\right) l_F, \tag{23}$$

$$l_V^* = (\tilde{\sigma}^* - 1)\frac{\bar{h}_F}{\bar{h}_V} l_F, \tag{24}$$

$$N^* = \frac{\bar{h}_V}{\bar{h}_V + (\tilde{\sigma}^* - 1)\bar{h}_F} \frac{L}{l_F}. \tag{25}$$

To analyze the markup dependence upon the moments of the joint tastes-labor productivity distribution in the next section, we will use Lerner index $m^* \equiv (p^* - c)/p^*$ as an equivalent of the equilibrium markup:

$$m^* = \frac{1}{\tilde{\sigma}^*}. \tag{26}$$

In accordance with (26), markup is inversely related with «effective» sigma. Taking into account the «alpha-sigma relation» $\alpha^* \tilde{\sigma}^* = 1$, we may conclude that the value of income share of «creative» workers in our model is equal to the markup (26): $\alpha^* = 1/\tilde{\sigma}^* = m^*$, providing an alternative expression for equilibrium income share (18). The higher the markup magnitude the larger is the income share of the «white collars».

The case of identical taste-labor productivity distributions in both of the two groups of consumers/workers should be considered separately. Noting that in such a case both groups of employees have identical tastes and labor productivity statistics, we may denote $\bar{h}_V = \bar{h}_F = \bar{h}$,

$\mathbf{Var}(\sigma_F) = \mathbf{Var}(\sigma_V) = \mathbf{Var}(\sigma)$, $\overline{\sigma}_F = \overline{\sigma}_V = \overline{\sigma}$, $\rho_F = \rho_V = \rho$, and get $\alpha^* \tilde{\sigma} = 1$ or $\alpha^* = 1/\tilde{\sigma}$, where «effective» preference for variety, common to both groups, is equal to

$$\tilde{\sigma} = \overline{\sigma} + \rho \cdot \frac{\sqrt{\mathbf{Var}(\sigma)} \cdot \sqrt{\mathbf{Var}(h)}}{\overline{h}}. \tag{27}$$

This expression depends exclusively upon the set of exogenously given parameters of the model. Equivalency of the consumers' attributes in both of the two groups of employees makes it possible to simplify the formulas (21)-(26) for an equilibrium outcome, which can be rewritten as $q^* = (\tilde{\sigma} - 1)\overline{h}^2 l_F$, $l^* = \tilde{\sigma} l_F$, $l_V^* = (\tilde{\sigma} - 1) l_F$, $\alpha^* = \theta^* = 1/\tilde{\sigma}$, $N^* = L/(\tilde{\sigma} l_F)$, and $m^* = 1/\tilde{\sigma}$, respectively, with $\tilde{\sigma}$ equal to (27).

Formally, outlined expressions for the general equilibrium outcome in the heterogeneous case turn out to be quite similar to those in the homogeneous (Dixit-Stiglitz) model of monopolistic competition. Nevertheless, there is an essential difference between the two models. While the taste parameter in the Dixit and Stiglitz approach is a constant, in the heterogeneous case (in accordance with (7) and (20)) it depends upon exogenously given moments of the joint distribution of the consumers' tastes and labor productivities. What is also important, all variables in these formulas explicitly depend upon the average values of the productivities of the consumers/workers, constituting a new element of the model, which is absent in the traditional model of Dixit and Stiglitz. For example, in accordance with (22), the output of a firm in our model turns out to be directly proportional to the average productivities of both groups of employees, which is in line with economic intuition and empirical regularities. By varying the moments of the joint taste-productivity distribution and average values of the labor productivities, we can investigate the impact of the exogenously given shocks on the market outcome.

5 Comparative statics of the model

In order to clarify our set-up and make our comparative static analysis easier to follow, let us specify the exogenous parameters of the model. Here they are: 1) population (size) of the economy L; 2) the employment of the firm's «creative» workers l_F [4]; 3) the first two moments of consumers' taste distribution of either group of employees $\overline{\sigma}_F$, $\overline{\sigma}_V$, $\mathbf{Var}(\sigma_F)$, $\mathbf{Var}(\sigma_V)$;

[4] This variable is equivalent to the exogenously given fixed cost a appearing in the Dixit and Stiglitz (1977) paper.

2) the first two moments of labor productivity distribution in both groups of workers $\bar{h}_F$, $\bar{h}_V$, $\mathbf{Var}(h_F)$, $\mathbf{Var}(h_F)$; 3) the correlation coefficients between tastes and productivities in either group of consumers/workers ρ_F, ρ_V. All other parameters of the model are expressed through this set of fundamentals.

Inspecting formulas (20)-(26) for the market outcome of the model, we may conclude that the correlation coefficients between tastes and productivities ρ_F, ρ_V, averages of the taste parameters $\bar{\sigma}_F$, $\bar{\sigma}_V$, and variances of the tastes and productivities $\mathbf{Var}(\sigma_F)$, $\mathbf{Var}(\sigma_V)$, $\mathbf{Var}(h_F)$, $\mathbf{Var}(h_F)$ exert the influence on the market outcome only through the value of the «effective» preference for variety, thus placing the «effective» sigma into the center of our comparative static analysis when considering the impact of these parameters on the general equilibrium of the model. What is important, the appearance of these parameters in the extended model of monopolistic competition preserves the form of linkages, existing in the traditional Dixit-Stiglitz set-up, and connecting all the key equilibrium variables of the model.

Unlike the above-mentioned set of fundamentals, the influence of the average productivities $\bar{h}_F$, $\bar{h}_V$ on the market outcome of the model is of entirely different character, as long as these parameters appear in the formulas for the equilibrium price, firm size, employment and number of firms along with the «effective» sigma. This fact is very important because it brings the new elements into the behavior of the market outcome.

In accordance with this peculiar feature of the model, we will have completely different scenarios of the equilibrium outcome response to the deviations in exogenous parameters of the model, which can be divided into two groups. The first group of scenarios is related with the set of parameters which influences the market outcome only through the «effective» sigma. Among these parameters we highlight separately the correlation coefficients and average values of the taste parameters of consumers, which influence the market outcome unambiguously, and the taste and productivity dispersions, which impact on the market outcome has an ambiguous character. The second group of scenarios is related with the average productivities of the consumers/workers which influence the market outcome both directly and through the «effective» sigma. These scenarios are the most interesting for us because they provide more (compared to what the first group of scenarios provides) effects, which are outside the scope of the traditional setting. As we will show below, either $\bar{h}_F$ or $\bar{h}_V$ may exert ambiguous influence on one part of the equilibrium parameters of the model and unambiguous influence on the other. By analyzing both types of scenarios we will focus our attention on (and discuss in greater detail) how markups evolve along with the change of the exogenous parameters of the model, since the variability of markups is the one of the key findings of ours.

As is well known, despite the numerous evidence on the variability of markups (Oliveira Martins *et al*., 1996; Ripatti and Vilmunen, 2001; Raurich et al, 2012; Tamminen and Chang, 2012), they are often assumed to be constant in the traditional models of monopolistic competition as well as in the literature on economic growth (Dixit-Stiglitz, 1977; Melitz, 2003; Blanchard, 2008). This fact was vigorously criticized in the literature (Blanchard, 2008; Markusen, 2010). There are at least two ways to overcome this inconsistency. The first assumes that individual preferences are non-homothetic and identical across consumers. Examples include Behrens and Murata (2007), Zhelododko *et al*. (2012) and Bertoletty and Etro (2013). The second (the one adopted in the present paper) incorporates heterogeneity in consumers' tastes, making markups to be dependent upon the moments of the joint tastes-labor productivity distribution. As a consequence, the demand-side conditions turn out to be the very important determinants in shaping the market outcome. The role of the elasticity of demand in setting markups were highlighted and empirically investigated in Lundin (2004).

As it stems from (20), the «effective» preference for variety $\tilde{\sigma}^*$, which is inversely related with the markup value through (26), is a nonlinear function of the correlation coefficients between tastes and productivities, showing that $\tilde{\sigma}^*$ and ρ_r $(r = F,V)$ evolve in the same direction (see A8 in Appendix for details): an increase in the magnitude of either of these coefficients is accompanied by an increase in the magnitude of «effective» preference for variety and vice versa. This makes it possible to formulate the following proposition:

Assume the given taste and productivity distributions in both groups of consumers/workers. Then, markup value gets lower (higher) and, hence, the degree of firm's market power gets less pronounced (more pronounced), if and only if the correlation coefficient between consumers' tastes and productivities in either group of consumers/workers increases (decreases). Furthermore, the degree of firm's market power is unaffected if and only if the tastes and productivities are uncorrelated.

Formally, the intuition behind this result is quite straightforward. Indeed, an increasing magnitude of the correlation coefficient, by increasing «effective» sigma, will simultaneously increase the price elasticity of the market demand.[5] This makes the market demand curve (which

[5] As it will be shown in Appendix, the price elasticity of market demand in our setting is equal to the «effective» preference for variety.

is faced by any firm) more elastic, thus restricting the ability of firms to exercise their monopoly power through charging higher markups.

Taking into account that $-1 \le \rho_r \le 1$ ($r = F,V$), we may conclude that the highest markups (and, hence, the highly pronounced market power on the product market) are realized when the taste parameters and productivities are negatively correlated and correlation coefficients are equal to their minimum value ($\rho_r = -1$). In such a case the magnitude of the «effective» taste parameter in either of the two groups of consumers/workers also has its minimum. Examining expressions for equilibrium firm size (22), firm employment (23) and number of firms (25), one can conclude that in such a case the market outcome is characterized by the smallest firm size (both in terms of output and employment) and by the largest number of firms on the market (hence by the highest degree of product differentiation).

Conversely, the lowest markups (and, hence, the least pronounced market power) occurs when taste parameters and productivities are positively correlated and correlation coefficient has its maximum value ($\rho_r = 1$) together with the «effective» taste parameter in both groups of consumers/workers. This case of the lowest degree of firm market power (provided by the maximum value of the «effective» sigma) is characterized by the biggest firm size (both in terms of output and employment) and the least number of firms on the market. As a consequence, this leads to a narrowest range of differentiated varieties.

The above predictions of the model seem rather surprising and deserve additional comments. How can it be that the highest markups and, hence, the greatest monopoly power, is realized on the market with the largest number of firms (and vice versa)? To answer this question we should notice that in our setting each variety is produced by a single firm and each firm produces a single variety. In such a case an extension of the market power by virtue of increasing the degree of product differentiation is automatically accompanied by an increase in the number of firms on the market.

To see this more clearly, let us take the Dixit-Stiglitz model of monopolistic completion and consider the specific role played by the sigma parameter in this model. In accordance with the Dixit-Stiglitz approach, both the degree of product differentiation and degree of market power are an unambiguously determined by the magnitude of the same parameter sigma, which is inversely related with the number of firms.[6] On the one hand, the lower sigma means the greater product differentiation and, hence, the greater market power of a firm (which is realized

[6] Using the notations accepted in the present paper, the equilibrium number of firms in the Dixit-Stiglitz model of monopolistic competition can be written as $N^* = L/(\sigma l_F)$.

through product differentiation). On the other hand, the lower sigma means the greater number of firms, which is in a contradiction with greater monopoly power (intuitively, the greater monopoly power should be accompanied by a smaller number of firms, which is not so).

Our answer to this contradiction is as follows. It seems that the number of firms in our setting cannot serve both as an indicator of the toughness of competition and also as criteria of the degree of the market power of a firm. Indeed, the two cases with different sigmas cannot be strictly compared, because they correspond to different economies producing different goods: the economy with very big sigma produces the nearly homogenous good, while the economy with small sigma produces strongly differentiated varieties. The homogeneity of goods makes the first economy very competitive, despite the small number of firms on the market.[7] On the contrary, the higher degree of product differentiation in the second economy enables any firm to exercise market power despite the large number of firms surrounding it. In such a case an incentive arises to call the first economy «more competitive» than the second, despite the very small number of firms, compared to the second. By saying so, we give the priority in definition of the «intensity of competition» to markups at the expense of the number of firms, since we characterize the environment as «more competitive» when firms cannot exercise their market power (no matter how many firms is present on the market).

Turning back to our analysis, and inspecting the market outcome of the model, we may conclude that all the key variables in formulas (21)-(26) unambiguously depend upon the average values of the taste parameters $\bar{\sigma}_F$ and $\bar{\sigma}_V$ in groups *F* and *V*. This unambiguity is explained by the corresponding unambiguity in the «effective» preference for variety behavior. For example, the greater the average value of the taste parameter in either group of consumers/workers the larger is the magnitude of the «effective» sigma and, hence, the less is the magnitude of firm markups. The formula (20) for «effective» sigma shows that the meaningful effects to the market outcome can be triggered by any transformation of the consumers'/workers' tastes distributions, accompanied by a change in the average values of the tastes parameters $\bar{\sigma}_F$ and $\bar{\sigma}_V$. The long-run transformation of this kind may be due to a change of the proportion of the consumers/workers sharing specific values of the tastes parameters arising in the process of a generational shift.

[7] When sigma is very large, the good is almost homogeneous. In this case we know from Bertrand oligopoly that only two firms are sufficient to get perfect competition.

Since the key parameters of the market outcome (21)-(26) tend to react similarly in response to both an increase in the correlation coefficients ρ_F, ρ_V and to an increase in the averages of the taste parameters $\bar{\sigma}_F$, $\bar{\sigma}_V$, we place corresponding results in the same table:

Table 1

	$\tilde{\sigma}^*$	m^*	p^*	q^*	l^*	N^*
$\rho_r \uparrow$ or $\bar{\sigma}_r \uparrow$ ($r = F,V$)	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$

In contrast to the correlation coefficients ρ_F, ρ_V and averages of the taste parameters $\bar{\sigma}_F$, $\bar{\sigma}_V$, the influence of the taste and productivity dispersions $\mathbf{Var}(\sigma_F)$, $\mathbf{Var}(\sigma_V)$, $\mathbf{Var}(h_F)$, $\mathbf{Var}(h_V)$ and the average productivities $\bar{h}_F$, $\bar{h}_V$ on the «effective» sigma has an ambiguous character. Whether the response of the «effective» preference for variety to an increase in the magnitude of these parameters will be positive or negative will be determined by the sign of the correlation coefficients ρ_F and ρ_V. For example, a growing dispersion in either productivity $\mathbf{Var}(h_F)$ or $\mathbf{Var}(h_V)$ will be accompanied by a decrease in the magnitude of «effective» sigma only when the correlation coefficients between tastes and productivities obtain negative values. Since dispersions in productivities in our set-up is equivalent to the income dispersions of consumes/workers, this prediction is consistent with Yurko (2011), who showed in a very different setting that a growing income inequality leads to a widening range of vertically differentiated varieties. Nevertheless, our model will also demonstrate an alternative scenario when either coefficient ρ_F or coefficient ρ_V will turn out to be positive.

So far as the equilibrium parameters of the model depend upon the taste and productivity variances only through the «effective» sigma, all of these parameters will automatically demonstrate the ambiguity in their own behavior in response to deviations in the taste and productivity dispersions. Results of the comparative static analysis of the market outcome response to an increase in variances $\mathbf{Var}(h_F)$, $\mathbf{Var}(h_V)$ and $\mathbf{Var}(\sigma_F)$, $\mathbf{Var}(\sigma_V)$ is shown in table 2 below:

Table 2

	$\tilde{\sigma}^*$	m^*	p^*	q^*	l^*	N^*
$-1 \le \rho < 0$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$
$0 < \rho \le 1$	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$

Unlike the correlation coefficients and taste and productivity dispersions, the impact of the average productivities $\overline{h}_F$, $\overline{h}_V$ on the market outcome may provide different (and somewhat more realistic) scenarios, as long as these two parameters appear in the formulas for the equilibrium firm size, employment and number of firms in combination with the «effective» sigma.

Response of the markups to an increase in the average labor productivity of «non-production» workers can be revealed by differentiating markups with respect to $\overline{h}_F$, which yields $\partial m^* / \partial \overline{h}_F = A\rho_F$, where A is a positive coefficient (see section A8 in Appendix). Hence, an increase in $\overline{h}_F$ may either increase or decrease the markup magnitude, depending on the sign of the correlation coefficient between tastes and productivities in the group of «white-collars». The ambiguity in markups with respect to the average labor productivity of «non-productive» workers $\overline{h}_F$ is accompanied by the corresponding ambiguity in prices (see section A9 in Appendix).

Unlike prices and markups, the firm size, firm employment and number of firms demonstrate a somewhat more complicated form of an ambiguity in response to an increase in the average productivity of the «creative staff». This kind of an ambiguity (observed at positive values of the correlation coefficient) is inherently difficult to study due to analytical intractability (see section A11 Appendix). More concretely, it is very difficult to formulate sufficient and necessary conditions at which each of these parameters increase and/or decrease. The pattern of the equilibrium outcome response to an increase in the average productivity $\overline{h}_F$ of «white-collar» workers is represented in table 3:

Table 3

	$\tilde{\sigma}^*$	m^*	p^*	q^*	l^*	N^*
$-1 \le \rho_F < 0$	↑	↓	↓	↑	↑	↓
$0 < \rho_F \le 1$	↓	↑	↑	↑↓	↑↓	↑↓

Response of the markups to an increase in the average labor productivity of «production» workers also has an ambiguous character. Indeed, differentiating markups with respect to $\overline{h}_V$ yields $\partial m^* / \partial \overline{h}_V = B\rho_V$ where $B > 0$ (see A9 in Appendix). Hence, similar to the markup reaction to an increase in $\overline{h}_F$, its response to an increase in $\overline{h}_V$ also depends on the sign of the correlation coefficient between tastes and productivities. The ambiguity in markups behavior in response to an increase in productivities is a key prediction of our model, which is in a full accordance with empirical evidence documented in the literature (Roberts and Supina, 1996; Tamminen and Chang, 2012).

In contrast to the «white collar» workers, the impact of the productivity of «blue-collars» on the equilibrium price level has more sophisticated character, since in accordance with (21), it influences prices not only through the «effective» sigma, but also through the marginal costs $c = 1/\bar{h}_V$. When $\rho_V < 0$, than an increase in $\bar{h}_V$ forces the price level to decrease along with the ratio $\tilde{\sigma}^* /(\tilde{\sigma}^* - 1)$ and the marginal costs $c = 1/\bar{h}_V$. Nevertheless, when $\rho_V > 0$, than the ratio $\tilde{\sigma}^* /(\tilde{\sigma}^* - 1)$ and the marginal costs $c = 1/\bar{h}_V$ change in the opposite directions. This may end up with either increase or decrease in prices, depending on what effect dominates. Unfortunately, we failed to derive an exact condition determining intervals of variations in productivity $\bar{h}_V$ at which prices behave unambiguously, but our numerical calculations showed that in this case prices may not only decrease, but also increase at some combination of fundamentals.

It is worth noting that an ambiguity in prices with respect to the average labor productivities of both groups of workers completely disappears in the setting where both groups of employees have identical tastes and labor productivity statistics. Comparative static analysis shows (see section A12 in Appendix) that in such an event an increase in the average productivity is always accompanied by a decrease in prices just like in Melitz model of trade (Melitz, 2003). Nevertheless, by contrast to Melitz, in our setting more productive firms can simultaneously charge lower prices and set higher markups, compared to the less productive ones. This is also a new prediction of our model, which is to be empirically verified elsewhere.

As far as the output of a firm, firm employment, and number of firms are concerned, they change unambiguously, whatever the sign of the correlation coefficient between tastes and productivities is (see sections A13-A15 Appendix), providing increase in firm size and number of firms and decrease in firm employment. This result is in contrast to what is observed in the case with «creative staff» productivity deviation. It enables us to formulate the following proposition:

Assume the given taste and productivity distributions of non-production workers, the given taste and productivity dispersions of the «creative» workers and the fixed correlation coefficients between taste and productivities in both groups of consumers/workers. Then, an increase in the average productivity of production workers will simultaneously increase both firm size and the number of firms on the market.

In other words, increasing productivity in the production sector stimulates new firms to enter the market and also stimulates firms to grow. This prediction of our model is quite reasonable and is in line with economic intuition. Notice that this result cannot be obtained by using conventional model of monopolistic competition where reduction in firm employment leads to an increase in number of firms, but keeps their size unchanged.

The pattern of the equilibrium outcome response to an increase in the average productivity $\bar{h}_V$ of «blue-collar» workers is shown in table 4:

Table 4

	$\tilde{\sigma}^*$	m^*	p^*	q^*	l^*	N^*
$-1 \le \rho_V < 0$	↑	↓	↓	↑	↓	↑
$0 < \rho_V \le 1$	↓	↑	↑↓	↑	↓	↑

As table 4 demonstrates, when the correlation coefficient between tastes and productivities in the group of «production» workers is negative, than an increase of productivity in production sector is accompanied by a decrease in both markups and prices and an increase in the number of firms and firm size. This scenario looks more appealing empirically since it provides an agreement between the market power (which is measured by markup) and degree of product differentiation (which is equivalent to the number of firms on the market).[8]

5.1 Comparative statics of the coefficient Gini

One of the interesting applications of our model is the investigation of how the income inequality evolves along with an increase in the average productivities of either group of consumers/workers. This can be done by using the comparative static analysis of the coefficient Gini. As is well known, Gini varies between 0 and 1 with its higher values corresponding to a greater income inequality. In the case of an economy hosting only two different groups of consumers/workers, it is given by[9]

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[8] Relative love for variety, which measures the degree of product differentiation in the Dixit-Stiglitz model ($RLV = 1/\sigma$) is not relevant here because it is determined through the utility function ($RLV \equiv -xU''/U'$). When all consumers are the same, the utility function of the collective of consumers is equivalent to the utility of an individual. This cannot be so in our approach, because the utility function of the collective of consumers cannot be derived via the utility function of the individuals. Speaking other words, the utility function of a collective of heterogeneous consumers doesn't exist.

[9] We use an approximate expression for Gini based on the average characteristics of the two groups of employees.

$$Gini^* = \begin{cases} \alpha^* - \theta^*, \ if \ \ \alpha^* > \theta^* \\ \theta^* - \alpha^*, \ if \ \ \alpha^* < \theta^* \end{cases} . \quad (28)$$

So far as $\alpha^* \equiv (\bar{h}_F / \bar{h})\theta^*$ and the average productivity in our model is equivalent to the average wage/income of an individual, it is reasonable to assume that the average productivity of «white-collars» is greater than that of «blue-collars» and, hence, greater than the average productivity in the economy ($\bar{h}_F > \bar{h}$). In such a case the income share of «non-production» workers turns out to be greater than their employment share ($\alpha^* > \theta^*$)[10], and Gini becomes unambiguously determined as

$$Gini^* = \alpha^* - \theta^* . \quad (29)$$

Substituting α^* and θ^* into (29) yields (see section A16 in Appendix):

$$Gini^* = \frac{\bar{h}_F - \bar{h}_V}{\bar{h}_V + (\tilde{\sigma}^* - 1)\bar{h}_F} \frac{\tilde{\sigma}^* - 1}{\tilde{\sigma}^*} . \quad (30)$$

The formula for Gini shows that the meaningful effects to the degree of inequality can be triggered by any transformation of the labor market, accompanied by a change in the average productivity of either group of consumers/workers.

As evidence suggests, replace of «blue-collar» production activities by automated processes shifts demand towards «white-collar» workers in management and control, skill-intensive service and science-based research and development. This leads to a steady rise in the relative employment of the «white collars» and generates a structural shift in the production towards a knowledge-intensive production process (Adams, 1999; Berman *et al.*, 1994; Machin and van Reenen, 1998).

This structural shift may be described by our set-up. Actually, by differentiating the share of the «non-production» workers with respect to the average productivity in the group of «blue-collars», we get $\partial\theta^* / \partial\bar{h}_V > 0$ (see A17 in Appendix), which means that the share of «white collars» really increases along with increase in the average labor productivity in the production sector. Whether this change in the share of the «creative staff» will provide an increase or

[10] These assumptions are in a full accordance with data on non-production/production wage differential (Nahuis and Smulders, 2002) and data on relation between non-production wage-bill and non-production employment share in the USA (Machin and van Reenen, 1998).

decrease in income inequality, depends on the sign of the derivative $\partial(Gini^*)/\partial\bar{h}_V$. By differentiating Gini with respect to $\bar{h}_V$ we get

$$\frac{\partial(Gini^*)}{\partial\bar{h}_V} = B\rho_V - D, \tag{32}$$

where B and $D \equiv \partial\theta^*/\partial\bar{h}_V$ are both positive: $B > 0$ and $D > 0$ (see section A18 in Appendix), while ρ_V may be either positive or negative. When $\rho_V < 0$, than $\partial(Gini^*)/\partial\bar{h}_V < 0$, i.e. an increase in the productivity of «blue-collar» workers (other things being fixed) makes economy more egalitarian. This option corresponds to the scenario, represented by the first row of the table 4. Nevertheless, when $\rho_V > 0$, than the difference $B\rho_V - D$ may be of either sign. The negative $B\rho_V - D$ will lead to the same outcome as in the former case with $\rho_V < 0$, while the positive $B\rho_V - D$ will provoke an increase in degree of income inequality. The latter outcome occurs when an increase in income share exceeds an increase in the employment share $\partial\alpha^*/\partial\bar{h}_V > \partial\theta^*/\partial\bar{h}_V$. The last option was discussed in (Nahuis and Smulders, 2002), where it was argued that the steady increase in the supply of educated workers (that most Western economies have experienced in recent decades) may be viewed as the driving force behind the observed pattern of wage inequality.

In contrast to the model, developed in (Nahuis and Smulders, 2002), our set-up predicts more versatile scenario, since $\rho_V < 0$ unambiguously guarantees a reduction in income inequality.[11] As far as the sign of the correlation coefficient between the tastes and productivities in our model crucially depends upon the type of goods (see the last sections below), we may claim that our prediction concerning the income inequality response may be different for different industries. As a consequence, the final result of Gini transformation in the economy as a whole will be determined by the competing contributions of different industries into this process. Besides, it will depend upon the reaction of Gini on an increase in the average productivity (hence, average wage) of «white-collars», which goes along with the process of the average productivity increase in the production sector (Nahuis and Smulders, 2002), but cannot be taken into account by applying comparative statics.

[11] The same prediction corresponds to the limiting case with $\rho_V = 0$, where our model also provides $\partial(Gini^*)/\partial\bar{h}_V < 0$.

Addressing the income inequality response to an increase in the average productivity of the «non-production» workers, one can obtain:

$$\frac{\partial(Gini^*)}{\partial\bar{h}_F} = A\rho_F - C\,, \tag{33}$$

where $A > 0$, while $C \equiv \partial\theta^* / \partial\bar{h}_F$ may be either positive or negative (see section A19 in Appendix). When $\rho_F \leq 0$, than $C \equiv \partial\theta^* / \partial\bar{h}_F > 0$ and $\partial(Gini^*) / \partial\bar{h}_F < 0$, i.e. an increase in the average productivity (accompanied by an increase in the average income) of «creative» workers makes our economy more egalitarian. This option corresponds to the scenario, reflected in the first row of the table 3. Nevertheless, when $\rho_F > 0$, than things may go differently, since the sign of the difference $A\rho_F - C$ may be either positive or negative.

Combining results of the coefficient Gini response to the average productivity growth in both production and non-production sectors, we may conclude that the case with both ρ_V and ρ_F being negative unambiguously ensures reduction in income inequality, while the opposite case with both ρ_V and ρ_F being positive may provide different outcomes.

6 The sign of the correlation coefficient estimation

Results of the comparative static analysis of the model, carried out in the previous section, show that the sign of the correlation coefficient between tastes and labor productivities plays an important role in what concerns predictions of the model. This means that it would be interesting to determine the sign of this coefficient and how it varies with the labor productivity (income) and taste distributions.

To shed some light on the relationships between the two distributions, and particularly, on the sign of the correlation coefficient, assume for a moment that both groups of consumers/workers in our model have identical tastes and labor productivity statistics. Assume also that the joint distribution between tastes parameters σ and labor productivities h is Gaussian[12] with density

[12] An assumption of the Gaussian joint tastes-labor productivity distribution is used here exclusively for illustrative purposes.

$$g(\sigma,h)=\frac{1}{2\pi\delta_\sigma\delta_h\sqrt{1-\rho^2}}\exp\left\{-\frac{1}{2(1-\rho^2)}(z_\sigma^2-2\rho\, z_\sigma z_h+z_h^2)\right\}, \tag{34}$$

where $z_\sigma=\dfrac{\sigma-\bar{\sigma}}{\delta_\sigma}$, $z_h=\dfrac{h-\bar{h}}{\delta_h}$ $(\delta_\sigma>0\,,\delta_h>0\,,|\rho|\le 1)$. As is well known, in such a case the conditional distribution of σ is also normal, generating the following conditional expectation of the tastes parameter:

$$E(\sigma\,|\,h)=\bar{\sigma}+\rho\frac{\delta_\sigma}{\delta_h}(h-\bar{h})\,. \tag{35}$$

As immediately stems from the last formula, the regression of σ on h, defined by $E(\sigma\,|\,h)$, for this type of distribution is linear. So, if the joint distribution of σ and h is normal, then σ and h are linearly correlated. This means that running linear regressions of the kind (35) allows one to retrieve the sign of the correlation coefficient by looking at the slope of the corresponding line.

This observation may be useful in trying to find an empirical verification of our results. Indeed, taking into account that the joint distribution of tastes (σ) and labor productivities (h) and the joint distribution of tastes (σ) and incomes (y) can be used interchangeably, and taking into account that the price elasticity coefficient of individual demand in our model coincides with the tastes parameter sigma for a particular consumer: $\varepsilon=\sigma(\omega)$ (see section A20 in Appendix), we may run the following regression

$$E(\varepsilon\,|\,y)=\bar{\varepsilon}+\rho\cdot\frac{\delta_\varepsilon}{\delta_y}(y-\bar{y}) \tag{36}$$

instead of (35) to estimate the sign of the correlation coefficient ρ between tastes and labor productivities (incomes) in the particular group of consumers/workers.

The type of (36) regression can be run by using empirical results, collected in the EERC report, presented by Ivanova (Ivanova, 2005), who employed panel data analysis to estimate price and income elasticities for disaggregated domestic and imported goods in Russia. In doing so, she used the Budget Survey of Russian households and prices of imported and domestic goods. Results, obtained in her working paper, indicate the presence of certain differences between estimated elasticities and reveal its relation with the personal income of the consumers.

Specifically, in accordance with Ivanova's findings, the line of regression of the price elasticity for different goods on consumers' income turns out to be tilted both upward and downward, which clearly shows that the sign of the correlation coefficient between tastes and incomes (labor productivities) may be both positive and negative. The very observation that the slope of linear regression (and correspondingly the sign of the correlation coefficient) crucially depends upon the type of good, produced in the economy, is very important. It means that the toughness of competition in particular industry substantially depends upon the type of good this industry produces.

The graphs represented below clearly demonstrate both options. Fig. 1 plots the market price elasticity coefficient for textile vs income of the Russian consumers, divided into ten income groups (from the first group, which is poorest, up to tenth group, which is the richest one).

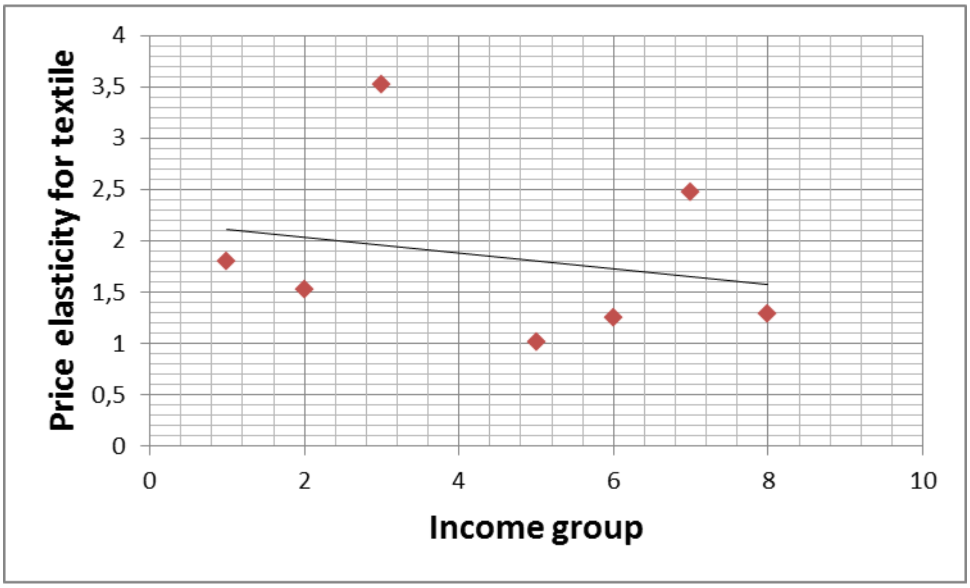

Fig. 1: Market price elasticity coefficient for textile vs income groups of consumers

As the graph shows, the market price elasticity coefficient tends to decrease along with increase of the income of the consumers, signifying that the corresponding correlation coefficient between tastes and incomes of the consumers acquire negative value.

Fig. 2 plots the market price elasticity coefficient for furniture vs income groups of the Russian consumers. In contrast to the previous graph, it clearly demonstrates that the price elasticity may increase along with increase in income of the consumers, thus pointing out on the positive values of the correlation coefficient between tastes and incomes.

These examples clearly demonstrate that the sign of the correlation coefficient between tastes and incomes of the consumers/workers may depend upon the type of good sold on the market, this way providing ambiguous dependency of the «effective» preference for variety upon labor productivity (income) of the consumers/workers.

More specifically, it means that an increase of labor productivity (income) of the particular group of consumers/workers may end up with either increase or decrease in the magnitude of the «effective» preference for variety, depending on the sign of the correlation coefficient between tastes and incomes of the consumers/workers.

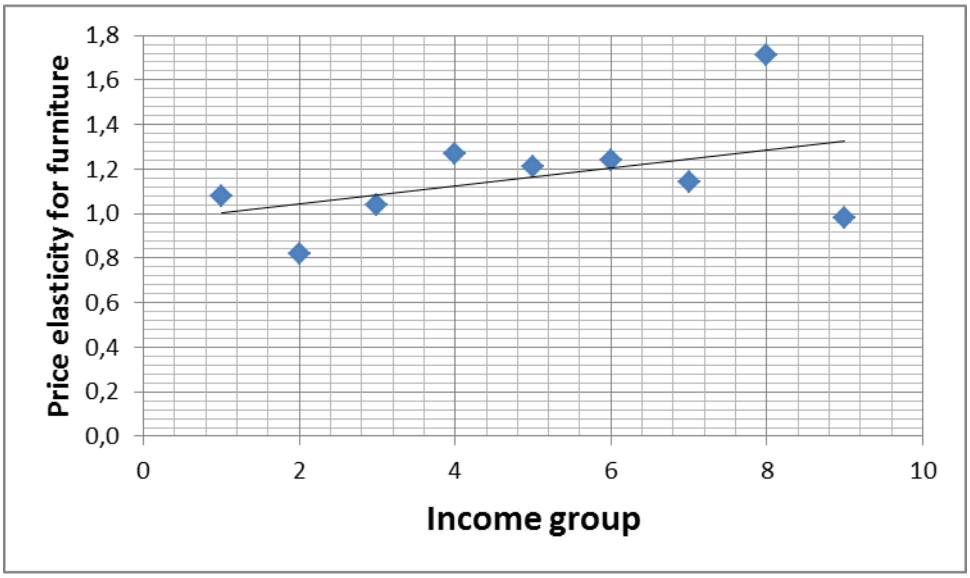

Fig. 2: Market price elasticity coefficient for furniture vs income groups of consumers

This also shows that the toughness of competition within particular industry depends considerably upon the type of good, produced within this industry. Production of goods which perception provides larger values of the correlation coefficient (between tastes and incomes of the consumers) automatically makes the corresponding industry more competitive compared to other ones, since it provides the smaller values of the markups, charged by firms.

7 Conclusions

We have developed a general equilibrium model of monopolistic competition featuring heterogeneity in consumers' preferences. The incorporation of the heterogeneity into traditional monopolistic competition setting is achieved by assuming different elasticities of substitution in the CES utility function for different consumers. Although very simple, our model exhibits a wide range of predictions regarding the impact of exogenous parameters on the market outcome.

It retains the tractability of the standard CES model with identical consumers and can be used to revisit several issues where the Dixit–Stiglitz and Melitz models have been applied.

By assuming that consumers and workers are the same people and splitting consumers/workers into two different groups of employees enables us to reflect heterogeneity of the labor market structure in the models of monopolistic competition. The difference between employees fulfilling different functions, provided by the structure of the costs, is a specific feature of any model of monopolistic competition. Nevertheless this difference is not ordinarily accounted for, since it requires an appropriate modification of the utility function. This modification is made in the present approach.

The incorporation of the socioeconomic heterogeneity into the model of monopolistic competition makes it possible to reveal an equilibrium price dependence upon the number of firms, making prices to demonstrate both pro- and anti-competitive behavior. Such a behavior drops out of the Dixit and Stiglitz set-up, where prices do not depend upon the number of firms. The uncovered mechanism of the pro- and anti-competitive behavior of the short-run equilibrium prices in the CES-like model of monopolistic competition is new. It has an empirical appeal and affects the market outcome through a specific channel that has been completely ignored before.

Our main motivation in developing a modified model of monopolistic competition is in accounting for the variability of markups observed empirically. Unlike the Dixit-Stiglitz and Melitz approaches, where markups are constant, the present model, by taking consumers' heterogeneity into account, provides markups which depend upon the covariance of the tastes and productivities of consumers/workers. The aforementioned dependence is of an ambiguous character and is determined by the sign of the correlation coefficient between tastes and labor productivities of consumers/workers. This is a key finding of our model, which is in a full accordance with empirical regularities documented in the literature.

In order to demonstrate some applications of the model, we carry out comparative static analysis of the employment shares and Gini coefficient response to an increase in the average productivities of the different groups of consumers/workers. Our findings demonstrate that an increase of the average productivity in the production sector leads to an increase in the share of «white-collar» workers, which is in line with empirical observations. The model fails to provide an unambiguous prediction of the Gini response to an increase in the average labor productivities of the two groups of consumers/workers, demonstrating that this response may be of different sign in different industries. The key parameter which is responsible to this kind of behavior is the correlation coefficient between tastes and productivities.

In order to sign this coefficient, we make use of empirical estimations of the price elasticities for disaggregated goods, obtained in the literature, to show that this ambiguity takes place in reality. These estimations also demonstrate that the sign of the correlation coefficient between tastes and productivities (incomes) of the consumers depend upon the type of good sold on the market. Production of goods associated with larger values of this coefficient automatically makes the corresponding industry more competitive compared to others by preventing firms from charging higher markups and setting higher prices.

Appendix

A1. Derivation of the effective sigma-parameter

Inserting market demands (4) into (5) and maximizing profits for every firm, considering the number of firms N as given, yields the following relation for equilibrium price p_i

$$p_i^* = \frac{\tilde{\sigma}_i}{\tilde{\sigma}_i - 1} c \, ,$$

where $\tilde{\sigma}_i$ is the effective parameter:

$$\tilde{\sigma}_i = \frac{\int_{\Omega_F} \frac{\sigma_F(\omega_F) h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F + \int_{\Omega_V} \frac{\sigma_V(\omega_V) h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V}{\int_{\Omega_F} \frac{h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F + \int_{\Omega_V} \frac{h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V}$$

Rewriting effective sigma parameter as

$$\tilde{\sigma}_i = \frac{\int_{\Omega_F} \frac{h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F}{\int_{\Omega_F} \frac{h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F + \int_{\Omega_V} \frac{h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V} \frac{\int_{\Omega_F} \frac{\sigma_F(\omega_F) h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F}{\int_{\Omega_F} \frac{h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F} +$$

$$+ \frac{\int_{\Omega_V} \frac{h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V}{\int_{\Omega_F} \frac{h_F(\omega_F)}{P_F(\omega_F)} p_i^{-\sigma_F(\omega_F)} d\mu_F + \int_{\Omega_V} \frac{h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V} \frac{\int_{\Omega_V} \frac{\sigma_V(\omega_V) h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V}{\int_{\Omega_V} \frac{h_V(\omega_V)}{P_V(\omega_V)} p_i^{-\sigma_V(\omega_V)} d\mu_V}$$

and simplifying the last expression by assuming identical firms providing symmetric equilibrium with $p_i^* = p^*$ ($i = 1,2,..., N$), we get:

$$\tilde{\sigma} = \alpha \tilde{\sigma}_F + (1-\alpha) \tilde{\sigma}_V \, ,$$

where

$$\tilde{\sigma}_F = \frac{\int_{\Omega_F} \sigma_F(\omega_F) h_F(\omega_F) d\mu_F}{\int_{\Omega_F} h_F(\omega_F) d\mu_F} = \frac{Cov(\sigma_F h_F)}{\bar{h}_F}, \quad \tilde{\sigma}_V = \frac{\int_{\Omega_V} \sigma_V(\omega_V) h_V(\omega_V) d\mu_V}{\int_{\Omega_V} h_V(\omega_V) d\mu_V} = \frac{Cov(\sigma_V h_V)}{\bar{h}_V}.$$

Using relation $\overline{\sigma_r h_r} = Cov(\sigma_r h_r) + \bar{\sigma}_r \bar{h}_r$, where $Cov(\sigma_r h_r)$ is the covariance between σ_r and h_r, obtained expressions can be represented alternatively in the form (8)-(9).

A2. Derivation the expression for the income share of the «creative staff»

By definition, income share of the «creative staff» is $\alpha \equiv Y_F / Y$. Inserting here expressions for the total incomes of the groups, we get

$$\alpha \equiv \frac{Y_F}{Y} = \frac{\bar{h}_F L_F}{\bar{h}_F L_F + \bar{h}_V L_V} = \frac{\bar{h}_F (L_F / L)}{\bar{h}_F (L_F / L) + \bar{h}_V (L_V / L)} = \frac{\theta \bar{h}_F}{\theta \bar{h}_F + (1-\theta)\bar{h}_V}.$$

A3. Positive relation between number of firms and income and population shares

The positive relation between the population share of the «creative staff» and the number of firms is obvious as long as $\theta \equiv L_F / L = (N l_F)/L$. Inserting the latter into $\alpha = (\theta \bar{h}_F)/[\theta \bar{h}_F + (1-\theta)\bar{h}_V]$, we have

$$\frac{\partial \alpha}{\partial N} = \frac{\bar{h}_F \bar{h}_V}{[\theta \bar{h}_F + (1-\theta)\bar{h}_V]^2} \frac{\partial \theta}{\partial N} > 0.$$

A4. Collective sigma vs number of firms

Rewriting $\tilde{\sigma} = \alpha \tilde{\sigma}_F + (1-\alpha)\tilde{\sigma}_V$ as $\tilde{\sigma} = \tilde{\sigma}_V + \alpha(\tilde{\sigma}_F - \tilde{\sigma}_V)$ and differentiating the latter with respect to the number of firms yields

$$\frac{\partial \tilde{\sigma}}{\partial N} = (\tilde{\sigma}_F - \tilde{\sigma}_V)\frac{\partial \alpha}{\partial N} = (\tilde{\sigma}_F - \tilde{\sigma}_V)\frac{\partial}{\partial N}\left(\frac{\theta \bar{h}_F}{\theta \bar{h}_F + (1-\theta)\bar{h}_V}\right)$$

Plugging here $\theta \equiv L_F / L = (N l_F)/L$, one can get

$$\frac{\partial \tilde{\sigma}}{\partial N} = \frac{\bar{h}_V \bar{h}_F (l_F / L)}{\left((\bar{h}_F - \bar{h}_V)(l_F / L)N + \bar{h}_V\right)^2}(\tilde{\sigma}_F - \tilde{\sigma}_V).$$

A5. Short-run equilibrium price vs number of firms

By differentiating short-run prices (6) with respect to the number of firms by taking into account $\partial\tilde{\sigma}/\partial N$ from the previous section one can get

$$\frac{\partial p}{\partial N}=\frac{\partial}{\partial N}\left(\frac{\tilde{\sigma}}{\tilde{\sigma}-1}\frac{1}{\bar{h}_V}\right)=-\frac{1}{\bar{h}_V}\frac{\partial\tilde{\sigma}/\partial N}{(\tilde{\sigma}-1)^2}=\frac{1}{(\tilde{\sigma}-1)^2}\frac{\bar{h}_F(l_F/L)}{[(\bar{h}_F-\bar{h}_V)(l_F/L)N+\bar{h}_V]^2}(\tilde{\sigma}_V-\tilde{\sigma}_F)$$

The sign of this derivative coincides with the sign of the bracket $(\tilde{\sigma}_V-\tilde{\sigma}_F)$ signifying that the price level increases along with the number of firms, when $\tilde{\sigma}_V>\tilde{\sigma}_F$, and decreases along with increasing number of firms, when $\tilde{\sigma}_V<\tilde{\sigma}_F$. The absolute value of the derivative has its maximum at $N\to 1$ and approaches its minimum (equal to zero) when the number of firms tends to infinity. This means that price dependence upon the number of firms is most pronounced at small number of firms; it vanishes when firm number gets very large.

A6. The uniqueness of the root

Quadratic equation (17) has the following general solution

$$\alpha^*=\frac{\tilde{\sigma}_V\pm\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}{2(\tilde{\sigma}_V-\tilde{\sigma}_F)}.$$

Let us show that the root with positive sign provides $\alpha^*>1$, and, hence, should be eliminated. Proof by contradiction, assuming that

$$0<\frac{\tilde{\sigma}_V+\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}{2(\tilde{\sigma}_V-\tilde{\sigma}_F)}<1$$

If $\tilde{\sigma}_V-\tilde{\sigma}_F<0$ than $\frac{\tilde{\sigma}_V+\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}{2(\tilde{\sigma}_V-\tilde{\sigma}_F)}<0$, which is senseless. So, consider the opposite case with $\tilde{\sigma}_V-\tilde{\sigma}_F>0$. If $\tilde{\sigma}_V-\tilde{\sigma}_F>0$, than it is equivalent to the inequality $\tilde{\sigma}_V+\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}<2\tilde{\sigma}_V-2\tilde{\sigma}_F$ or $\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}<\tilde{\sigma}_V-2\tilde{\sigma}_F$. If $\tilde{\sigma}_V-2\tilde{\sigma}_F<0$, i.e. $\tilde{\sigma}_V<2\tilde{\sigma}_F$, than this inequality is satisfied. Else if $\tilde{\sigma}_V-2\tilde{\sigma}_F>0$, i.e. $\tilde{\sigma}_V>2\tilde{\sigma}_F$, than we have $\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)<(\tilde{\sigma}_V-2\tilde{\sigma}_F)^2$ or $\tilde{\sigma}_F(\tilde{\sigma}_F-\tilde{\sigma}_V)>\tilde{\sigma}_F-\tilde{\sigma}_V$. Taking into account $\tilde{\sigma}_V-\tilde{\sigma}_F>0$, this is equivalent to $\tilde{\sigma}_V-\tilde{\sigma}_F>\tilde{\sigma}_F(\tilde{\sigma}_V-\tilde{\sigma}_F)$, which can be satisfied only when $\tilde{\sigma}_F<1$, which is impossible. So, our assumption $\frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2(\tilde{\sigma}_V - \tilde{\sigma}_F)} < 1$ is wrong. This means that $\frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2(\tilde{\sigma}_V - \tilde{\sigma}_F)} > 1$ and the root $\alpha^* = \frac{\tilde{\sigma}_V - \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2(\tilde{\sigma}_V - \tilde{\sigma}_F)}$ is unique.

A7. Derivation of the market outcome

Substituting $\theta^* = (\alpha^* \bar{h}_V)/[\alpha^*(\bar{h}_V - \bar{h}_F) + \bar{h}_F]$ into $\bar{h}^* = \theta^* \bar{h}_F + (1-\theta^*)\bar{h}_V$ yields

$$\bar{h}^* = \theta^* \bar{h}_F + (1-\theta^*)\bar{h}_V = \frac{\bar{h}_F \bar{h}_V}{\alpha^*(\bar{h}_V - \bar{h}_F) + \bar{h}_F}.$$

By plugging the latter into $l^* = (\bar{h}_F / \bar{h}^*)\tilde{\sigma}^* l_F$ and into $N^* = L / l^*$ we have

$$l^* = \frac{\bar{h}_F}{\bar{h}^*}\tilde{\sigma}^* l_F = \left(1 + (\tilde{\sigma}^* - 1)\frac{\bar{h}_F}{\bar{h}_V}\right) l_F,$$

$$N^* \equiv \frac{L}{l^*} = \frac{\bar{h}_V}{\bar{h}_V + (\tilde{\sigma}^* - 1)\bar{h}_F}\frac{L}{l_F}.$$

A8. Markups vs correlation coefficients

Rewrite (21) for markup as $m^* = 1/\tilde{\sigma}^* = \left(\tilde{\sigma}_V / 2 + \sqrt{(\tilde{\sigma}_V / 2 - 1)^2 + \tilde{\sigma}_F - 1}\right)^{-1}$ and denoting $a_V \equiv \bar{\sigma}_V / 2$, $a_F \equiv \bar{\sigma}_F - 1$, $b_F \equiv \left(\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}\right)/\bar{h}_F$, $b_V \equiv \left(\sqrt{\mathbf{Var}(\sigma_V)} \cdot \sqrt{\mathbf{Var}(h_V)}\right)/\bar{h}_V$, $c_V \equiv \bar{\sigma}_V / 2 - 1$, we have

$$m^* = 1/\tilde{\sigma}^* = \left(a_V + b_V\rho_V + \sqrt{(c_V + b_V\rho_V)^2 + a_F + b_F\rho_F}\right)^{-1}$$

Differentiating this expression with respect to ρ_r $(r = F, V)$ yields $\frac{\partial m^*}{\partial \rho_r} = \frac{\partial}{\partial \rho_r}\frac{1}{\tilde{\sigma}^*} = -\frac{1}{(\tilde{\sigma}^*)^2}\frac{\partial \tilde{\sigma}^*}{\partial \rho_r}$. Calculating derivatives $\partial \tilde{\sigma}^* / \partial \rho_r$, we get

$$\frac{\partial \tilde{\sigma}^*}{\partial \rho_F} = \frac{1}{2}\frac{b_F}{\sqrt{(c_V + b_V\rho_V)^2 + a_F + b_F\rho_F}} > 0,$$

$$\frac{\partial \tilde{\sigma}^*}{\partial \rho_V} = \left(1 + \frac{c_V + b_V\rho_V}{\sqrt{(c_V + b_V\rho_V)^2 + a_F + b_F\rho_F}}\right) b_V > 0.$$

This shows that $\frac{\partial m^*}{\partial \rho_r} < 0,\ r = F, V$.

A9. Markups vs average productivities

Differentiating markup (26) with respect to the average productivities $\bar{h}_F$ and $\bar{h}_V$ yields: $\partial m^* / \partial \bar{h}_F = A\rho_F$, $\partial m^* / \partial \bar{h}_V = B\rho_V$, where $A \equiv \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{(\tilde{\sigma}^*)^2 \left(\bar{h}_F\right)^2} \frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}} > 0$ and $B \equiv \frac{\sqrt{\mathbf{Var}(\sigma_V)} \cdot \sqrt{\mathbf{Var}(h_V)}}{2(\tilde{\sigma}^*)^2 \left(\bar{h}_V\right)^2} \left(1 + \frac{\tilde{\sigma}_V - 2}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right) > 0$ are the positive coefficients.

Consider $\partial m^* / \partial \bar{h}_F$:

$$\frac{\partial m^*}{\partial \bar{h}_F} = \frac{\partial}{\partial \bar{h}_F}\left(\frac{1}{\tilde{\sigma}^*}\right) = -\frac{1}{(\tilde{\sigma}^*)^2} \frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_F} \frac{\partial \tilde{\sigma}_F}{\partial \bar{h}_F},$$

where

$$\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_F} = \frac{\partial}{\partial \tilde{\sigma}_F} \frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2} = \frac{\partial}{\partial \tilde{\sigma}_F} \frac{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2} = \frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}} > 0$$

$$\frac{\partial \tilde{\sigma}_F}{\partial \bar{h}_F} = \frac{\partial}{\partial \bar{h}_F}\left(\bar{\sigma}_F + \rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\bar{h}_F}\right) = -\rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\left(\bar{h}_F\right)^2}.$$

Plugging the last two into the derivative $\partial m^* / \partial \bar{h}_F$ yields

$$\frac{\partial m^*}{\partial \bar{h}_F} = \frac{1}{(\tilde{\sigma}^*)^2}\left(\frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right) \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\left(\bar{h}_F\right)^2} \rho_F$$

Consider now $\partial m^* / \partial \bar{h}_V$:

$$\frac{\partial m^*}{\partial \bar{h}_V} = \frac{\partial}{\partial \bar{h}_V}\left(\frac{1}{\tilde{\sigma}^*}\right) = -\frac{1}{(\tilde{\sigma}^*)^2} \frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V} \frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}$$

where

$$\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V} = \frac{\partial}{\partial \tilde{\sigma}_V} \frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2} = \frac{1}{2}\left(1 + \frac{\tilde{\sigma}_V - 2}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right),$$

$$\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V} = -\rho_V \cdot \frac{\sqrt{\mathbf{Var}(\sigma_V)} \cdot \sqrt{\mathbf{Var}(h_V)}}{\left(\bar{h}_V\right)^2}$$

Let us show that the right-hand side of the derivative $\partial \tilde{\sigma}^* / \partial \tilde{\sigma}_V$ is positive. Indeed, we have

$$\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V} = \frac{1}{2}\left(\frac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)} - 2}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right) = \frac{1}{2}\left(\frac{2\tilde{\sigma}^* - 2}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right) = \frac{\tilde{\sigma}^* - 1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}} > 0$$

A10. Prices vs average productivity of «white-collars»

The ambiguity in price dependence upon the average productivity of the «creative» workers can be confirmed by the following calculations:

$$\frac{\partial p^*}{\partial \bar{h}_F} = \frac{\partial}{\partial \bar{h}_F}\left(\frac{\tilde{\sigma}^*}{\tilde{\sigma}^* - 1}\frac{1}{\bar{h}_V}\right) = -\frac{1}{(\tilde{\sigma}^* - 1)^2}\frac{1}{\bar{h}_V}\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_F}\frac{\partial \tilde{\sigma}_F}{\partial \bar{h}_F} =$$

$$= -\frac{1}{(\tilde{\sigma}^* - 1)^2}\frac{1}{\bar{h}_V}\frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\left(-\rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\left(\bar{h}_F\right)^2}\right) =$$

$$= \frac{1}{(\tilde{\sigma}^* - 1)^2}\frac{1}{\bar{h}_V\left(\bar{h}_F\right)^2}\frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\rho_F = C\rho_F ,$$

where $C \equiv \frac{1}{(\tilde{\sigma}^* - 1)^2}\frac{1}{\bar{h}_V\left(\bar{h}_F\right)^2}\frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}} > 0$.

A11. Firm employment response to an increase in the average productivity of non-production workers

This section illustrates specifics of the firm size, firm employment and number of firm response to an increase in the average labor productivity of «non-productive» workers. Firm output reaction is given as an example. By differentiating firm output with respect to $\bar{h}_F$, we have

$$\frac{\partial q^*}{\partial \bar{h}_F} = \bar{h}_V\bar{h}_F l_F \frac{\partial}{\partial \bar{h}_F}(\tilde{\sigma}^* - 1) + (\tilde{\sigma}^* - 1)\bar{h}_V l_F \frac{\partial \bar{h}_F}{\partial \bar{h}_F} = \bar{h}_V\bar{h}_F l_F \frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_F}\frac{\partial \tilde{\sigma}_F}{\partial \bar{h}_F} + (\tilde{\sigma}^* - 1)\bar{h}_V l_F$$

$$= \bar{h}_V\bar{h}_F l_F \frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\left(-\rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\left(\bar{h}_F\right)^2}\right) + (\tilde{\sigma}^* - 1)\bar{h}_V l_F =$$

$$= \left[(\tilde{\sigma}^* - 1) - \frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\left(\rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\bar{h}_F}\right)\right]\bar{h}_V l_F$$

If $\rho_F \le 0$, than the square bracket is positive and $\partial q^* / \partial \bar{h}_F > 0$, but if $\rho_F > 0$ than situation is ambiguous. Actually, using some algebra, one can get

$$\frac{\partial q^*}{\partial \bar{h}_F} = \left[(\tilde{\sigma}^* - 1) - \frac{1}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\left(\rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\bar{h}_F}\right)\right]\bar{h}_V l_F =$$

$$= \left[(\tilde{\sigma}^* - 1) - \frac{1}{2\left[\dfrac{\tilde{\sigma}_V + \sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}{2} \right] - \tilde{\sigma}_V} \left(\bar{\sigma}_F + \rho_F \cdot \frac{\sqrt{\mathbf{Var}(\sigma_F)} \cdot \sqrt{\mathbf{Var}(h_F)}}{\bar{h}_F} - \bar{\sigma}_F \right) \right] \bar{h}_V l_F =$$

$$= \left[(\tilde{\sigma}^* - 1) - \frac{\tilde{\sigma}_F - \bar{\sigma}_F}{2\tilde{\sigma}^* - \tilde{\sigma}_V} \right] \bar{h}_V l_F$$

Consider

$$\frac{\partial q^*}{\partial \bar{h}_F} = \left[\tilde{\sigma}^* - 1 - \frac{\tilde{\sigma}_F - \bar{\sigma}_F}{2\tilde{\sigma}^* - \tilde{\sigma}_V} \right] \bar{h}_V l_F$$

This derivative may be negative if $\tilde{\sigma}^* - 1 < \dfrac{\tilde{\sigma}_F - \bar{\sigma}_F}{2\tilde{\sigma}^* - \tilde{\sigma}_V}$ or $\tilde{\sigma}^* < 1 + \dfrac{\tilde{\sigma}_F - \bar{\sigma}_F}{2\tilde{\sigma}^* - \tilde{\sigma}_V}$ is satisfied. As long as $\dfrac{\tilde{\sigma}_F - \bar{\sigma}_F}{2\tilde{\sigma}^* - \tilde{\sigma}_V} > 0$, this is potentially realizable. Similar conclusion can be made by inspecting firm employment and the number of firm response to an increase in the average productivity of «creative» workers.

A12. Prices vs average productivity of workers in the case of identical joint distributions of tastes and productivities

When $\bar{h}_F = \bar{h}_V = \bar{h}$, we have $p^* = \dfrac{\tilde{\sigma}}{\tilde{\sigma} - 1} c$, where $c \equiv 1/\bar{h}$. Differentiating price with respect to the average productivity, we obtain:

$$\frac{\partial p^*}{\partial \bar{h}} = \frac{\partial}{\partial \bar{h}} \left(\frac{\tilde{\sigma}}{\tilde{\sigma} - 1} \frac{1}{\bar{h}} \right) = \frac{1}{\bar{h}} \frac{\partial}{\partial \bar{h}} \left(\frac{\tilde{\sigma}}{\tilde{\sigma} - 1} \right) + \frac{\tilde{\sigma}}{\tilde{\sigma} - 1} \frac{\partial}{\partial \bar{h}} \left(\frac{1}{\bar{h}} \right) = -\frac{1}{\bar{h}} \frac{\partial \tilde{\sigma} / \partial \bar{h}}{(\tilde{\sigma} - 1)^2} - \frac{\tilde{\sigma}}{\tilde{\sigma} - 1} \left(\frac{1}{\bar{h}^2} \right) =$$

$$= -\frac{1}{\bar{h}} \frac{1}{\tilde{\sigma} - 1} \left(\frac{\partial \tilde{\sigma} / \partial \bar{h}}{\tilde{\sigma} - 1} + \frac{\tilde{\sigma}}{\bar{h}} \right) = -\frac{1}{\bar{h}} \frac{1}{\tilde{\sigma} - 1} \left(-\frac{\rho \cdot \dfrac{\sqrt{\mathbf{Var}(\sigma)} \cdot \sqrt{\mathbf{Var}(h)}}{\bar{h}}}{(\tilde{\sigma} - 1)\bar{h}} + \frac{\tilde{\sigma}}{\bar{h}} \right) =$$

$$= -\frac{1}{\bar{h}} \frac{1}{\tilde{\sigma} - 1} \left(-\frac{\bar{\sigma} + \rho \cdot \dfrac{\sqrt{\mathbf{Var}(\sigma)} \cdot \sqrt{\mathbf{Var}(h)}}{\bar{h}} - \bar{\sigma}}{(\tilde{\sigma} - 1)\bar{h}} + \frac{\tilde{\sigma}}{\bar{h}} \right) = -\frac{1}{\bar{h}} \frac{1}{\tilde{\sigma} - 1} \left(-\frac{\tilde{\sigma} - \bar{\sigma}}{(\tilde{\sigma} - 1)\bar{h}} + \frac{\tilde{\sigma}}{\bar{h}} \right) =$$

$$= -\frac{1}{\bar{h}^2} \frac{1}{\tilde{\sigma} - 1} \left(\tilde{\sigma} - \frac{\tilde{\sigma} - \bar{\sigma}}{\tilde{\sigma} - 1} \right) = \frac{1}{\bar{h}^2} \frac{1}{\tilde{\sigma} - 1} \left(\frac{\tilde{\sigma} - \bar{\sigma}}{\tilde{\sigma} - 1} - \tilde{\sigma} \right)$$

This expression is negative, because of $\frac{\tilde{\sigma}-\bar{\sigma}}{\tilde{\sigma}-1}-\tilde{\sigma}<0$. Indeed,

$$\frac{\tilde{\sigma}-\bar{\sigma}}{\tilde{\sigma}-1}-\tilde{\sigma}=\frac{\tilde{\sigma}-\bar{\sigma}-\tilde{\sigma}(\tilde{\sigma}-1)}{\tilde{\sigma}-1}=-\frac{\tilde{\sigma}^2-2\tilde{\sigma}+\bar{\sigma}}{\tilde{\sigma}-1}=-\frac{(\tilde{\sigma}-1)^2+\bar{\sigma}-1}{\tilde{\sigma}-1}<0$$

A13. Firm output response to an increase in the average productivity of production workers

Differentiating output of a firm with respect to the average productivity $\bar{h}_V$, we have

$$\frac{\partial q^*}{\partial \bar{h}_V}=\bar{h}_V\bar{h}_F l_F\frac{\partial}{\partial \bar{h}_V}(\tilde{\sigma}^*-1)+(\tilde{\sigma}^*-1)\bar{h}_F l_F\frac{\partial \bar{h}_V}{\partial \bar{h}_V}=\bar{h}_V\bar{h}_F l_F\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V}\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}+(\tilde{\sigma}^*-1)\bar{h}_F l_F=$$

$$=\bar{h}_V\bar{h}_F l_F\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V}\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}+(\tilde{\sigma}^*-1)\bar{h}_F l_F$$

Inserting $\frac{\partial \tilde{\sigma}^*}{\partial \tilde{\sigma}_V}=\frac{\tilde{\sigma}^*-1}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}$ and $\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}=-\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\left(\bar{h}_V\right)^2}$ into above expression, yields

$$\frac{\partial q^*}{\partial \bar{h}_V}=\bar{h}_V\bar{h}_F l_F\frac{\tilde{\sigma}^*-1}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}+(\tilde{\sigma}^*-1)\bar{h}_F l_F=\bar{h}_F l_F(\tilde{\sigma}^*-1)\left\{\frac{\bar{h}_V}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}\frac{\partial \tilde{\sigma}_V}{\partial \bar{h}_V}+1\right\}$$
$$=\bar{h}_F l_F(\tilde{\sigma}^*-1)\left(1-\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\bar{h}_V}\frac{1}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}\right)$$

Rewrite this in the following way:

$$\frac{\partial q^*}{\partial \bar{h}_V}=\bar{h}_F l_F(\tilde{\sigma}^*-1)\left(1-\left(\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\bar{h}_V}+\bar{\sigma}_V-\bar{\sigma}_V\right)\frac{1}{2\frac{\tilde{\sigma}_V+\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}{2}-\tilde{\sigma}_V}\right)=$$

$$=\bar{h}_F l_F(\tilde{\sigma}^*-1)\left(1-\frac{\tilde{\sigma}_V-\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}\right)=\bar{h}_F l_F(\tilde{\sigma}^*-1)\frac{2\tilde{\sigma}^*-\tilde{\sigma}_V-\tilde{\sigma}_V+\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}=\bar{h}_F l_F(\tilde{\sigma}^*-1)\frac{2(\tilde{\sigma}^*-\tilde{\sigma}_V)+\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}$$

As long as $\tilde{\sigma}^*-\tilde{\sigma}_V>0$ we finally obtain

$$\frac{\partial q^*}{\partial \bar{h}_V}=\bar{h}_F l_F(\tilde{\sigma}^*-1)\frac{2(\tilde{\sigma}^*-\tilde{\sigma}_V)+\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}>0$$

A14. Firm employment response to an increase in the average productivity of production workers

Differentiating firm employment with respect to the average productivity of «blue-collars» yields

$$\frac{\partial l^*}{\partial \bar{h}_V} = \frac{\partial}{\partial \bar{h}_V}\left(1+(\tilde{\sigma}^*-1)\frac{\bar{h}_F}{\bar{h}_V}\right)l_F = \bar{h}_F l_F \frac{\partial}{\partial \bar{h}_V}\left(\frac{\tilde{\sigma}^*-1}{\bar{h}_V}\right) = \bar{h}_F l_F\left[\frac{1}{\bar{h}_V}\frac{\partial\tilde{\sigma}^*}{\partial\tilde{\sigma}_V}\frac{\partial\tilde{\sigma}_V}{\partial\bar{h}_V}+(\tilde{\sigma}^*-1)\frac{\partial}{\partial\bar{h}_V}\left(\frac{1}{\bar{h}_V}\right)\right]=$$

$$= \bar{h}_F l_F\left[\frac{1}{\bar{h}_V}\frac{\tilde{\sigma}^*-1}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}\left(-\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\left(\bar{h}_V\right)^2}\right)-(\tilde{\sigma}^*-1)\frac{1}{\left(\bar{h}_V\right)^2}\right]=$$

$$= -\frac{\bar{h}_F l_F}{\left(\bar{h}_V\right)^2}(\tilde{\sigma}^*-1)\left[\frac{\bar{h}_V}{\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}\left(\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\left(\bar{h}_V\right)^2}\right)+1\right]$$

Rewrite this in the following way:

$$\frac{\partial l^*}{\partial \bar{h}_V} = -\frac{\bar{h}_F l_F}{\left(\bar{h}_V\right)^2}(\tilde{\sigma}^*-1)\left[1+\frac{\bar{h}_V}{2\frac{\tilde{\sigma}_V+\sqrt{\tilde{\sigma}_V^2-4(\tilde{\sigma}_V-\tilde{\sigma}_F)}}{2}-\tilde{\sigma}_V}\left(\rho_V\cdot\frac{\sqrt{\mathbf{Var}(\sigma_V)}\cdot\sqrt{\mathbf{Var}(h_V)}}{\bar{h}_V}+\bar{\sigma}_V-\bar{\sigma}_V\right)\right]=$$

$$= -\frac{\bar{h}_F l_F}{\left(\bar{h}_V\right)^2}(\tilde{\sigma}^*-1)\left(1+\frac{\tilde{\sigma}_V-\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}\bar{h}_V\right)$$

This shows that

$$\frac{\partial l^*}{\partial \bar{h}_V} = -\frac{\bar{h}_F l_F}{\left(\bar{h}_V\right)^2}(\tilde{\sigma}^*-1)\left(1+\frac{\tilde{\sigma}_V-\bar{\sigma}_V}{2\tilde{\sigma}^*-\tilde{\sigma}_V}\bar{h}_V\right)<0$$

A15. The number of firm response to an increase in the average productivity of production workers

Taking into account that $N^* = L/l^*$, we can reduce the analysis of $\partial N^*/\partial\bar{h}_V$ to the analysis of $\partial l^*/\partial\bar{h}_V$, which was done in the previous section. As far as $\partial N^*/\partial\bar{h}_V = \partial(L/l^*)/\partial\bar{h}_V = -L(\partial l^*/\partial\bar{h}_V)/(l^*)^2$, we have $\partial N^*/\partial\bar{h}_V > 0$.

A16. Gini formula

In accordance with definition in section 5.1, we have

$$Gini^* = \alpha^* - \theta^* = \frac{1}{\tilde{\sigma}^*} - \frac{\bar{h}_V}{\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F} = \frac{\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F-\bar{h}_V\tilde{\sigma}^*}{\tilde{\sigma}^*[\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F]} = \frac{\bar{h}_V+\tilde{\sigma}^*\bar{h}_F-\bar{h}_F-\bar{h}_V\tilde{\sigma}^*}{\tilde{\sigma}^*[\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F]}=$$

$$= \frac{(\bar{h}_F-\bar{h}_V)\tilde{\sigma}^*-(\bar{h}_F-\bar{h}_V)}{\tilde{\sigma}^*[\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F]} = \frac{(\bar{h}_F-\bar{h}_V)(\tilde{\sigma}^*-1)}{\tilde{\sigma}^*[\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F]} = \frac{\bar{h}_F-\bar{h}_V}{\bar{h}_V+(\tilde{\sigma}^*-1)\bar{h}_F}\frac{\tilde{\sigma}^*-1}{\tilde{\sigma}^*}$$

A17. An employment share of «white-collars» response to an increase in the average productivity of production workers

The influence of an increase in the average productivity in the sector of production upon the employment share of the «creative staff» is determined by

$$\frac{\partial \theta^*}{\partial \bar{h}_V} = \frac{\partial}{\partial \bar{h}_V}\left(\frac{l_F}{l^*}\right) = l_F\left(-\frac{1}{\left(l^*\right)^2}\right)\frac{\partial l^*}{\partial \bar{h}_V} = -\frac{l_F}{\left(l^*\right)^2}\frac{\partial l^*}{\partial \bar{h}_V}$$

Taking into account that $\partial l^* / \partial \bar{h}_V < 0$ as it was previously obtained, we may conclude that $\partial \theta^* / \partial \bar{h}_V > 0$.

A18. Comparative statics of Gini vs average productivity of production workers

Taking derivative of Gini with respect to the average productivity of workers, we have

$$\frac{\partial (Gini^*)}{\partial \bar{h}_V} = \frac{\partial \alpha^*}{\partial \bar{h}_V} - \frac{\partial \theta^*}{\partial \bar{h}_V}.$$

As long as

$$\frac{\partial \theta^*}{\partial \bar{h}_V} = -\frac{l_F}{\left(l^*\right)^2}\frac{\partial l^*}{\partial \bar{h}_V} > 0 \text{ and } \frac{\partial \alpha^*}{\partial \bar{h}_V} = \frac{\partial m^*}{\partial \bar{h}_V} = \frac{\partial}{\partial \bar{h}_V}\left(\frac{1}{\tilde{\sigma}^*}\right) = B\rho_V,$$

where $B \equiv \dfrac{\sqrt{\mathbf{Var}(\sigma_V)} \cdot \sqrt{\mathbf{Var}(h_V)}}{2(\tilde{\sigma}^*)^2\left(\bar{h}_V\right)^2}\left(1 + \dfrac{\tilde{\sigma}_V - 2}{\sqrt{\tilde{\sigma}_V^2 - 4(\tilde{\sigma}_V - \tilde{\sigma}_F)}}\right) > 0$, one can get

$$\frac{\partial (Gini^*)}{\partial \bar{h}_V} = \frac{\partial \alpha^*}{\partial \bar{h}_V} - \frac{\partial \theta^*}{\partial \bar{h}_V} = B\rho_V + \frac{l_F}{\left(l^*\right)^2}\frac{\partial l^*}{\partial \bar{h}_V} = B\rho_V + \frac{l_F}{\left(l^*\right)^2}\left[-\frac{\bar{h}_F l_F}{\left(\bar{h}_V\right)^2}(\tilde{\sigma}^* - 1)\left(1 + \frac{\tilde{\sigma}_V - \bar{\sigma}_V}{2\tilde{\sigma}^* - \tilde{\sigma}_V}\bar{h}_V\right)\right].$$

If $\rho_V < 0$ than $\dfrac{\partial (Gini^*)}{\partial \bar{h}_V} < 0$, else if $\rho_V > 0$, than $\dfrac{\partial (Gini^*)}{\partial \bar{h}_V}$ may be either positive or negative.

A19. Comparative statics of Gini vs average productivity of non-production workers

Gini response to an increase in the average productivity of «white-collars» is determined by

$$\frac{\partial (Gini^*)}{\partial \bar{h}_F} = \frac{\partial \alpha^*}{\partial \bar{h}_F} - \frac{\partial \theta^*}{\partial \bar{h}_F}$$

We have already shown that $\partial \alpha^* / \partial \bar{h}_F = \partial m^* / \partial \bar{h}_F = \partial\left(1/\tilde{\sigma}^*\right)/\partial \bar{h}_F = A\rho_F$ (see section *A9. Markups vs average productivities* above), where $A > 0$. As far as

$\partial\theta^* / \partial\bar{h}_F = -\left[l_F / (l^*)^2\right]\partial l^* / \partial\bar{h}_F$ and $\partial l^* / \partial\bar{h}_F < 0$ only at $\rho_F \le 0$, we may conclude that $\partial\theta^* / \partial\bar{h}_F > 0$ at $\rho_F \le 0$. As a consequence, $\partial(Gini^*) / \partial\bar{h}_F < 0$ when $\rho_F \le 0$ and has an ambiguous response at $\rho_F > 0$.

A20. Price elasticity coefficients for individual and market demand curves

Using definition of the price elasticity coefficient for individual demands $\varepsilon_{ri} \equiv -\frac{p_i}{x_i(\omega_r)}\frac{\partial x_i(\omega_r)}{\partial p_i}$ and differentiating (3) yields

$$\varepsilon_{ri} \equiv \varepsilon_r = \sigma(\omega_r),$$

$i = 1, 2, ..., N$. As it follows from the latter, the price elasticity coefficient is the same across varieties and is defined exclusively by the consumers' tastes. Assuming that both groups of consumers/workers in our model have identical tastes and labor productivity statistics gives:

$$\varepsilon_{ri} \equiv \varepsilon = \sigma(\omega).$$

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