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Measuring competition in a frictional economy

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Abstract

This paper analyses the relationship between the selected measures of competition and the actual intensity of the interaction in the product market under the presence of market frictions. The first part of the study compares the industry-level price-cost margin and profit elasticity within a model of monopolistic competition where the degree of substitutability among the product varieties is the determinant of the level of firm-to-firm interaction. The second part studies the empirical performances of the indices through a panel of manufacturing firms operating in Ukraine during 2004-2007. Particular attention is devoted on the method of the profit elasticity. However, this paper deviates from the literature by developing an alternative approach to measure the elasticity of profits to productivity that relies on the structural estimation of the industry production functions. The estimation methodology takes into account the unobservable prices at the firm level by introducing the demand side, and retrieves elasticity of substitution estimates jointly with the TFP. The findings imply that while the proposed method provides a robust measure, the price-cost margin and the traditional profit elasticity fail to indicate the true level of competition especially when the intensity of interaction among the firms is relatively low.

1 Introduction

The impact of competition on the market dynamics has been a long interest in the fields of economic growth and development. Particular attention is devoted to the effect of competition on the firms' productivity performances and the driving forces of productivity such as the technology-innovative and adaptive activities. However, while various competition-enhancing policies have been implemented or take a primary place in the agenda of today's economic authorities with the main or secondary aim of accelerating the productivity growth, the empirical findings on the link between competition and productivity are still limited and ambiguous.

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Competition may affect productivity through the dynamic and static channels where the dynamic one may motivate or demotivate production units to innovate or adopt more advanced technologies into the production process. In other words, the dynamic effects of competition play a role in the determination of the level of the (technological) production frontier, where this often happens through the innovation in the most advanced economies and the adaptation of new technologies in the developing countries.

On the other hand, competition can also alter the productivity performance of an industry by enhancing the efficiency in the allocation of production factors. Namely, more intense interaction among the production units may induce the accumulation of the production factors in the most productive establishments, which increases the aggregate productivity of the industry without affecting the idiosyncratic productivity levels. If the possible exit of inefficient units and the entry of potentially more productive ones due to more intense competition are further taken into account, the static effects of competition through the factor allocation can significantly alter the productivity performance of an industry. Moreover, although the productivity enhancing effect of the more efficient factor allocation may be expected to be higher in the developing countries, Bartelsman et al. (2009) show that there are also significant potential gains from the reallocation of production factors in the Western Europe.

Recently, research on the relationship between productivity and competition is reduced to the analysis of the effects of competition on the innovative behavior of firms. One of the reasons behind the choice of the innovation as the productivity performance measure of firms is the difficulty of measuring the actual productivity. Traditional methods of productivity measurement rely on somewhat strict assumptions on the competitive structure of the market that is necessary when the output prices are unobservable at the firm level. Furthermore, even if the firm level prices are observed by the researcher, it is still difficult to avoid the problem of comparing apples with peers, namely, achieve the quality adjusted firm level output. Therefore, the productivity indices based on the restrictive assumptions, such as perfect competition, are not expected to provide valuable insights on the actual relationship between competition and productivity.

However, considering the role of competition in the innovative behavior of production units would also be insufficient, if one aims to analyze the productivity enhancing effects of the more intense interaction among firms. For instance, firm level innovation measures cannot capture the static effects of competition on productivity. In addition to this, if the question is asked for a developing country, it is hard to find an indicator of innovation for which it is often used the copyright and patent ownership based measures in the advanced country studies.

Another difficulty in the analysis of the link between competition and productivity, which is rather neglected in the related literature and constitutes the main question of this paper, is the problem of measuring the intensity of competition. In the analysis of the economic effects of competition, most widely used indices can be listed as the price-cost margin, the concentration based measures such as Hirschman-Herfindahl Index and the profit elasticity. Accordingly, the first part of this study develops a discussion over the performances of alternative measures of competition through a theoretical model where the firms differ according to their productivity levels and there are frictions on the operational activities of the production units. In the last part, we further compare the empirical performances of the indices by using a panel of the firms operated in the manufacturing sectors of Ukraine during 2004-2007. While doing so, we offer an alternative measure of competition that is a modification of the profit elasticity method, and relies on the firm level productivity retrieved from the estimation of production functions at the industry level. The estimation methodology takes into account the unobservable firm level prices up to a degree of constant industry markup by introducing the demand side into the econometric model. Therefore, the obtained firm level productivity index does not have the above mentioned drawbacks such as the underlying assumption of perfect competition, so that we are able to derive insights on the actual relationship between competition and productivity.

2 Indicative Quality of the Leading Measures of Competition

Recently, it is almost a common sense that Hirschman-Herfindahl index (HHI), which measures the degree of concentration in an industry, is not a robust indicator of the actual intensity of competition in the product market. HHI fails to proxy the competition for many reasons, for instance, it does not account for the competitive pressure due to the openness to international trade. Moreover, HHI is strongly correlated with the number of firms in the industry, so that in case the firm number falls because of a higher exit rate, which may be a sole result of more intense competition, the index would still indicate a fall in the intensity of competition.

On the other hand, the price-cost margin (PCM) that is often calculated by the ratio of the total costs over revenues, does not seem to have such drawbacks. For instance, in case the domestic firms partially lose their market share due to an increase in the consumption of the imported goods, PCM would still indicate a rise in the level of competition, even if the competitive pressure stemming from the international trade is not observed by the researcher. Furthermore, PCM can even be calculated for an industry that is consist of a single firm, and the results would be still comparable with the other industries whatever the number of firms operating in each segment. Thus, PCM is often preferred as a proxy for the level of competition in the empirical research.[1]

However, PCM can also deviate from the actual intensity of competition especially when there are frictions in the industry. For instance, in case of suffi-

[1] In particular, the seminal studies that analyze the relationship between competition and productivity enhancing innovations such as the papers of Nickell, (1986); Geroski, (1995); Blundell et al. (1995, 1999); Aghion et al. (2005, 2006) use the price-cost margin while measuring the intensity of interaction among the firms in a market.

ciently high barriers on firm entry, more intense competition would lead the exit of the least efficient firms, while the efficient ones would have the opportunity to capture the released market share due to insufficient number of new entries. This may lead an increase in the profitability of the incumbent firms, although the firm-to-firm interaction is more intensive within the industry. In that case, PCM would still reflect a fall in the intensity of competition.

The performance of different empirical measures of competition is extensively analyzed in Boone (2008a, 2008b). Besides indicating the poorness of HHI as a measure of competition, Boone further shows that PCM fails to proxy the intensity of competition in a duopoly model with Cournot competition, and offers an alternative approach that relies on the elasticity of the relative profits to the relative efficiency. Boone (2001) points out the shortcomings of using PCM while analyzing the relationship between competition and productivity, since the firm level PCM is an endogenous variable that is mainly driven by productivity. Therefore, using PCM as a proxy may lead to find significant link between competition and productivity, but the findings would be quite far away from the true nature of the relationship.

In the next section, we evaluate the theoretical performances of the empirical price-cost margin and the profit elasticity in measuring the competition, and provide insights on the drawbacks of the concentration based indices within a Dixit and Stiglitz (1977) type monopolistic competition model. Our approach is similar to Montagna (1995) in the sense that we introduce the firm level heterogeneity, and add a fixed cost of operation that also serves as an entry barrier in the model economy. The model differs from Montagna's partial equilibrium analysis, since rather than defining the efficiency within the cost function, we define an explicit firm level production function with an idiosyncratic productivity variable and consider the labor market equilibrium in order to take into account the wealth effects on the pricing behavior of the heterogeneous firms.

2.1 The Model

The model industry consists of N number of firms and a representative consumer who supplies the labor inelastically and does not drive utility from leisure. There are firm entry and exit in the model. Therefore, the potential entrant firm firstly considers its expected profits, and then makes the decision to enter in or stay out of the market. If the potential entrant makes the entry decision, the firm realizes its productivity draw as soon as it starts to produce its variety, and the fixed cost of operation is paid simultaneously with the production process. Once the productivity is drawn, the firm operates with it during all out of its life time.

The incumbent firms also pay the fixed operational cost in every period and exit, if the expected future profits are negative. It is worth mentioning that the firm level productivity is observable for only the manager of the firm, so that neither the representative consumer nor the other firms' managers know the firm's productivity draw. However, the productivity distribution function is known by all agents of the industry.

2.1.1 Representative Consumer's Problem

The representative consumer's preferences are characterized by Dixit and Stiglitz (1977) type utility function. There are N number of firms in the industry. Each firm is assumed to produce a single variety of output that does not have any perfect substitutes, so that N also represents the number of product varieties. Throughout the formulization of the theoretical model, we drop the time indices and the utility function is given by the below formula.

$$U = \left[\sum_{i=1}^{N} d_i^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)} \tag{1}$$

In the utility function, d_i stands for the consumption of firm i's product and $\gamma > 1$ is the elasticity that determines the degree of substitutability among the product varieties. The utility function implies that the preferences are symmetric and the consumer imperfectly substitutes among the product varieties.

The representative consumer does not benefit from leisure, and the labor is supplied inelastically $\left(L^S = 1\right)$. Moreover, the firms are owned by the consumer, so that the firms' total profits constitute a source of income. Accordingly, the consumer maximizes the utility function subject to the following budget constraint.

$$R = \sum_{i=1}^{N} p_i d_i \tag{2}$$

In the above identity, R stands for the income level of the consumer that is equal to the industry sum of the firm-revenues ($r_i = p_i d_i$), so that p_i is the firm level price or price of the variety i.

The utility maximization problem of the representative consumer provides the following $N-1$ first order conditions.

$$\frac{d_i}{d_j} = \left(\frac{p_i}{p_j} \right)^{-\gamma} \tag{3}$$

Therefore, the relationship between the relative demand and price is intensified by lower values of γ, so that the monopoly power is negatively correlated with the substitution elasticity.

The industry level aggregate price index is the following function of the firm level prices[2].

$$P = \left(N^{-1} \sum_{i=1}^{N} p_i^{1-\gamma} \right)^{1/(1-\gamma)} \tag{4}$$

[2] The price index given in equation (4) is a traditional way of representing the link between aggregate and frim level prices (e.g. Dixit and Stiglitz, 1977; Montagna, 1995; Levinson and Melitz, 2004; Dobbelaere and Mairesse, 2007; Jaimovich and Floetotto, 2008).

Therefore, as the degree of substitutability falls ($\gamma \rightarrow 1$) the index approaches to the unweighted average of the firm level prices. Moreover, holding the variety-prices constant, more intense competition driven by higher values of γ decreases the aggregate price index.

Thus, the consumer's problem further provides the following demand function for firm i's product.

$$d_i = \frac{R}{N} P^{\gamma-1} p_i^{-\gamma} \tag{5}$$

According to equation (5), the variety specific demand is a function of the number of varieties (N) that also stands for the number of imperfect substitutes, the aggregate income level (R), the aggregate price index (P) and the variety's price (p_i) with γ (the elasticity of substitution) also representing the absolute value of the price elasticity of demand.

2.1.2 Firm's Problem

The industry is populated by N number of firms where each firm produces a single variety of output that does not have any perfect substitutes. The firm's output is produced by the following type of production function.

$$q_i = \theta_i l_i^{\alpha} \qquad \theta_i \sim N(\mu, \sigma) \tag{6}$$

The firms differ according to their time-invariant productivity parameters (θ_i) and use one type of input (labor) in the production. $\alpha < 1$ represents the returns from labor input that is assumed to be constant over time and same for all firms in the industry. The idiosyncratic productivity is randomly drawn from a density function $f(\theta)$ which is also constant and same for all firms. We assume the firms draw their productivity from the normal distribution with a positive mean (μ) and standard deviation (σ). One can interpret the mean as the industry-wide aggregate component of the productivity. However, since we only consider the steady state dynamics of the model industry, the aggregate component is assumed to be constant over time. Furthermore, jointly with the constant mean, the variance determines the degree of firm level heterogeneity or the level of productivity dispersion in the industry.

Defining $p_i(d_i)$ to be the firm level inverse demand function of firm i's product (eq.5), the firm's per-period profit function $\pi_i(.)$ can be given by the following formula.

$$\pi_i(\theta_i) = p_i(\theta_i l_i^{\alpha})\, \theta_i l_i^{\alpha} - W l_i - \kappa \tag{7}$$

In the profit function, W is the wage level, and κ represents the per-period exogenous and fixed operational cost that is same for all firms. Whatever it is an entrant or incumbent, every firm has to pay the fixed operational cost in the beginning of every period. Thus, κ also serves as a barrier on the entry that decreases the potential entrants' expected profits.

It is worth mentioning that by defining the industry sum of the firm-revenues to be equal to the income of the consumer (eq.2), we do not allow the operational costs to disappear in the economy. This is because, in realistic scenario, fixed costs on the operational activities of firms often arise from different forms of regulatory costs such as taxes, mandatory fees to obtain licences and permits, or even the presence of corruption. However, from a macroeconomic perspective, it is more plausible to think that the total fixed costs paid by the firms should increase either the government earnings or other income related variables such as the wealth of the corrupt officers. Therefore, without introducing an economic authority into the model, we define the aggregate income to also involve the total fixed operational costs ($N\kappa$) paid by all the firms in the industry.

Assuming the aggregate and firm specific productivity components to be time invariant, the firm's decision process turns out to be a static optimization problem where each firm maximizes the per-period profits. Therefore, the first order condition equates the marginal revenue of labor to the marginal cost up to a degree of markup that provides with the following labor demand function for firm i.

$$l_i^*(\theta_i) = \left[\left(\frac{\alpha(\gamma-1)}{\gamma}\right)^{\gamma} P^{\gamma-1}\theta_i^{\gamma-1}W^{-\gamma}\frac{R}{N}\right]^{\frac{1}{\gamma-\alpha(\gamma-1)}} \tag{8}$$

Thus the firms' labor demand is a positive function of the productivity and a negative function of the wage level as long as $\gamma - \alpha(\gamma-1)$ is larger than zero. This is also the main reason behind the assumption of decreasing returns from labor ($\alpha < 1$), so that the labor demand function is consistent with the predictions of the standard theory. Furthermore, the condition of $\gamma - \alpha(\gamma-1) > 0$ is satisfied for a particular region where the returns from the labor is increasing, but the behavior of the model does not change significantly, so that in the calibration exercise, we restrict the parameter space with the inequality condition of $\alpha < 1$.

2.1.3 Steady State Equilibrium

In the equilibrium, the industry wide variables, R, W, P and N are constant. In addition to this, one can define a threshold level of productivity where an incumbent firm is indifferent between continuation and exit the market. Accordingly, the profit of the threshold incumbent is zero in the steady state.

$$\pi_T\left(\theta^T, W^*, P^*, N^*, R^*\right) = 0 \tag{9}$$

θ^T is the threshold productivity level to stay in the market, and the starred variables represent the steady state equilibrium values. In case the firm's productivity is lower than this threshold level, its expected profits is negative, so that exit is the optimal decision.

Since a firm cannot directly observe the others' productivity draws, it develops its expectations over the known distribution function. Thus, the expected total sales can be calculated by an integral over the revenues (r_i) of the operating firms that could exceed the threshold productivity level (θ^T) of the industry.

$$E\left[R^*\right] = N\int_{\theta^T}^{\infty} r_i\left(\theta_i, W^*, P^*, N^*, R^*\right) f\left(\theta\right) d\theta \tag{10}$$

In equation (10), R^* appears on the both sides of the identity, where it stands for the income level of the consumer on the right-hand side and the industry sum of the revenues on the left-hand side, which are equal in the equilibrium.

The expected aggregate price index is given by the following formula.

$$E\left[P^*\right] = \left[\int_{\theta^T}^{\infty} p_i\left(\theta_i, P^*, N^*, R^*\right)^{1-\gamma} f\left(\theta\right) d\theta\right]^{1/(1-\gamma)} \tag{11}$$

Therefore, the expected industry-wide price index is calculated by the integral over the incumbents' prices.

The equilibrium entry condition requires the expected value of entry to be driven to zero. Therefore, the free entry condition can be written as follows.

$$E\left[V^E\right] = \int_{-\infty}^{\infty} \pi_i\left(\theta_i, W^*, P^*, N^*, R^*\right) f\left(\theta\right) d\theta = 0 \tag{12}$$

According to equation (12) the potential entrant firm calculates the value of entry by considering any possible productivity draw within the interval $(-\infty,\ \infty)$.

Lastly, in the equilibrium, the labor supply $\left(1 = L^S\right)$ equates the labor demand, so that the steady state labor market clearing condition can be represented by the below identity.

$$1 = N^*\int_{\theta^T}^{\infty} l_i\left(\theta_i, W^*, P^*, N^*, R^*\right) f\left(\theta\right) d\theta \tag{13}$$

The right-hand side of equation (13) is the expected firm level labor demand times the number of firms in the industry that gives the expected total labor demand in the equilibrium.

As a result, the steady state is characterized by five equilibrium conditions, so that the five endogenous variables, that are P^*, W^*, N^*, R^* and θ^T, can be fully identified in the steady state.

2.1.4 The Measures of Competition

We consider the substitution elasticity of demand $(\gamma > 1)$ as the main determinant of the intensity of competition in the model industry. Accordingly, as γ rises, $(\gamma - 1)/\gamma$ approaches 1 indicating a perfect substitution among the product varieties that constitutes highest level of interaction among the firms.

Therefore, the indicative performance of the competition measures are compared by observing their reaction to the changes in γ for alternative parameter settings. To simplify the interpretations, all the measures of competition indices are formulated in a way that a higher value corresponds to a higher degree of competition.

At the firm level, the price-cost margin (PCM) is given as the ratio of total cost to revenues.

$$pcm_i = \frac{Wl_i + \kappa}{r_i} \tag{14}$$

Therefore, PCM consist of two ratios that we name the variable (Wl_i/r_i) and fixed (κ/r_i) components. The variable cost component can be expressed in terms of price-cost mark-up, so that the total variable costs to revenues ratio is equivalent to factor share to mark-up ratio in the steady state. More specifically, the following identity is valid for every firm in the model industry.

$$\frac{Wl_i}{r_i} = \frac{\alpha}{\eta} \tag{15}$$

Where $\eta = \gamma/(\gamma - 1)$ represents the mark-up and is a negative function of the substitution elasticity. However, as we will see in the calibration analysis, the fixed component may not necessarily be an increasing function of γ. This is because, the total size of the industry in terms of total revenues increases with γ due to the rise in the total number of firms and varieties. Therefore, when the new entries are restricted by a fixed cost, the incumbent firms may expand their market share. Additionally, as a direct consequence of more intense interaction, the less efficient firms may exit the market that would further facilitate the remaining firms to increase their sales in the equilibrium. Therefore, the reaction of PCM to the changes in the substitution elasticity depends on the relative importance of the variable and fixed components that may move in the opposite directions.

In the steady state, the industry level PCM can be calculated by an integral over the distribution of the operating firms that are productive enough to stay in the market. Thus, the industry-wide PCM can be given by the following identity.

$$PCM = \int_{\theta^T}^{\infty} pcm_i(\theta_i) f(\theta) \, d\theta \tag{16}$$

Thereby, as PCM approaches to 1, the share of industry profits (costs) in total sales are decreasing (increasing), which may or may not be interpreted as a rise in the intensity of competition depending on the steady state dynamics of the industry.

The Theoretical Profit Elasticity (TPE)

The profit elasticity method (Boone, 2008b) suggests that the ratio of the profit of an efficient firm to an inefficient one is higher when competition is more intensive. Namely, high interaction leads the inefficient firms to suffer more or benefit less from competition than the efficient one.

The profit elasticity method can be simply expressed by assuming an industry with two firms where π_i represents the per-period profits of firm i. If firm 2 is more efficient than firm 1, holding everything else same for these two firms, one would expect the profit of the more efficient firm to be higher ($\pi_2 > \pi_1$). Therefore, if the competition is more intensive at time $t+1$ than it is at time t, the inequality $(\pi_2/\pi_1)_{t+1} > (\pi_2/\pi_1)_t$ holds. In other words, more intense competition widens the gap between the efficient and inefficient units, while some of the inefficient ones may be driven out of the market as a direct consequence of intensive interaction.

In case there are N number of firms in the industry, by assuming that firm j is the benchmark firm that is the least efficient production unit, one would expect the inequality to hold for every firm $i \neq j$. Therefore, if we define the relative profits as a sole function of the relative efficiency, the absolute value of the slope of the relative profits curve would be higher when competition is intensified.

While in the theoretical model (Boone, 2008a; 2008b), Boone defines the firm level marginal cost as the source of firm level heterogeneity and the measure of efficiency, in our model, the firm level efficiency is captured in the productivity parameter θ_i. Since our focus is on the relative efficiency measure to be used in the measurement of the profit elasticity, one first needs to check the dependent variable side of the equation is a robust measure of the firm performance as a function of productivity.

Proposition 1 *Firm profits are monotonically increasing in θ.*

Therefore, in the model, the theoretical measure of the profit elasticity is the slope of the relative profits (π_i/π_j) as a function of relative productivity (θ_i/θ_j).

Proposition 2 *When $\kappa = 0$, the elasticity of relative profits to relative productivity is increasing as the substitution elasticity rises.*

Thus, in a frictionless economy, in case the intensity of interaction among the firms rises through an increase in γ, the elasticity of profits to productivity indicates a higher level of competition in the steady state. However, when $\kappa \neq 0$, the profit function is not homogeneous, and a numerical derivation of the elasticity is inapplicable. Therefore, we investigate the behavior of the elasticity of the profits to the productivity in the presence of positive operational costs by calibrating the steady state equilibrium in the model industry for a wide range of alternative parameter values. Throughout the rest of this paper, we refer the productivity elasticity of profits as the "theoretical" profit elasticity (TPE).

The Empirical Profit Elasticity (EPE)

In the estimation of the profit elasticity[3], Boone et al. (2007) use the ratio of the variable costs to sales as a proxy for the measure of firm level efficiency and regress the profits on this efficiency measure. However, as it is shown in equation (15), the variable cost to revenue ratio is identical to the factor share to mark-up ratio in the model industry. Therefore, the firm level efficiency measure of Boone et al. (2007) is same for all firms, so that the empirical technique is inapplicable in our theoretical setting. One can introduce firm level variation in the mark-up (η) or the returns to scale parameter (α), but non of the parameters can be expected to be correlated with the true firm level efficiency unless they are assumed to be a function of the productivity. However, there is a strong correlation between α or η and the firm level profits. Thus, if α or η are modified to be variable across the firms and over time, the methodology would still indicate a significant relationship between the profits and the cost to revenue ratio without measuring the elasticity of profits to the real efficiency.

Secondly, it is very hard to distinguish between perfectly variable and fixed factors of production in the empirical analysis. Various studies ignore any kind of hiring or firing costs, or frictions in the labor market, and consider the labor input to be a perfectly variable factor of production. However, introducing any type of fixed costs into the input expenditures to revenue ratio would significantly distort the theoretical predictions. In order to capture the distorting effects of imperfectly variable costs on the index of profit elasticity, we further modified the efficiency measure to involve the fixed operational cost (κ), so that we retrieve firm level variation in the cost efficiency variable.

It is also worth mentioning that when one uses a cost efficiency measure, say c_i, where lower values of c_i indicates higher efficiency, the plot of the function that represents the relationship between the relative profits and relative efficiency has a negative slope. Conversely, if one uses productivity as the efficiency measure, the relative profits line would have a positive slope coefficient. Nevertheless, such a distinction does not alter the theoretical predictions of the profit elasticity method, so that, whatever the efficiency measure is used, the profit elasticity would indicate higher level of competition as the relative profits line becomes steeper. Namely, the more efficient firms, that have lower c_i or higher productivity, would experience higher profit gains (or lower reduction in profits) relative to the less efficient firms when the competition is intensified. Therefore, in case c_i is the efficiency measure, multiplying the profit elasticity with -1 would be sufficient to compare the results with the profit elasticity based on productivity, so that both competition indices would be expected to be positively correlated with the actual intensity of competition. However, the

[3] Boone et al. (2007) measure the slope of the relative profits curve through the estimation of the following equation by OLS.

$$\ln(\pi_{i,t}) = \mu_t + \beta_{0,i} + \beta_{1,t} \ln(c_{i,t}) + \varepsilon_{i,t}$$

Assuming index j represents the benchmark firm, the time variant intercept satisfies $\mu_t = \ln(\pi_{j,t}) - \beta_{1,t} \ln(c_{j,t})$, so that the selection of the benchmark does not affect the slope coefficient. The profit elasticity as a measure of competition is simply the slope coefficient $\beta_{1,t}$. So, if the linear regression line becomes steeper, in other words, $\beta_{1,t}$ is larger, the relative profits method concludes that the competition is intensified.

main difference arises in the search of the empirically robust measure of the firm level efficiency as we will see below.

We define the total cost share in revenue, hereafter the unit cost ($c_i = 1 - \pi_i/r_i$), as the alternative efficiency measure and refer the elasticity of the profits to c_i as the "empirical" measure of the profit elasticity (EPE). Therefore, the efficiency measure of EPE is identical to the firm level PCM and consists of the variable ($Wl_i/r_i = \alpha/\eta$) and fixed (κ/r_i) costs to revenue ratios where the variable cost component is same for all firms, so that only the fixed cost component is firm specific. Moreover, since the firm's revenue is a positive function of productivity (a proof is given in the appendix part jointly with the proof of Proposition 1), the efficiency measure of EPE gives the same efficiency ordering of firms with the productivity index. However, as it is mentioned before, a rise in γ directly effects the efficiency measure of EPE in the steady state equilibrium.

Accordingly, if the firm's revenue is a positive function of γ, the rise in γ leads the efficiency measures of any two firms to converge due to the decrease in the firm-specific, fixed component, and the increase in the firm-invariant, variable component. This would further lead the cost efficiency ratio of the more to less efficient firm (c_i/c_j where $c_j > c_i$) to rise with γ in the steady state. Moreover, if the rate of the increase in c_i/c_j is higher than the increase in π_i/π_j, EPE would indicate a fall in the competition as the elasticity of substitution rises.

In the calibration of the theoretical model, we need two points on the relative profits curve to retrieve the slope of the linear approximation. This means evaluating three firms with three different efficiency measures where the least efficient firm is taken to be the benchmark firm. It is important to keep these firms, so their productivity parameters, fixed throughout different parameter settings, otherwise it is impossible to compare the slope of the relative profits curve between any two experiments. Moreover, its also crucial that these three firms should stay in the market during different experiments, so that we require the firm level productivity values to be higher than the threshold productivity in alternative cases. Assuming the efficiency ordering of the three firms is $\theta_3 > \theta_2 > \theta_1$, so that $c_3 < c_2 < c_1$, the true profit elasticity is calculated as follows.

$$TPE = \frac{\dfrac{\pi_3(\theta_3)}{\pi_1(\theta_1)} - \dfrac{\pi_2(\theta_2)}{\pi_1(\theta_1)}}{\dfrac{\theta_3}{\theta_1} - \dfrac{\theta_2}{\theta_1}} \tag{17}$$

Similarly, in order to retrieve the identity for EPE, one should substitute θ_i's with c_i's in the above formula and multiply the right hand side with -1.

2.2 Calibration Exercise

For the calibration analysis, we need to calculate the steady state values of the industry-wide endogenous variables that are R, W, P, N and θ^T. Therefore, we apply an iterative method over the equilibrium identities listed in the previous parts under the title of "*steady state equilibrium*". Given the exogenous parameter values for $\gamma, \sigma, \alpha, \mu$ and κ, the procedure starts by assuming initial values for wage $W^{(0)}$, $P^{(0)}$ and $\theta^{T(0)}$.

In the benchmark equations of the model, the income level shows up in the form of the average firm sales ($\tilde{r} = R/N$), so that we use $\tilde{r}$ in the formulation of the calibration algorithm. Given the initial values of the wage, aggregate price level and threshold productivity, one can calculate the steady state $\tilde{r}$ through equation (10). It is worth noting that although the right-hand side of the equation is also a function of $\tilde{r}$, the average income level is independent of the idiosyncratic productivity (θ) at the steady state. Thus, one can take $\tilde{r}$ out of the integral. Therefore, given $W^{(0)}$, $P^{(0)}$ and $\theta^{T(0)}$, equation (10) provides an explicit identity for the average income level $\left(\tilde{r}^{(1)}\right)$. η representing the mark-up, the identity can be written as follows.

$$E\left[\tilde{r}\right] = \left(\int_{\theta^T}^{\infty} \left[\left(\frac{\alpha}{\eta W} \right)^{\alpha} P\theta_i \right]^{\frac{1}{\eta-\alpha}} f\left(\theta\right) d\theta \right)^{\frac{\eta-\alpha}{1-\alpha}} \tag{18}$$

In the next step, for given $\tilde{r}^{(1)}$, $W^{(0)}$ and $P^{(0)}$, one can update the initial guess of the threshold productivity through the threshold incumbent's equilibrium condition given in equation (9). By using the new value for the threshold productivity ($\theta^{T(1)}$) and for given $\tilde{r}^{(1)}$, $\theta^{T(1)}$ and $P^{(1)}$, the initial guess of the aggregate price index is updated through the steady state aggregate price identity (eq. 11) for given $\tilde{r}^{(1)}$ and $W^{(0)}$. In the next step, the initial guess of the aggregate wage level is updated by the free entry condition (eq. 12). Lastly, the number of firms or varieties are calculated through equation (13) by using the updated values of the endogenous variables ($\tilde{r}^{(1)}$, $W^{(1)}$, $P^{(1)}$ and $\theta^{T(1)}$) .

After updating the initial guesses for the five endogenous variables, we repeat the procedure with the new values, and the iterative algorithm is continued until the convergence is achieved in the five equilibrium conditions simultaneously.

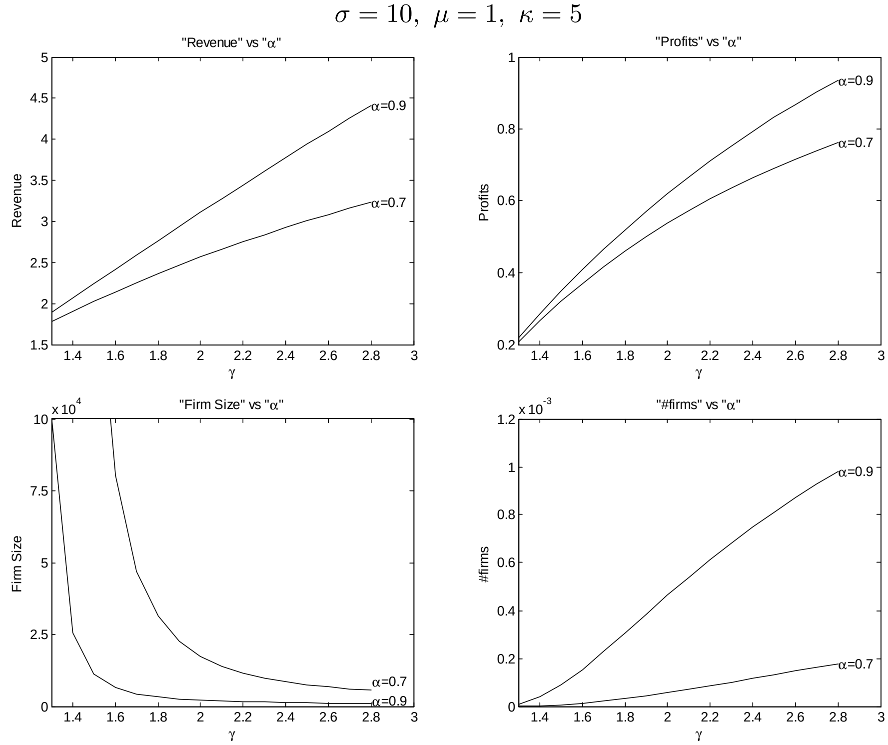
2.2.1 Parameter Values

We have a set of 6 exogenous parameters, $\gamma, \sigma, \mu, \alpha$ and κ, for which we need to assume numeric values for the calibration analysis. Rather than assigning a single value, we consider an interval for each parameter and conduct the robustness checks simultaneously with the interpretations of the results. Accordingly, we consider the effects of alternative degrees of decreasing returns from labor input by allowing α to lie between 0.7 and 0.9. In the econometric part, the calculated coefficient of variations for the productivity distributions in the Ukrainian manufacturing industries range between 1 and 50. The coefficient of variation corresponds to the ratio of the standard deviation to mean that is σ/μ in the theoretical model, so that $\sigma \in [5,\ 15]$ and $\mu \in [0.5,\ 1.5]$ are set to approximately match with the observed productivity dispersion in the data. The elasticity of substitution γ is considered to lie between 1.3 and 2.8, so that we ignore very high degrees of substitutability where the mark-up is close to 1 and the model dynamics tend to replicate the predictions of the standard perfect competition model. Lastly, the value of the operational cost (κ) is allowed to range between 4 and 6, so that κ is approximately equal to 10% of the revenue of the average firm in the industry.

2.2.2 Results of the Calibration Exercise

Throughout the interpretation of the theoretical results, we consider the substitution elasticity to be the main determinant of the intensity of interaction among firms, so that the performances of the competition indices are evaluated according to their responses to the changes in γ. Therefore, in the first scenario, the steady state equilibrium values of the respective endogenous variables are plotted against the elasticity of substitution ($\gamma \in [1.3,\ 2.8]$) for alternative returns to scale parameters ($\alpha \in \{0.7,\ 0.9\}$). While doing so, two variables that determine the degree of the productivity dispersion are assumed to be $\sigma = 10$ and $\mu = 1$, and the value of the operational cost is $\kappa = 5$.

Figure I: Calibration Results
$\sigma = 10,\ \mu = 1,\ \kappa = 5$

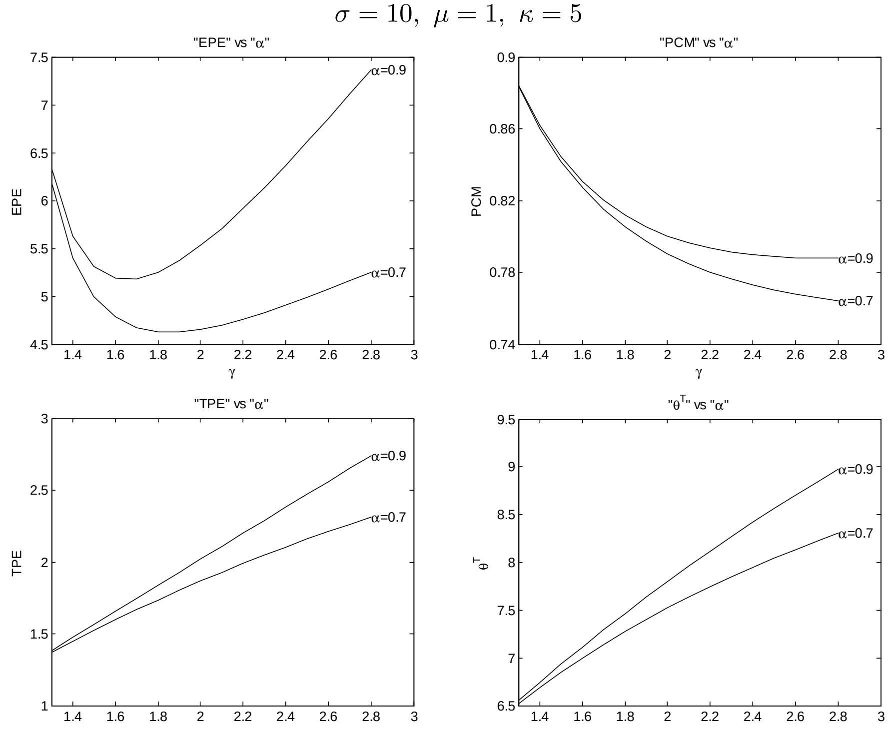


The top panel of Figure I displays the reaction of the expected firm-level revenue and profits to the changes in the elasticity of substitution for alternative degrees of returns from the labor input. As the intensity of interaction increases, both the expected profits and revenues rise in the steady state. Moreover, the number of firms goes up with γ, which implies the aggregate income level to expand with higher competition. Therefore, the industry-wide PCM falls, if the rise in the revenues outpace the profits, while the reaction of EPE depends on the relative importance of the increase in the efficiency measure (c_i/c_j) due to the shrinking fixed-cost component (κ/r).

The down-left panel of Figure I shows that the firm size measured by the amount of labor used in the production is a decreasing function of the elasticity of substitution. Since, γ enters into the production function through the labor input, the expected quantity of firm's output falls with γ for given α. Therefore, we can conclude that the increasing effect of γ on the expected firm revenues is mainly driven by the firm level prices, which will be further displayed in the following scenarios.

The degree of the returns from labor input (α) also affects the steady state values, so that the expected firm size is larger for higher α, while the revenues and profits are lower in the equilibrium. However, the main picture of the industry does not really sensitive to the changes in α as we will further see below.

Figure II: Calibration Results
$\sigma = 10,\ \mu = 1,\ \kappa = 5$



The up-left panel of Figure II displays that EPE is negatively correlated with the substitution elasticity for lower values of γ, while the relationship turns out to be positive as the intensity of interaction rises. Therefore, the increase in the relative efficiency measure of EPE outpaces the rise in the relative profits when γ is relatively low. However, since the firm invariant variable-cost component (α/η) is increasing with γ due to the lower mark-ups (η), and the fixed-cost component falls (κ/r), the rate of the rise in the the relative efficiency measure (c_i/c_j where $c_i = \alpha/\eta + \kappa/r_i$) slows down as the competition intensifies. Therefore, for sufficiently high values of γ, EPE is positively correlated with the true intensity of interaction among the firms. It is worth mentioning that higher values of α lead the benchmark value of γ, which corresponds to the point where EPE reaches the minimum, to be lower. This is because the relative importance of the variable-cost component in the firm level efficiency index rises, while the fixed-cost component shrinks with the higher returns from labor. As a result, the relative efficiency measure of EPE does not reflect the true efficiency ratios of the firms when γ is relatively low.

In the up-right panel, PCM exhibits negative correlation with the level of competition where the negative relationship weakens as γ rises[4]. The downward sloping PCM curve is mainly driven by the dominance of the decreasing effect of the fixed-cost component over the rising variable-cost component.

Intuitively, the negative relationship between PCM and γ heavily relies on the presence of the operational costs. As it is shown in Figure I, the overall income level increases with higher degrees of competition, but whether the incumbents would increase their profit to sale ratios as a response to γ depends on the entry and exit dynamics. Therefore, if we diminish the expected value of entry and facilitate the exit of less efficient incumbents by introducing sufficiently high operational cost, the incumbent firms that are productive enough to stay in the market would increase their share of the profits in revenues as the competition rises. In other words, more intense interaction provides the high productivity incumbents with the opportunity to push the low productivity firms out of the market, while the potential competitive pressure coming from the new entries is restricted by the cost parameter. This can be also seen at the down-right panel of Figure II, where the threshold productivity to stay in the market goes up by higher values of γ.

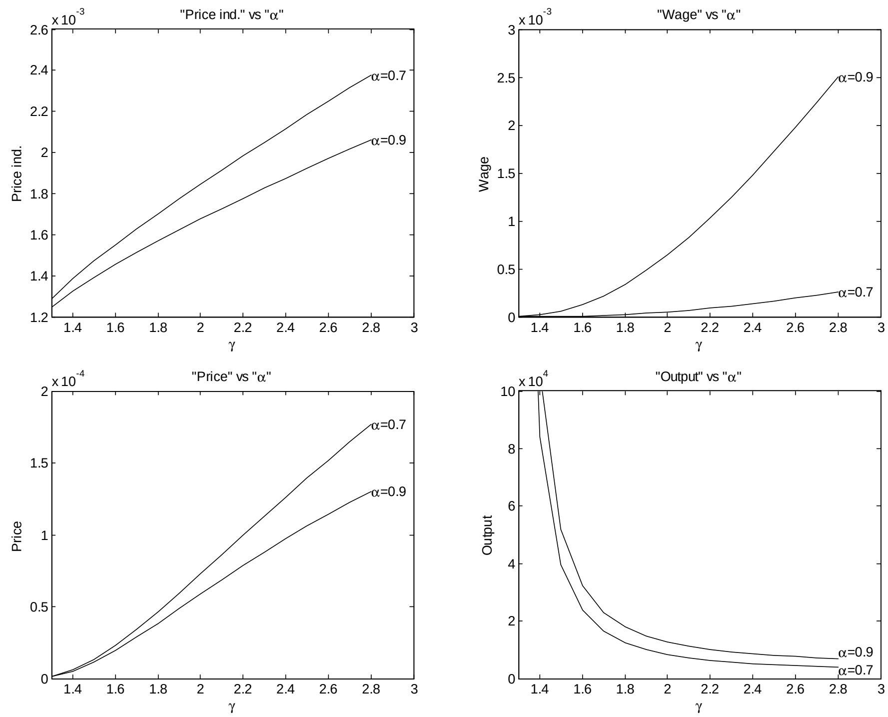
Conversely, one can think of the income expanding role of the high level of competition having an opposite effect that encourage the potential firms to enter into the market, so that for sufficiently high values of γ, the negative correlation between PCM and the substitution elasticity disappears. Moreover, as the returns from the labor input increases, the negative correlation between PCM and γ further weakens, while PCM rises with α for given γ. This is mainly due to the increasing importance of the labor input in comparison to the idiosyncratic productivity parameter in the production function, so that

[4] The results for values of γ higher than 2.8 are not reported basically because the model industry tends to replicate the dynamics of the perfectly competitive market. However, all the measures of competition listed in this paper are theoretically positively correlated with the real intensity of interaction as the model approaches to perfect competition.

the productivity advantage of the more efficient units disappears as the labor becomes the dominant component of the production function.

The down-left panel of Figure II also shows that TPE is monotonically increasing in γ, and the relationship is almost linear for alternative values of α.

Figure III: Calibration Results
$\sigma = 10,\ \mu = 1,\ \kappa = 5$



According to Figure III, the industry-wide price index and the wage level boost by more intense competition. This is a direct consequence of the income expanding effect of the elasticity of substitution that rises the aggregate nominal variables in the steady state. Moreover, while higher α leads the total labor demand and the wage level to increase, it also shifts the expected output curve up for given amount of labor, which in turn diminishes the aggregate price index in the equilibrium.

Besides, the firm level price function derived from the firms' demand identity (eq. 5) is a negative function of the productivity, the bottom panel of Figure III further shows that the expected firm level price and the quantity of the output move in the opposite directions as the competition intensifies. This is an important feature of the model for the empirical analysis, so that if one uses revenues as a proxy for the quantity of output with the aim of, for instance, to calculate the labor productivity, the empirical productivity index would involve the price effects and be a highly distorted measure of the actual productivity. Deflating the firm revenues with an aggregate price index would be also problematic due to the negative correlation between the firm level prices and the productivity, so that the empirical productivity index based on the price adjusted revenues would underestimate (overestimate) the actual productivity level of the more (less) efficient production units[5].

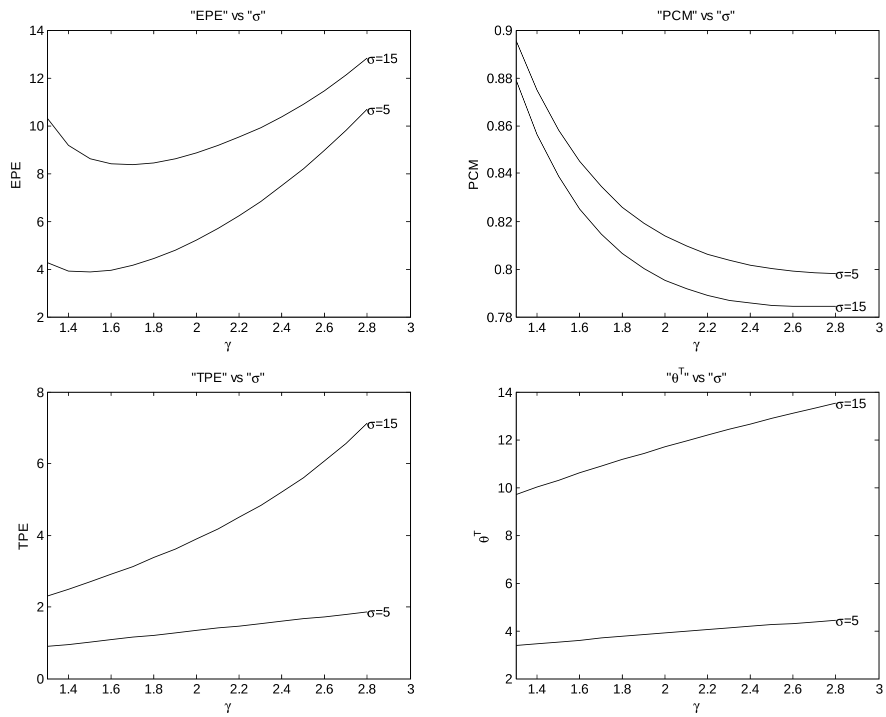
The asymmetric effect of competition on the price and the output levels of the firms play a key role in the mechanism that cause PCM and EPE to deviate from the direction of the true intensity of interaction. Since the quantity of output is a decreasing function of γ, the rise in the firm revenues with higher level of competition is mainly driven by the upward shift in the firm level prices, so that the fixed and variable components involved in the firm level PCM and the efficiency measure of EPE move in the opposite directions. Therefore, if the empirical researcher would observe the prices at the firm level, it would be possible to extract the distorting part of EPE; for instance, a quantity based input to output ratio would be a suitable efficiency measure that would lead EPE to be monotonically increasing in γ.

In the second scenario, we investigate the effects of the substitution elasticity ($\gamma \in [1.3,\ 2.8]$) on the industry dynamics for alternative degrees of productivity dispersion. While doing so, the industry-wide component of the idiosyncratic productivity held constant ($\mu = 1$), and the standard deviation of the productivity distribution (σ) takes two alternative values. As in the first experiment, the operational cost is set to $\kappa = 5$, and the returns from labor is $\alpha = 0.9$.

It is important to notice that as the degree of the firm level heterogeneity diminishes, the industry collapses into a model of a single representative firm and variety of output, where the effects of the substitution elasticity vanishes. Conversely, as the standard deviation of the productivity distribution increases, the effects of competition on the model industry dynamics are amplified. We do not report the behavior of the expected firm size, revenues, profits and output, but all of them except the expected firm size further rises with σ for given degree of substitutability among the product varieties. Since the firm size is a negative function of γ, it further shrinks with the higher levels of productivity dispersion.

[5] For further discussion and empirical support on the negative relationship between firm level prices and the quantity based productivity see Foster et al. (2008).

Figure IV: Calibration Results
$\alpha = 0.9,\ \mu = 1,\ \kappa = 5$



The down-right panel of Figure IV shows that the threshold productivity level to stay in the market goes up by σ, and the rising effect of the substitution elasticity on θ^T is amplified when the productivity is more dispersed. Therefore, for higher σ, the market conditions are stricter for the low productivity incumbents, which facilitates the productive ones to further enhance their profitability. As a result, for given γ, PCM falls with σ in the steady state.

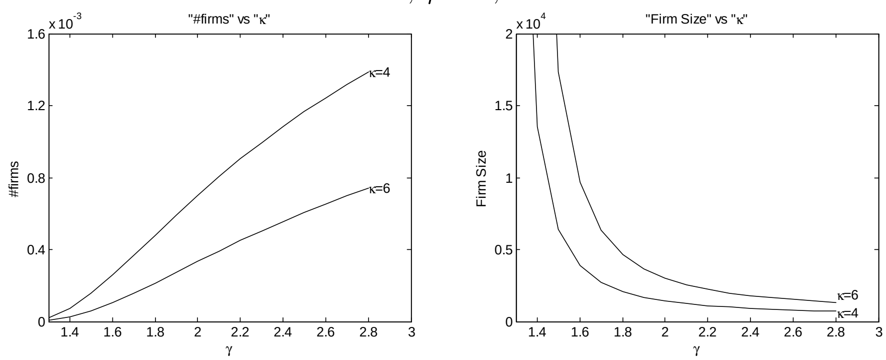
The U-shaped relationship between EPE and the elasticity of substitution becomes more apparent as the productivity is more dispersed. Moreover, the benchmark level of γ, where EPE curve has a zero slope, shifts to the right, indicating the relative efficiency measure of EPE requires higher levels of firm interaction to reflect the true relationship. On the other hand, TPE is monotonically increasing in γ for alternative degrees of firm heterogeneity, and sensitivity of TPE to γ rises with σ.

As we use the coefficient of variation (σ/μ) to measure the productivity dispersion in the empirical part, one can think of a fall in μ to create the same impact with the higher degree of firm heterogeneity driven by an increase in σ. Therefore, we do not display the effects of μ on the industry dynamics separately, since the mechanism described in Figure IV is same when we change the productivity dispersion by the industry mean of the productivity distribution where a lower μ corresponds to a higher value of σ.

In the next set of graphs, the relationship between the level of competition and the response of the endogenous indicators are investigated for alternative values of the operational cost parameter. Therefore, $\kappa \in \{4, 6\}$, $\alpha = 0.9$, $\sigma = 10$ and $\mu = 1$.

It is also worth mentioning that when the fixed cost is zero ($\kappa = 0$), PCM is identical to the factor elasticity to mark-up ratio (α/η) that is monotonically increasing in the elasticity of substitution. Namely, the violation of the positive correlation between PCM and γ mainly depends on the introduction of the fixed costs into the model industry. On the other hand, in the absence of κ, the efficiency measure of EPE is also identical to α/η that is same for all firms, so that EPE is not measurable in the case of $\kappa = 0$. In addition to this, as it is stated in Proposition 2 and analytically proved in the appendix part, TPE is monotonically increasing in γ when the operational cost is zero. However, as long as the operational cost is strictly positive and sufficiently high, the responses of the regarding competition indices to the changes in the elasticity of substitution are irrespective of the alternative values of κ.

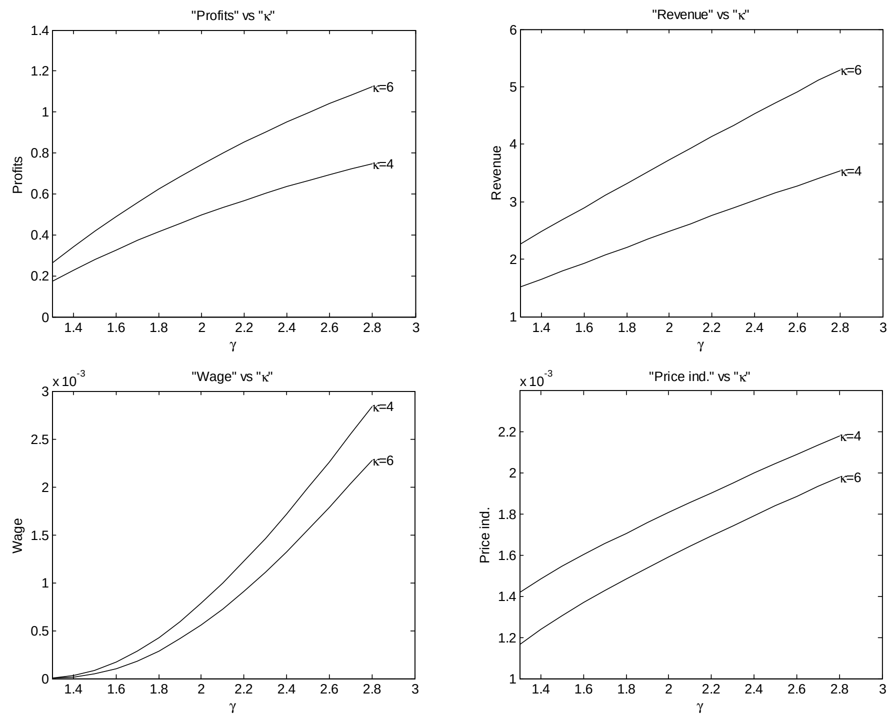
Figure V: Calibration Results
$\alpha = 0.9,\ \mu = 1,\ \sigma = 10$



When the operational cost is higher, the total size of the industry (R) shrinks and the concentration rises in the steady state. Figure V shows that total number firms falls and the expected firm size in terms of the amount of labor employed in the production expands with κ. In that case, both the negative relationship between firm size and γ, and the positive correlation of the number of firms with the elasticity of substitution are still valid for alternative values of the cost parameter. However, higher κ facilitates the less efficient firms to exit the market and lowers the expected value of entry that leads the remaining firms to increase their market share, so that market concentration rise without any change in the degree of the substitutability among the product varieties.

Figure VI: Calibration Results

$\alpha = 0.9, \ \mu = 1, \ \sigma = 10$



As it is shown in the bottom panel of Figure VI, the expected wage level and the industry-wide price index are lower in the equilibrium with higher values of κ. This is mainly due to the fall in the total income created in the industry, because the resources are further transferred from the productive production process to the representative consumer as a component of income.

Top panel of Figure VI further shows that the expected revenues and profits increase with κ. In addition to this, the upward shift in the firm revenues is proportional to the rise in κ, so that the share of the fixed operational cost in the firm's revenue stays same for alternative values of the operational cost parameter. The variable cost to revenue ratio is also independent of κ, so that PCM does not change with the magnitude of the frictions in the industry. Moreover, since the operational costs are symmetric for all firms, every incumbent firm experiences a proportional increase in the profits that further leads EPE and TPE to be independent of κ in the steady state. However, for given γ, concentration based measures of competition would indicate lower intensity of interaction with higher values of κ.

3 Emprical Analysis of the Competition Indices

Throughout the theoretical discussions in the previous part, we point out the possible factors that distort the measurement of the product market competition through the price-cost margin (PCM) and the empirical profit elasticity (EPE). Accordingly, PCM deviates from the true direction of competition when we introduce the operational costs at the firm level. In that case, the fixed cost to revenue ratio falls with more intense competition, which leads PCM to be negatively correlated with the elasticity of substitution for relatively lower degrees of substitutability among the product varieties. Intuitively, the presence of the operational costs lowers the expected value of entry and makes the survival more difficult for the less efficient production units, so that the more efficient incumbents expand their market share and enhance their profitability with more intense competition.

Moreover, the firm level PCM is also used as the cost efficiency measure of EPE, and does not reflect the true relative efficiency between any two firms, when the elasticity of substitution is relatively low. While the competition leads the profit of the more efficient firm to increase at a higher rate than that of the less efficient one, the cost efficiency levels (measured by total input expenditures to revenue ratio) of the two firms converge, so that the relative efficiency also rises with the elasticity of substitution in the equilibrium. The convergence of the cost efficiency measures is driven by the shrinking fixed-cost component due to the rise in the firm revenues, while the variable costs to revenue ratio is equal to α/η and same for all firms. Therefore, the rate of increase in the relative cost efficiency outpaces the rise in the relative profits, so that EPE exhibits negative correlation with the substitution elasticity for the region where the degree of substitutability is relatively low.

Additionally, the rise in the firm revenue, so the fall in the fixed cost component of the firm level PCM is mainly due to the opposite movements in the firm level prices and the quantity of output with more intensive competition driven by higher degrees of substitutability. Therefore, the deviation of EPE from the true direction of the intensity of interaction relies on the implicit assumption that the firm level prices are unobservable for the empirical researcher. Otherwise, it would be possible to calculate a quantity based input to output ratio that would reflect the real level of productivity, and EPE would give similar results with TPE for the model industry.

3.1 Econometric Model

This part of the analysis aims to find a robust productivity measure that does not include the output price effects, so that we can robustly measure the intensity of competition in Ukraine's manufacturing industries. While doing so, we introduce the capital stock and the materials to be the other two factors of production. We further assume a Cobb-Douglas type production function in the following form, where Q_{it}, Θ_{it}, K_{it}, L_{it} and M_{it} are the firm level output, total factor productivity, capital, labor and material inputs respectively, and α^i's are the respective factor elasticity parameters.

$$Q_{it} = \Theta_{it} K_{it}^{\alpha^K} L_{it}^{\alpha^L} M_{it}^{\alpha^M} \tag{19}$$

As it is often the case in the empirical analysis with firm-level datasets, we do not observe the actual quantity of output but the revenues. In order to express the production function in terms of revenues, we utilize the demand side of the theoretical model depicted in the previous part. The firm level demand function (eq. 5) provides the following identity that links the quantity of the output to the revenue of a firm in the equilibrium and eliminates the firm-level prices in the formulation.

$$\frac{R_{it}}{P_t} = \left(\frac{\bar{R}_t}{P_t}\right)^{\frac{1}{\gamma}} Q_{it}^{\frac{1}{\eta}} \tag{20}$$

As in the previous part, $\eta = \gamma / (\gamma - 1)$ represents the mark-up variable and $\bar{R}_t = N_t^{-1} \sum_i^N R_{it}$ is the mean of the revenue in the industry. Therefore, the aggregate term $\bar{R}_t / P_t$ stands for the industry level demand shifter that provides a direct estimate of the industry specific substitution elasticity (for discussions and examples of alternative demand specifications see Melitz and Levinsohn, 2004; Martin, 2005; De Loecker, 2007). By introducing the production function in the place of Q_{it} in equation (20), we retrieve the following estimation equation at the industry level where the lower case letters represents the respective variables in logarithms. We further remove the aggregate price index from the formulation so that r_{it} and $\bar{r}_t$ are the logs of the deflated revenues at the firm and industry level respectively.

$$r_{it} = \beta_0 + \beta_E \bar{r}_t + \beta_M m_{it} + \beta_L l_{it} + \beta_K k_{it} + \theta_{it}/\eta + \epsilon_{it} \tag{21}$$

Therefore, the coefficient of the demand shifter is equal to $\beta_E = 1/\gamma$, and the production factors' coefficients satisfy the identity that $\beta_j = \alpha^j / \eta$ where $j \in \{M,\ L,\ K\}$. The markup parameter that appears jointly with the idiosyncratic productivity variable (η) is fully identified through the estimated coefficient of β_E, so η that lies below the unobserved productivity term (θ_{it}) is substracted from the rest of the formulation of the econometric model.

3.2 Estimation Methodology

The main difficulty in the estimation of the production functions is the correlation between the unobserved productivity shocks and the amount of inputs used in the production. In other words, the manager can observe the firm's productivity and use this knowledge in the decision phase of the optimal amount of input to be used in the production, so that one would expect endogeneity in the firms' input usage.

As dealing with the endogeneity problem, our method does not differ from the two step estimation procedure with a proxy variable inspired by Olley and Pakes (1996) (OP). OP deal with the endogeneity of inputs by assuming the firms to immediately alter their investments in response to the productivity shocks. However, while the investments as a proxy for productivity can theoretically answer the endogeneity problem, in practice, it creates its own shortcomings such as the presence of zero investments in the estimation sample. So far the most common ways of dealing with the zero investment problem is replacing them with a small positive number or deleting the regarding observation that may introduce additional error or cause severe selection bias in the estimation procedure. Especially in the developing countries, the firms often decide not to invest for reasons such as the high levels of uncertainty, the frictions in the financial markets and high regulatory burden of investing. In addition to this, approximately one third of the total number of the firms report zero investment in our sample which makes the OP method rather infeasible to apply in our case.

In the estimation of the modified production function, we utilize Levinsohn and Petrin's (2003) approach (LP) that suggests the materials to be used as the proxy for the unobserved productivity. LP further argue that, besides solving the zero investment problem, the modified method offers a better proxy for unobserved component since the investments are rather lumpy in responding the productivity shocks.

Accordingly, we define the firm's material usage as a function of productivity and the capital stock as the state variable ($m_{it}\left(\theta_{it}, k_{it}\right)$). Assuming m_{it} is monotone in θ_{it}, we can invert the materials equation to obtain the proxy function that is $\theta_{it} = \phi_{it}\left(m_{it}, k_{it}\right)$, where $\phi\left(.\right) = m^{-1}\left(.\right)$. However, introducing the proxy identity into the production function makes it impossible to identify the coefficients of the capital and materials in a single step, so that we require a second stage to recover all factor elasticity parameters. LP routine combines all the terms of the production function that includes materials and capital in a control function $g_{it}(m_{it}, k_{it})$ which is defined as a third order polynomial in its arguments. Therefore, by introducing the demand shifter ($\bar{r}_t$) as a variable that is independent of the idiosyncratic and i.i.d. shock component (ϵ_{it}), the first stage regression equation takes the following form.

$$r_{it} = \beta_E \bar{r}_t + \beta_L l_{it} + g_{it}(m_{it}, k_{it}) + \epsilon_{it} \tag{22}$$

In the above regression equation, $g_{it}(m_{it}, k_{it}) = \beta_0 + \beta_M m_{it} + \beta_K k_{it} + \phi_{it}\left(m_{it}, k_{it}\right)$ constitutes the non-parametric part of the estimation equation that takes into account the endogeneity between the productivity and the amount of capital and materials used in the production.[6]

The second stage, relies on the assumption that θ_{it} evolves as a first-order Markov process. Namely, $\theta_{it} = E\left\{\theta_{it} \mid \theta_{it-1}\right\} + \xi_{it}$ where ξ_{it} is i.i.d. Thus, for any candidate values of β_K^* and β_M^*, the method retrieves the estimates of $\hat{\phi}_{it} = \hat{g}_{it} - \beta_M^* m_{it} - \beta_K^* k_{it}$, and a consistent nonparametric approximation of

[6] As Ackerberg (2006) argues, there is a possible correlation between the labor input and the shock term (ϵ_{it}) which may result in biased estimates of β_L in the first stage regression of LP algorithm. As in the original structural model, we rule out the endogeneity of the labor input by assuming that the manager does not have perfect knowledge on the productivity shocks firm face as long as the labor is hired. This assumption further allows us to consistently estimate β_E and β_L by using OLS.

$E\{\theta_{it} \mid \theta_{it-1}\}$ for given β_K^* and β_M^* can be obtained by the following regression.

$$E\{\theta_{it} \widehat{\mid \theta_{it-1}}\} = \delta_0 + \delta_1 \hat{\phi}_{it-1} + \delta_2 \hat{\phi}_{it-1}^2 + \delta_3 \hat{\phi}_{it-1}^3 + \xi_{it} \qquad (23)$$

We obtain the estimates of β_K and β_M by implementing GMM minimization method as in the Levinsohn et al. (2004) on the joint error term given by the following equation[7].

$$\xi_{it} + \epsilon_{it} = r_{it} - \hat{\beta}_E \bar{r}_t - \beta_M^* m_{it} - \hat{\beta}_L l_{it} - \beta_K^* k_{it} - E\{\theta_{it} \widehat{\mid \theta_{it-1}}\} \qquad (24)$$

In order to identify β_K and β_M, we assume that the previous periods' levels of the materials, labor and the aggregate demand shifter are uncorrelated with this period's productivity shock, so that m_{t-1}, k_{t-1}, l_{t-1} and $\bar{r}_{t-1}$ provides the necessary moment conditions. Moreover, assuming the today's capital stock to be determined by the previous periods' investments that are uncorrelated with the period t's error, k_t is further used as the instrument for the GMM algorithm.

3.3 The Dataset

Our dataset consists of an annual sample of the manufacturing firms operating in Ukraine during 2004-2007. The revenue variable is represented as the nominal sales after tax and the labor input is the total hours worked by the full and part time employees of a firm in a given year. The materials input is proxied by the total nominal costs of goods and services, acquired for the re-sale and realized without an additional processing plus expenses for power, and for the capital input, we use the reported depreciation of the capital stock at a given enterprise.

The State Statistical Committee of Ukraine reports the producer price indices (PPI) for the manufacturing sector at the 2-digit industry level. While constructing the deflated revenues, we take account of the multi-product firms that simultaneously operate in more than one industry. Therefore, each product category is deflated by its own industry level PPI, and the firm's main industry is classified according to the industry code of its largest product category.

However, we do not have any industry specific deflators for the capital and material inputs for which we define economy-wide price indices. The material expenses are price-adjusted by the consumer price index, and for the capital stock we construct a price index that is a weighted average of the PPI's of the 2-digit manufacturing industries that are classified as the capital goods and services producing sectors. Although, we neglect the possible bias due to ignoring the variation in input prices, we can still refer Eslava et al. (2005) that analyzes Colombian data with detailed input and output prices. Therefore, they conclude that while ignoring the firm-variation in the output prices can dramatically affect the TFP measure, ignoring the variation in the input prices has only minor effects on the estimated productivity indices.

[7] The LP (levpet) routine written for Stata uses Newton's method for the minimization problem, and employs the bootstrap to estimate the standard errors. For details, see Levinsohn et al., (2004).

It is worth mentioning that our methodology necessitates an industry specific price index which prevents us from estimating the production functions at the more disaggregated industry level. Thus, the production functions are estimated separately for Ukrainian manufacturing industries where the grouping of each segment is identical to the 2-digit NACE industry classification. The basic statistics on the dataset and the definition of the industry codes used in the following charts and tables can be found in the appendix part.

3.4 Productivity estimates

We estimate the production functions for 14 Ukrainian manufacturing industries seperately where the estimation results and the standard errors can be found in the appendix part. Accordingly, for the two industries, the estimated coefficients of $\beta_E = 1/\gamma$ are significant at 5% level while for all the other industries the regarding estimates are significant at 1% level. However, in one industry, that is the manufacturing of basic metals and fabricated metal products, the estimated coefficient is significantly negative with a value of $1/\gamma = -0.12$. While our structural model rules out the negative values of the elasticity, the regarding competition measures indicate a high intensity of competition for this industry which is consistent with a low value of $1/\gamma$. Nevertheless, we extract the considerations for this sector (with the industry code of DJ) from the analysis, and report the results of the remaining 13 manufacturing industries for which the estimations of $1/\gamma$ lie between 0 and 1.

Table I displays the estimated substitution elasticity coefficients, the two dispersion measures that are the coefficient of variation and the inter-quartile range, and a sensitivity measure for the impact of γ on TFP. We also report the dispersion measures for the labor productivity (the ratio of deflated revenues to total work hours), so that we can compare our TFP estimations with an alternative measure of productivity that theoretically involves the variation in the output prices.

Table I. Statistics on Production Function Estimates						
Industry	Elasticity (γ)	C. of Variation		Inter-Q. Range		50% increase in γ
		TFP	LP	TFP	LP	
DA	9.4	2.2	17.7	0.5	1.8	1.7
DB	1.3	48.2	16.9	12.0	1.6	1.1
DC	1.7	11.8	6.5	2.2	2.2	2.0
DD	2.5	15.3	18.4	1.1	1.7	1.2
DE	2.2	5.5	27.4	1.4	1.7	3.4
DF	1.5*	16.7	1.9	2.3	2.1	29.2
DG	9.9*	1.7	3.0	0.5	1.6	1.6
DH	2.7	13.7	19.8	1.1	1.6	4.0
DI	9.2	0.9	7.4	0.5	1.8	0.6
DK	2.3	12.6	8.5	1.1	1.5	1.7
DL	3.8	6.3	5.3	0.7	1.8	1.8
DM	2.6	11.2	6.8	1.0	1.6	2.4
DN	1.5	55.4	6.9	4.1	1.9	4.3

* Significant at 5% level. The rest of γ's are significant at %1.

Accordingly, TFP is more dispersed in the manufacturing sectors that exhibit relatively low substitution elasticity. While analyzing the determinants of the productivity dispersion is beyond the scope of this paper, our findings support the argument that in the highly competitive industries the firms are less heterogenous in terms of their productivity draws which may be due to the well functioning of the creative destruction process and the efficiency of the allocation of the resources in more competitive sectors. Namely, when the interaction among the firms is intensive, the industry dynamics only allow for the highly productive units to stay in the market that leads a convergence in terms of the idiosyncratic productivity levels.

Moreover, the dispersion in the estimated TFP is greater than that of the labor productivity in the sectors where γ is estimated to be relatively low, such as the sectors DB, DC, DF, DK, DM and DN. Therefore, when the variation in the output prices is controlled for up to the degree of constant industry markup, the dispersion of the productivity widens especially in the industries that exhibit higher mark-ups. This is in line with our theoretical discussion where we point out the fact that the output prices are negatively correlated with the productivity, so that one would expect the more (less) productive firms measured to be less (more) productive, unless the productivity index is adjusted for the firm level price effects as in the standard measure of the labor productivity. Foster et al. (2008) further provide empirical support for the validity of the negative correlation between the firm level prices and the productivity draws.

The last column of Table I displays the impact of a 50% increase in γ on TFP, which is calculated by evaluating the industry specific production functions at the industry mean of the observables. Accordingly, in all listed industries, the substitution elasticity has a positive impact on the total factor productivity. Moreover, for the industries with relatively low values of γ, the productivity gains from a higher level of interaction are larger.

3.5 Comparative Analysis of the Competition Indices

The comparative analysis of the performances of the competition indices is separated into two parts where in the first part we only consider the time-invariant and industry specific results and in the second part the time dimension is added to the analysis. Furthermore, in the estimation of the profit elasticity, every variable is redefined as the log deviations from the benchmark firm. For each industry, the benchmark firm is selected to be the median of the firm level productivity vector that is constructed by averaging the idiosyncratic productivity values over time. For the time-invariant measure, we regress the relative profits on the relative efficiency by using the standard fixed effects estimator. We keep the same notation used in the previous parts and refer the elasticity of the profits to the productivity as TPE and the elasticity to the unit cost (variable costs to revenue ratio) as EPE.

It is worth nothing that the method of measuring the competition with the profit elasticity does not require to use all the firms in the sample, as long as the sample covers the same firms in all periods, while PCM necessitates considering all the units that have a positive market share. Accordingly, in the estimation of the profit elasticity with both efficiency measures, we remove the firms with non-positive profits from the sample, so that we are able to express the dependent variable in logarithms. Moreover, we extract the firms for which there are gaps in the data that may be due to the entry and exit. Thus, the estimation sample covers only the firms that operate for all years in the regarding industries.

The firm level PCM is retrieved through the following formula.

$$pcm_{it} = \frac{materials_{it} + payroll_{it} - depreciation_{it} + u_t^{ex} * Capital_{it}}{sales_{it}} \tag{25}$$

In the above identity, all the variables are in the nominal terms and the ex-post user cost of capital (u_t^{ex}) is calculated by the following formula.

$$u_t^{ex} = \left[r_t - \pi_t^K - \delta\left(1 + \pi_t^K\right)\right] P_t^K \tag{26}$$

Therefore, P_t^K stands for the price of the capital, and r_t represents the opportunity cost of the capital for which we use the interbank prime rate that is the weighted average of all the instruments. The inflation rate of the capital goods and services $\left(\pi_t^K\right)$ is calculated by the weighted average of the producers' price indices of the manufacturing industries that are classified to produce capital goods and services[8]. Lastly, the industry level PCM is calculated as the average of the firm level PCM's weighted by the revenue share of the firm in the industry.

[8] A derivation for the user cost of capital identity and the list of industries used in the calculation of π_t^K can be found in the appendix part.

Figure VII: Competition Indices

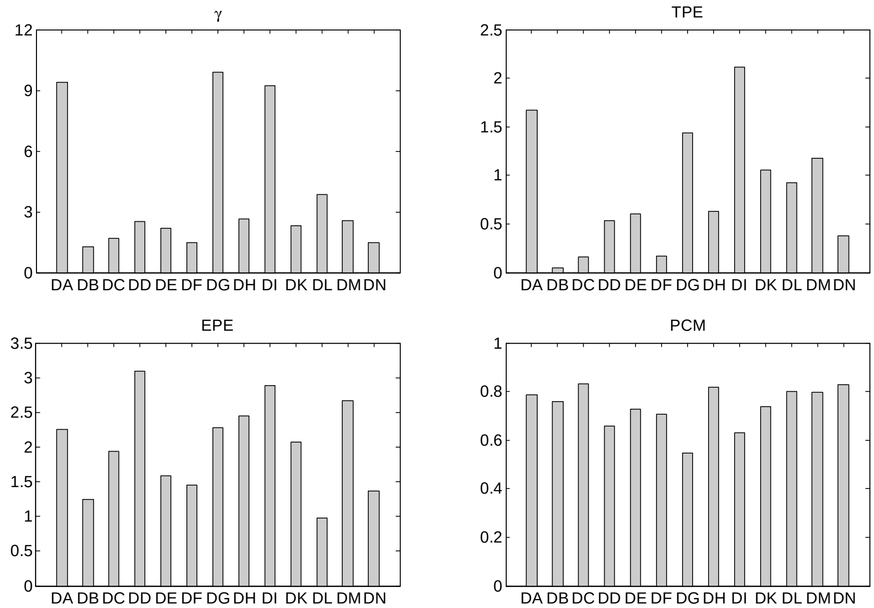


Figure VIII displays the time invariant competition measures and the estimated elasticity of substitution (γ) at the industry level. The estimated profit elasticity values with the both efficiency measures are significant at 1% level for all the listed industries. It is also worth noting that all the competition measures reported in this paper are arranged in a way that the higher values correspond to the higher level of competition, so that EPE is minus one times the estimated elasticity of the profits to the unit costs, while PCM represents the ratio of the total input expenditures over the nominal sales that is expected to approach one as competition intensifies.

Following the discussion developed in the theoretical part, we consider the industry level substitution elasticity as the benchmark indicator of the intensity of interaction among the firms. Accordingly, the first row of Figure VIII shows that the distribution of the estimated TPE's is quite similar to that of the substitution elasticity for the 13 Ukrainian manufacturing industries. The differences in the industry rankings of TPE and γ are only observed for the industries that exhibit similar levels of competitiveness. Therefore, if we group the industries according to the measured levels of competition, for both γ and TPE, the sectors DA, DG and DI constitutes the most competitive group, where DB, DC,DF and DN are observed to be the industries that exhibit lowest intensity of interaction among the firms.

However, EPE draws a somewhat different picture where the degree of competition seems to be overestimated especially for the sectors that have a lower level of substitution elasticity. The sectors that are measured to have relatively low level of competition in terms of γ and TPE, such as the industries DC,

DD, DH and DK, are among the most competitive group according to EPE. However, the most competitive ones in terms of TPE and γ, such as DA, DG and DI still exhibit high intensity of competition when it is measured by EPE.

On the other hand, Figure VIII does not provide a seemingly significant correlation between PCM and any other competition indices. PCM indicates a lower industry level heterogeneity in the competition intensity, so that it is hard to distinguish the most and the least competitive groups. The sectors DG and DI, which are among the most competitive industries according to the other indicators, are ranked as the two least competitive industries with respect to PCM. Furthermore, DN and DC, that are in the group of least competitive industries in terms of γ and TPE, are observed to indicate the highest level of competition according to PCM. Therefore, for the Ukrainian manufacturing sector, we consider PCM to be the possibly most divergent measure of competition among the indices listed in the graph.

So far the findings are in line with our theoretical discussion that when the intensity of interaction among firms is low in an industry, EPE gives distorted results and can even be negatively correlated with the true intensity of competition. PCM also performs poor in the case of lower competition, but it is more sensitive to the frictions such as fixed operational costs, which can explain the deviation of PCM from the other three measures of competition. Our results further support TPE as the robust indicator of the competition intensity that exhibits a higher degree of correlation with the estimated substitution elasticity.

However, empirical researchers often need to measure the level of competition at a point in time where our production function estimation methodology does not allow us to estimate the time variation in the substitution elasticity. This is also a practical reason for why it is often preferred simpler methods to analyze the time trend in the competition. Therefore, following discussion takes into account the time dimension in the measurement of competition with the three abovementioned empirical indices. While doing so we estimate the profit elasticity by OLS across the firms in a given year. We use the same sample of firms as in the previous part so that all the firms used in the estimation of the profit elasticity fully operate during the 4-year period. We further extend the analysis by introducing the industry level TFP and the labor productivity. Appendix Table IV presents the summary statistics on the calculated measures of competition used in this part of the analysis.

Table II Partial Corr. Matrix of Competition Indices (full sample)

	TPE	EPE	PCM	$Av.TFP$	$Av.LP$
TPE	1	-0.016	0.176	0.479*	0.181
EPE	-0.016	1	-0.046	0.032	0.075
PCM	0.176	-0.046	1	0.093	-0.244
$Av.TFP$	0.479*	0.032	0.093	1	-0.224
$Av.LP$	0.181	0.075	-0.243	-0.224	1

* Significant at 5% level.

Table II displays the partial correlation coefficients among the industry level measures of the competition and productivity where the industry fixed effects are assumed to be exogenous. Therefore, when we consider all 13 industries, there is a negative and insignificant correlation between TPE and EPE. The correlation between TPE and PCM is positive but insignificantly low. Moreover, TPE is positively and significantly correlated with the industry level TFP, but the correlation with the labor productivity is insignificant.

The reported partial correlations between EPE and the two productivity measures are close to 0 indicating that the elasticity measured by EPE does not seem to be significantly related with the industry level productivity dynamics. Moreover, the correlation of PCM with TFP is also not significantly different from zero, while the correlation of PCM with the labor productivity is insignificantly negative.

Table III P. Corr. Matrix of Competition In. (for industries $\gamma > 2$)

	TPE	EPE	PCM	$Av.TFP$	$Av.LP$
TPE	1	0.396*	0.222	0.488*	-0.124
EPE	0.396*	1	-0.161	0.239	0.142
PCM	0.222	-0.161	1	0.103	-0.258
$Av.TFP$	0.488*	0.239	0.103	1	-0.25
$Av.LP$	-0.124	0.142	-0.258	-0.25	1

* Significant at 5% level.

Table III presents the partial correlation matrix for the group of industries that exhibit more intense within-indusry competition. We categorize the industries according to the values of the estimated substitution elasticity, so that the more competitive group includes the industries that have a substitution elasticity higher than 2. It is worth mentioning that the benchmark value for the elasticity is chosen to satisfy the number of observations to be high enough to calculate the correlation coefficients.

Accordingly, there is a positive and significant correlation between TPE and EPE for the group of industries where the intensity of the interaction among the firms is relatively high. Moreover, the correlations between EPE and the two productivity measures also rise for the restricted group, but no significant correlation is detected between EPE and any of the productivity indices.

The partial correlation between TPE and PCM is calculated to be higher than the correaltion for the full sample, but it is still insignificantly low. However, the values of the correlation coefficients reported for PCM against the two productivity indices seem to be persistent whatever the sample is restricted or not. Therefore, the mechanism behind the relationship between the actual intensity of competition and PCM is possibly more sensitive to the other factors like the entry and operational costs, while EPE approaches to the true intensity of competition as the interaction among the firms intensifies.

As the potentially robust measure of competition, TPE exhibits the same degree of correlation with TFP for the restricted and the full sample, but it is still not significantly correlated with the labor productivity. Moreover, the insignificantly negative correlation between TFP and the labor productivity is persistent for alternative sample selections. We attribute this to the firm level price effects embodied in the productivity indices that are important enough to deteriorate the quality of the index even for the industries where the interaction among the firms is relatively more intensive.

4 Conclusion

Recently, in almost any field of economics, the empirical measures of competition are widely used with the aim of understanding the relationship between competition and main economic indicators. In particular, the price-cost margin, the market-concentration based ratios and the profit elasticity are among the widely used indices of competition, where one can possibly obtain different results from the empirical application of these alternative methods for the same industry and time period. This is mainly due to the inconsistency between the concept of competition or the theoretical setup underlying the measurement method and the structure of empirically observed industry dynamics.

This paper considers competition as the intensity of interaction among the firms in the product market that is mainly determined by the substitutability among the product varieties in an industry. Therefore, the first part of this study investigates the relationship between the foremost competition indices and the substitution elasticity in a model of monopolistic competition where each firm draws an idiosyncratic productivity from a continuous distribution in the entry phase, and produces a single variety under the presence of fixed operational costs.

The theoretical findings show that, in the steady state, the price-cost margin is negatively correlated with the competition when the substitution elasticity is relatively low. This is mainly due to the presence of the operational costs that restricts the possible increase in the number of new varieties and facilitates exit, while the industry size expands due to more intense interaction among the production units. Therefore, the incumbent firms that are productive enough to stay in the market expand their market share and enhance the profitability, so that price-cost margin decreases with higher degree of substitutability among the product varieties.

Moreover, when the total expenditure on the inputs to revenue ratio is used as an efficiency measure, the elasticity of profits to efficiency is also negatively correlated with the elasticity of substitution for relatively low degrees of substitutability. However, the elasticity of profits to productivity is monotonically increasing in the true intensity of competition for alternative parameter settings considered in the calibration analysis. The difference between the two alternative measures of the profit elasticity stems from the efficiency measures used in the calculation. Therefore, the costs to revenue ratio, which is the efficiency measure of the traditional method, involves price effects in the form of markups that are sensitive to changes in the substitutability. However, the productivity as an exogenous parameter in the theoretical model provides a robust measure of firm level efficiency that further eliminates the bias in the traditional empirical measure of profit elasticity.

In line with the predictions of the theoretical analysis, the empirical part aims to estimate a robust productivity index that is adjusted for the industry markups and compares the performances of the competition measures by considering the elasticity of substitution as the benchmark determinant of the intensity of interaction in the product market. While doing so, we utilize a panel of the manufacturing firms operating in Ukraine. However, we do not observe the prices at the firm level which necessitates introducing the demand side into the structural estimation of the production functions to retrieve a markup estimate. Therefore, the production function parameters are estimated for 14 Ukrainian manufacturing industries by controlling for both the endogeneity of inputs to productivity and the unobserved prices up to the degree of a constant industry markup.

The empirical findings imply that when the total factor productivity is estimated by taking account of the price variations at the firm level, the productivity is more dispersed in the sectors where the degree of interaction among firms is low. Namely, our results support the argument that competition leads the convergence in the productivity levels of firms, possibly due to the well-functioning of the creative destruction process that clears the market from the least efficient firms and motivates more productive potential entrants to enter. Moreover, in the sectors where the level of competition is relatively low, the dispersion of the estimated productivity index is much higher than the dispersion in the standard labor productivity that is based on the revenue per working hours adjusted by an aggregate price index. This result is in line with our theoretical predictions that the firm level prices are negatively correlated with the actual productivity, so that one would expect a productivity index that involves significant price effects to be less dispersed than the actual productivity.

The analysis of the comparative performances of the competition measures concludes that the traditional profit elasticity overestimates the level of competition in the industries where the estimated elasticity of substitution is relatively low. However, for the industries that exhibit intensive firm-to-firm interaction, the traditional profit elasticity tends to be positively correlated with the substitution elasticity. On the other hand, the modified measure of the profit elasticity, which is based on TFP, exhibits strong correlation with the elasticity of substitution. Moreover, the two profit elasticity measures are significantly correlated in the highly competitive industries, while no significant correlated is detected for the full sample. Besides, its correlation with the proposed measure of profit elasticity rises for the sample of highly competitive industries, the price-cost margin does not exhibit any significant relationship with none of the other measures of competition considered in this paper.

This paper sheds light on the use of competition indices in the analysis of the market dynamics, productivity and growth by arguing that the traditional methods do not always indicate the true nature of the intensity of interaction among the establishments in the product market. In particular, our results provide an alternative explanation for the recent empirical support on the non-linear relationship between the traditional measures of competition and productivity, where we find either non-linear or insignificant relationship between the actual level of competition and some of the widely used empirical measures of competition.

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Appendix

Proof of Proposition1. Firm profits are monotonically increasing in θ. ■

By using the factor share identity (eq.15), firm level profits as a function of productivity can be written in the following form where, as before, $r_i(\theta_i) = p_i(\theta_i)\, q_i(\theta_i)$ is the firm revenues and the mark-up term is $\eta = \dfrac{\gamma}{\gamma - 1}$.

$$\pi_i(\theta_i) = r_i(\theta_i)\left(1 - \frac{\alpha}{\eta}\right) - \kappa \tag{A.1}$$

Therefore, the first derivative of the revenue function with respect to productivity would be sufficient to calculate the first derivative of profit function. By substituting firm level price (obtained from eq. 5) and labor demand (eq.8) identities into the revenue equation, the function can be written as follows.

$$r_i = \bar{A}\theta_i^{\frac{1}{\eta-\alpha}} \tag{A.2}$$

$$\bar{A} = \left[\left(\frac{Y}{N}\right)^{\frac{1}{\gamma-1}} P \left(\frac{\alpha}{\eta W}\right)^{\alpha}\right]^{\frac{1}{\eta-\alpha}} \tag{A.3}$$

Where $\bar{A}$ is a function of industry level variables that are assumed to be independent of firms productivity draw. Moreover, $\bar{A}$ can take only positive values, since W, N, P, Y, N and $\alpha > 0$. Therefore, the first derivative of $r_i\left(\theta_i\right)$ can be expressed as follows.

$$\frac{\partial r_i}{\partial \theta_i} = \bar{A}\left(\frac{1}{\eta-\alpha}\right)\theta_i^{\frac{1}{\eta-\alpha}-1} \tag{A.4}$$

Therefore, for any positive and finite value of α, the following derivative proves the positive relationship between profits and productivity for $\gamma > 1$ and $\theta > 0$.

$$\frac{\partial \pi_i}{\partial \theta_i} = \frac{1}{\eta}\bar{A}\theta_i^{\frac{1}{\eta-\alpha}-1} > 0 \tag{A.5}$$

Proof of Proposition 2. When $\kappa = 0$, the elasticity of relative profits to relative productivity is increasing as the substitution elasticity rises. ■

When $\kappa = 0$, the elasticity of relative profits to relative productivity $(e_{\pi,\theta})$ can be given by the below formula where firm j is assumed to be the benchmark firm in the industry.

$$e_{\pi,\theta} = \frac{\partial\left(\pi_i/\pi_j\right)}{\partial\left(\theta_i/\theta_j\right)}\frac{\theta_i/\theta_j}{\pi_i/\pi_j} = \frac{1}{\eta-\alpha} \tag{A.6}$$

Therefore, the first derivative of the elasticity with respect to the elasticity of substitution is positive for $\gamma > 1$ and $\alpha \neq \gamma$.

$$\frac{\partial e_{\pi,\theta}}{\partial \gamma} = \left[\frac{1}{\left(\eta-\alpha\right)\left(\gamma-1\right)}\right]^2 > 0 \tag{A.7}$$

Appendix Table I. Description of Industry Codes

I. Code	Description
DA	Manufacture of food products, beverages and tobacco
DB	Manufacture of textiles and textile products
DC	Manufacture of leather and leather products
DD	Manufacture of wood and wood products
DE	Manufacture of pulp, paper and paper products; publishing and printing
DF	Manufacture of coke, refined petroleum products and nuclear fuel
DG	Manufacture of chemicals, chemical products and man-made fibres
DH	Manufacture of rubber and plastic products
DI	Manufacture of other non-metallic mineral products
DJ	Manufacture of basic metals and fabricated metal products
DK	Manufacture of machinery and equipment n.e.c.
DL	Manufacture of electrical and optical equipment
DM	Manufacture of transport equipment
DN	Manufacturing n.e.c.

Appendix Table II. Basic Statistics on the Variables used in the Production Function Estimation (Price Adjusted)									
	Revenue		Materials		Labor		Capital		#firms
	mean	std.	mean	std.	mean	std.	mean	std.	
DA	11654.0	48148.1	9223.1	34949.7	199974.2	450053.1	12370.8	78241.2	5598
DB	1791.6	6376.0	947.4	4493.0	133760.4	325081.5	2653.3	9931.1	2131
DC	5339.8	18777.1	3342.9	13095.3	138014.3	288659.4	3715.8	12037.8	377
DD	1056.3	6801.4	827.5	6110.1	50883.1	139671.4	1765.3	8884.1	2464
DE	2209.8	17428.1	1334.3	10526.2	45274.5	185642.2	2993.5	33656.7	4814
DF	201789.3	656273.1	350432.0	1252932.8	1230757.6	3532020.3	225433.6	1138618.8	132
DG	15935.3	93104.0	13020.9	75294.4	270367.5	1259210.4	25224.1	162517.4	1026
DH	4460.2	25563.4	3451.2	19535.1	89155.6	421337.9	5514.4	36037.9	1696
DI	3720.2	10864.3	3070.4	9499.4	135421.4	319218.8	5779.6	22997.7	2409
DJ	28785.0	322234.8	30319.1	326123.8	360760.0	3770655.3	24736.1	285845.8	3296
DK	3080.4	9545.2	2097.7	7543.2	119223.6	308423.9	3320.1	13455.1	3838
DL	5416.2	30057.5	3739.3	20709.2	131206.6	502733.4	5636.0	27677.4	2439
DM	14388.3	168774.0	10553.4	138770.9	328232.6	1813556.6	10641.1	75896.5	1914
DN	2786.4	12181.4	2940.0	14016.9	83625.4	213615.5	2696.1	11499.5	2500

Appendix Table III. Production Function Estimations					
Industry	Elasticity $(1/\gamma)$	Labor (β_L)	Materials (β_M)	Capital (β_K)	#obs.
DA	0.11 (0.02)	0.2 (0.01)	0.63 (0.12)	0.13 (0.02)	16872
DB	0.79 (0.04)	0.48 (0.01)	0.48 (0.09)	0.22 (0.03)	6148
DC	0.47 (0.06)	0.46 (0.03)	0.40 (0.13)	0.15 (0.08)	1056
DD	0.39 (0.05)	0.33 (0.01)	0.74 0.09)	0.11 (0.03)	6621
DE	0.46 (0.02)	0.33 (0.01)	0.39 (0.09)	0.22 (0.06)	14951
DF	0.68 (0.23)	0.10 (0.04)	0.58 (0.22)	0.36 (0.18)	338
DG	0.10 (0.05)	0.21 (0.02)	0.11 (0.20)	0.11 (0.09)	3149
DH	0.38 (0.05)	0.23 (0.01)	0.86 (0.06)	0.11 (0.03)	4876
DI	0.11 (0.03)	0.26 (0.10)	0.64 (0.10)	0.09 (0.02)	7036
DJ	-0.12 (0.05)	0.26 (0.01)	0.18 (0.02)	0.53 (0.14)	8796
DK	0.43 (0.04)	0.34 (0.01)	0.51 (0.06)	0.10 (0.03)	10852
DL	0.26 (0.03)	0.31 (0.01)	0.59 (0.03)	0.08 (0.02)	6844
DM	0.39 (0.04)	0.37 (0.02)	0.47 (0.07)	0.13 (0.03)	5504
DN	0.86 (0.03)	0.32 (0.01)	0.19 (0.10)	0.36 (0.05)	6822

Standard errors are in parenthesis.

Appendix Table IV. Basic Statisitcs on Time Variant Competition Measures

	Mean	*Std.*	*Max.*	*Min.*
PCM	0.73	0.09	0.86	0.49
TPE	0.88	1.23	3.75	-1.4
EPE	0.63	1.45	4.50	-5.96
Av. TFP	0.24	0.63	2.88	1.e-16
Av. LP	0.09	0.11	0.49	0.01

User Cost of Capital

The purchase price of a capital input is a component of not only the current period cost but also future periods' until the capital good is scrapped or sold.

Therefore, in order to retrieve firm level profits, one needs a variable that reflects per-period price of capital that we call the ex-post user cost (u_t^{ex}). The user cost can be given by the following identity.

$$u_t^{ex} = P_t \left(1 + r_t\right) - P_{t+1}^u \tag{A.8}$$

Therefore, P_t is the purchase price of new capital in the beginning of period t where P_{t+1}^u is the price of used capital good at the end of period t. r_t represents the opportunity cost of financial capital in the beginning of period t.

Assuming a constant depreciation rate (δ) for the industry, the ratio of the end-period prices of new to used capital goods satisfies the following identity.

$$(1 - \delta) = P_{t+1}^u / P_{t+1} \tag{A.9}$$

We further define the below identity for the inflation rate of the prices of capital goods $\left(\pi_t^K\right)$.

$$\left(1 + \pi_t^K\right) = P_{t+1} / P_t \tag{A.10}$$

Then, we can rewrite the ex-post user cost equation as follows.

$$u_t^{ex} = \left[r_t - \pi_t^K - \delta\left(1 + \pi_t^K\right)\right] P_t \tag{A.11}$$

For the opportunity cost of capital, r_t, we use the interbank prime rate that is the weighted average of all instruments. π_t^K and P_t are calculated by the weighted average of the producers' price indices of the industries with a two digit SIC code between 23-35 that are listed in Appendix Table V.

Appendix Table V. Industries Used in the Construction of Capital Prices
Manufacture of coke, refined petroleum products and nuclear fuel
Manufacture of chemicals and chemical products
Manufacture of rubber and plastic products
Manufacture of other non-metallic mineral products
Manufacture of basic metals
Manufacture of fabricated metal products, except machinery and equipment
Manufacture of machinery and equipment n.e.c.
Manufacture of office machinery and computers
Manufacture of electrical machinery and apparatus n.e.c.
Manufacture of radio, television and communication equipment and apparatus
Manufacture of medical, precision and optical instruments, watches and clocks
Manufacture of motor vehicles, trailers and semi-trailers
Manufacture of other transport equipment

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