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The development of the market structure of heterogeneous firms

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Abstract: The article focuses on oligopolistic market which development is modeled with a simulation of firms operating in them. In our model, we take into account findings in theoretical and empirical research of the new trade theory, specifically – the heterogeneity of firms in terms of their productivity and product quality. In the model, firms are allowed to evaluate over the years taking yearly decisions regarding investment into the improvement of product quality and productivity. As a result of this modelling, the authors suggest that in the conditions of imperfect Bertrand competition, firms are not only affected by other firms and market structures in the market, but the firms themselves can act to their advantage changing the competitive environment and subsequently – market structure. Also, the model shows that firms with higher productivity and lower marginal costs do not pass on all the benefits of such savings to their buyers - they apply higher margins and earn higher profits. However, firms that end up winning over the market in the simulation model, lose incentives for further investment, especially in marginal cost-cutting innovations.

Keywords: simulation, competition, market structure, model, demand curve.

1. INTRODUCTION

This paper contributes to the scientific debate on the development of oligopolistic markets. Several theoretical and empirical studies carried out over the past few decades have shown that companies can vary according to different parameters. These differences have a significant impact on the ability of undertakings to compete, influence the structure of the market, and plan and carry out investment and innovation activities. In other words, in addition to the heterogeneity of enterprises, emphasis is placed on the importance of technological progress (Uddin, 2021).

Our work uses industry organisations and new trade theories that imitate the structure of the market and its evolution. On the initial simulated attributes and properties model, we chose Melitz and Ottaviano (2008) with the Ottaviano demand function. But we have chosen a different approach to demand and its elasticity in the market, distribution functions for modelling market demand and demand for products of the company.

Because of the evolution of the market structure, the model has a crucial role in companies' ability to compete. In this case, the results of our study are consistent with the Meramveliotakis and Manioudis (2021) study small businesses are not the backbone of the economy.

What is more important is that it affects the formation of the market structure.

As regards innovation policy, this could not only mean the need for business support to their chances but keep her struggling through competition rather than collecting Ricardian income.

The paper structure is as follows. In section 2, the relevant scientific literature is examined. In section 3, the market supply and demand model proposed by the authors is presented in detail, which gives an insight into the evolution of the market structure and the companies. Finally, this article presents some conclusions of modelling.

2. LITERATURE REVIEW

The models of the new trade theory, which first examined homogeneously (Krugman, 1979, 1980, 1981, 1991, 1995), and then heterogeneous (in terms of productivity) enterprises (Melitz, 2003), are among the most realistic. Therefore, it is no coincidence that over the last few decades it has attracted a large group of researchers in both economic theory and empirical research.

At the theoretical level, Helpman et al. (2003) proposed and justified the idea that companies make decisions to export or engage in foreign direct investments (FDI) activities depending on their level of productivity: the more productive a company can be, the more expensive an activity it can engage in. At the same time, the more productive the company, the higher its market share. Baldwin et al. (2009) in their theoretical model have shown that the most productive companies can export their products to the furthest destinations, which can provide companies with greater access to foreign markets. However, if consumers are concerned about the quality of goods, the most competitive product will have the highest prices (Baldwin et al., 2011). Meanwhile, if companies produce a large number of products, this usually

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means that the production of one or more of them is of high productivity, which allows financing for the production of other products (Mayer et al., 2011). In other words, there is a need to examine the differentiation of goods between enterprises in theoretical models, together with the productivity of enterprises (Hallak et al., 2008; Kugler et al., 2008; Johnson, 2012). The importance of the size of the country's economy for competition between enterprises is also interesting: larger countries have a greater variety of goods; more companies with lower margins are active in the market (Melitz et al., 2008).

Heterogeneity of enterprises in terms of productivity, level of available capital and skills, size of the company, quality of products, etc. evidenced by extensive empirical research (Redding, 2010). Most companies are small, with a small share in the domestic market or industry, while only a small proportion are so productive that they can engage in more expensive export or even more expensive FDI activities (Melitz, 2008; Bernard et al., 2006). While the most productive companies seem to have the lowest prices and margins, empirical studies show the opposite. Here Schott (2004), Gervais (2013) and Duvaleix-Tréguer et al. (2015) revealed that more productive companies produce products that are more attractive to consumers. The level of margin applied by such undertakings is therefore a function not only of their productivity but also of quality (value-added). It is no coincidence that the quality of companies' products depends on the investments made by the companies, the research and development (R&D) activity expenditure on the innovations used and the costs of acquiring quality certificates. For example, Indian exporters have higher margins than companies selling their products on the domestic market.

However, it should be noted that both in the specificity of theoretical models and in the construction of empirical research, despite the disclosure of stylized facts, models still lack conformity with reality. This applies in particular to the parts of the demand for goods and differentiation.

3. THEORETICAL MODEL OF SIMULATION

The authors create a theoretical model of simulation using the quadratic utility function, which in 2008 was suggested by Melitz and Ottaviano, and presents the utility functions (Melitz et al., 2008):

$$U_i = q_0 \int_{j\in\Omega} \alpha_j q_j di - \frac{1}{2} \int_{j\in\Omega} \gamma_j \, {q_j}^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega} q(i)di\right)^2 \quad (1)$$

herein q_0, q_j shows demand for the concrete product: homogeneous product or differentiated products *i* accordingly. In the equation, α_j and γ_j coefficients are positive numbers. Coefficient α is used to denote substitutability for any differentiated product within the homogeneous products group: if this α coefficient increases, demand for the product, which is differentiated rises as well compared with homogeneous products. Coefficient α identifies the number of users that tend to interchange units from a homogeneous product to a differentiated product. Coefficient γ_j is used to denote vertically differentiated products. The demand curve has a slope which increases by γ_j. Factor α_j for each differentiated product is described as follows:

$$\alpha_j = -d(-c\alpha_0 - \gamma_j) \quad (2)$$

herein *c* - negative slope factor of demand, *d* - parameter that defines the slope of the influenced demand curve. When the slope of the demand curve $\gamma_j \to 0$, $\alpha_j = \alpha_0$.

Coefficient γ_j indicates not only the slope of the demand curve but revises the dispersion of customers' preferences: the higher value of the slope factor corresponding demand curve, the higher the variation around the average: $(\alpha_j\text{-}\gamma_j)\text{-}\gamma_j \gamma^E$ (where: γ^E is constant of Eulerio-Macheroni).

Coefficient η from equation (1) represents the extent to which market demand lies with homogeneous products (which corresponds to any alternatives): the marginal benefit is limited for differentiated products, i.e., customers can choose or not the differentiated products according to their preferences. Then the model focuses on differentiated products only, which we treat as $\eta \to 0$.

Later on, the utility function is differentiated by using the Lagrange method with budget constraints:

$$q_0 + \int_{j\in\Omega} q_j p_j dj \; = E \quad (3)$$

$$L = q_0 + \alpha_j \int_{j\in\Omega} q_j dj - \frac{1}{2}\int_{j\in\Omega} \gamma_j q_j^2 dj - \frac{1}{2}\,\eta \left(\int_{j\in\Omega} q_j dj\right)^2 - \lambda \left(q_0 + \int_{j\in\Omega} q_j q_j dj - E\right) \quad (4)$$

$$\frac{dL}{dq_j} = \boldsymbol{\alpha_j - \gamma_j q_j - \eta \int_{j\in\Omega} q_j dj - \lambda \, p_j} \quad (5)$$

herein *E* – the income of the consumer. And $\frac{dL}{dq_j} = 0$ (which is optimising the choice of the consumer), λ=1; $Q^c = \int_{j\in\Omega} q_j dj$ (when Q^c - total consumption of alternative homogeneous products), where demand functions for reverse differentiated products p_j are:

$$p_j = \alpha_j - \gamma_j \, q_j \quad (6)$$

$$p_{max} = \alpha_j \quad (7)$$

$$p_j = \frac{1}{2}(\alpha_j - c_j) \quad (8)$$

Demand for differentiated products (ε_j) and crossover ($\varepsilon_{kr,j}$) elasticity is defined as follows:

$$\varepsilon_j = \left(\frac{p_{max}}{p_j} - 1\right)^{-1} \quad (9)$$

$$\varepsilon_j = \frac{p_j \gamma_j}{\alpha_j - p_j} \frac{1}{\gamma_j} \quad (10)$$

$$\varepsilon_{kr,j} = \frac{p_j \gamma_j}{\alpha_j - p_j} \frac{1}{\gamma_{kr}} \quad (11)$$

Customers (S_{cu}) are calculated using the equation:

$$S_{cu} = \int_{j=1}^{J} \int_{0}^{q_j} L((\alpha_j - \gamma_j\, q_j)dq - \, p_j q_j) = \int_{j=1}^{J} \int_{0}^{q_j} L((\alpha_j - \gamma_j\, q_j)dq - \frac{\alpha_j - c_j}{2} q_j) \quad (12)$$

The single factor of production is the supply of on-demand work in a competitive market without restrictions.

By having such limitations, the production of a single homogeneous product requests one labour unit, where the value of acquisition latter is equal to the value of a homogeneous product. Production of both homogeneous and differentiated products has a return on the scale and constant marginal costs. The marginal costs for differentiated products c_j represent consumed labour units.

In the model suggested by Melitz and Ottaviano, companies have fixed costs f_E to enter the market i.e. they start from technology and production organisation. Companies identify the level of marginal costs c_j to start production, as a random number. The distribution $G(c_j)$ of the enterprise's marginal costs is the Pareto distribution function described as $c_j \in [0, c_M]$. These marginal costs cover fixed costs of entry f_E. The undertakings with marginal costs up to the cut-off point of threshold, as specified in the Melitz (2003) model, remain on market. If companies are sufficiently productive their marginal costs are equal to the threshold of c_D.

Melitz's (2003) model uses labour in production, which is a linear function:

$$l = f + \frac{q}{\varphi} \quad (13)$$

herein l - total labour consumption, f - fixed costs, φ – productivity expressed as marginal costs necessary to produce a single differentiated product $1/c_j$.

Price for maximising enterprise's profits $p_j(c_j)$ and quantity of produced products $q_j(c_j)$ meet such following conditions:

$$q_j(c_j) = \frac{L}{2\gamma_j}(p_j(c_j) - c_j) \quad (14)$$

The price $p_j(c_j)$ for maximising profit may exceed p_{max} as mentioned in the Melitz and Ottaviano model and is equal to α_j. This price corresponds to c_D. It is a marginal cost for ensuring that the company would survive in the industry sector. This means that the enterprise does not have zero profit as its price equals the marginal cost of competition in the market when the profits of sector entities are approaching zero.

Thus, important to mention that indicators describing the activity of the enterprise are defined in the model as α_j and c_j. Features:

$$p_j(c_j) = \frac{1}{2}(\alpha_j + c_j) \quad (15)$$

$$\mu(c_j) = \frac{1}{2}(\alpha_j - c_j) \quad (16)$$

$$q(c_j) = \frac{L}{2\gamma_j}(\alpha_j - c_j) \quad (17)$$

$$r(c_j) = \frac{L}{4\gamma_j}(\alpha_j{}^2 - c_j{}^2) \quad (18)$$

$$\pi(c_j) = \frac{L}{4\gamma_j}(\alpha_j - c_j)^2 \quad (19)$$

where $\mu(c_j)$ - enterprise's margin, $r(c_j)$ - enterprise's income, $\pi(c_j)$ - enterprise's profits.

The excess of enterprises consists of the total income of enterprises:

$$S_{pro} = \int_{j=1}^{J} \frac{L(\alpha_j{}^2 - c_j{}^2)^2}{4\gamma_j} \quad (20)$$

This shows that enterprises with lower marginal costs ask for lower prices but get higher revenues and profits than enterprises with higher marginal costs. In such a case, more productive enterprises apply higher margins and their customers benefit from the reduced marginal costs. The extent of such patterns largely depends on the coefficient γ_j of the product demand curve. The higher the slope γ_j of the demand function, the lower the market share and profits enterprises get.

By entering the market, the enterprise looks forward to getting a profit which is equal to the difference between the average margin in the market and fix entry costs. In case, the expected profit is negative, the enterprise would postpone entering the market. This equilibrium condition can be expressed from the enterprise's profit equation:

$$\int_0^{c_D} \pi(c_j) dG(c_j) = \int_0^{c_D} \frac{1}{4\gamma_j}(\alpha_j - c_j)^2 dG(c_j) = f_E \quad (21)$$

If the market is in balance as specified in Bertrand – Nash market for differentiated products: prices for products will not differ from exact marginal costs, but each of the products will get a different market share which depends on the slope of the demand function.

4. SIMULATION RESULTS

Secondary market data were simulated: customer preferences, their distribution by commodity, their prices, and budgetary constraints. The market of 17 goods (and the same number of enterprises) is analyzed, in which the estimates of demand and supply parameters of goods are selected at random.

Initially, the market is simulated, and the results of the simulation are presented in Figures 1-2.

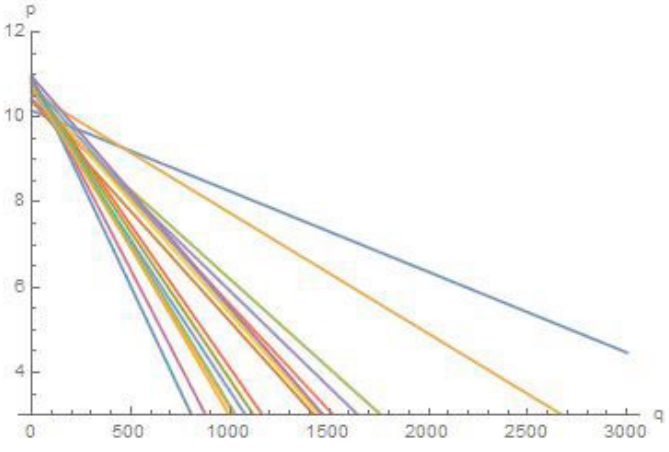

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Figure 1 Shredded demand for an imperfect market

The results of the simulation show that enterprises with higher productivity and lower marginal costs do not reach all benefits of economies by applying higher margins to customers and making higher profits. This allows some of them to get profit in case of a higher slope of the demand function. Following higher marginal costs, enterprises could compensate and generate profits thanks to higher value-added to products and a lower slope of the demand function.

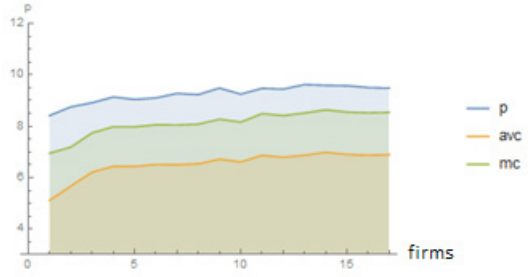

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Figure 2 Imperfect market commodity prices, marginal costs and average costs (avc) for companies

Further experimentation shows the competition in the following nearest period (i.e., the upcoming year). First, listed companies could re-invest the part of their profits, while other ones allocate profits for covering fixed costs. Most productive companies allocate profits to the creation of added value of products and demand accumulation. This could lead to the growth of several monopolists taking about 60% of the market share by the end of the next period (i.e. the second year) (Figures 3 and 4).

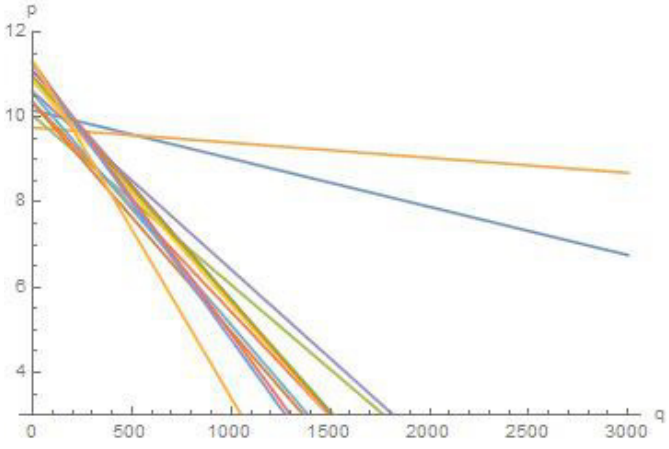

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Figure 3 Shredded demand for the imperfect market (2 years)

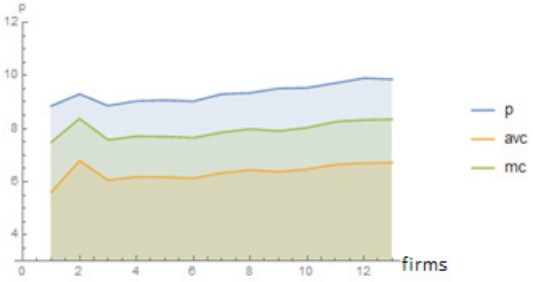

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Figure 4 Imperfect market commodity prices, marginal costs and average costs (avc), 2 years for companies

It is noted that the sixth enterprise is characterised as one with lower marginal costs, is limited by a higher slope of the demand function, and has a small percentage of customers willing to purchase its product (Burinskas et al., 2021). This means, that the particular enterprise can not generate higher profits, even by offering lower prices.

The first enterprises took the lead, and other enterprises, are not able to invest in their productivity or the accumulation of demand on time, and later they face an increase in investment barriers, i.e. the significant increase in their investments payback period. The incentives for the market leaders to invest are diminishing because the pressure on prices is no longer available. Such happens due to the increasing slope of the demand curve. This outcome is possible when the assumption is used not to take each other's actions into account in market competition (for example, a price war).

In the second year, the increase in market concentration is evident as the HHI index rises from 0.085 to 0.223. It should be noted here that this year market concentration rises to 0.25. It is clear that in terms of market shares the market power of the largest oligopolists is equivalent to the one that represents all other competitors. Lerner index used to determine the market power of enterprises does not sufficiently reflect differences in the market, which are significantly higher.

The application of industrial policy measures using the same step/year approach has also been assessed by experimental simulations of imperfect competition in the analyzed market.

In particular, several options for horizontal industrial policy measures were assessed: the division of financial resources equally among all enterprises and in proportion to the size of the enterprises. The results of these measures were practically no different from those presented in Figures 3 to 4 (although in the first case the differences in the market shares of the companies were smaller). Companies either lower prices or make higher profits.

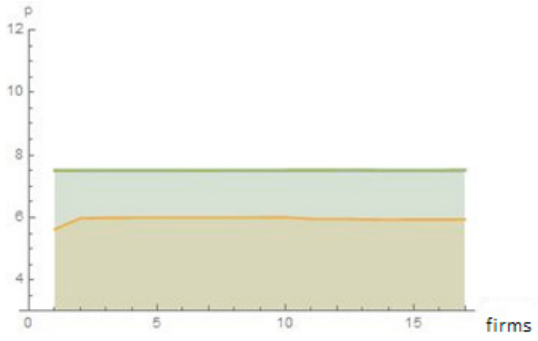

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Figure 5 Impact of the demand-side measure on an imperfect market for companies

Financial support for large enterprises continued: the larger the companies provided, the more stable and less dynamic the oligopolistic market structure was for R&D investment and innovation activities. Such measures are prohibited by competition policy.

Small and medium-sized enterprises' measures to buy and protect goods from large multinationals (soft intervention) and public procurement in a stable demand environment (The USA soft industrial policy) have similar results (see Figure 5).

This measure seems to be capable of effectively stimulating R&D and innovative activities: low-priced pricing allows the selection of the most efficient companies, and ensuring demand encourages increased production by increasing productivity. The model of industrial policy means that the most efficient company produces the most.

This industrial policy framework looks like it can work well when applied gradually, i.e. not immediately by reducing the radical price, but gradually. However, such a model requires protectionist measures against small and medium-sized enterprises, provided that guaranteed demand is ensured.

In experimental simulations, enterprises operate in an imperfect competition market and lose incentives to invest over time, in particular in marginal cost-reducing innovations. Two extremisms could be distinguished from the experimental simulation: (1) enterprises with high value for products and low slope of demand curve have to introduce competitive prices, i.e. the importance of productivity decreases. (2) The demand for products, the importance of enterprise heterogeneity in terms of productivity for the market share and the power of enterprises increase significantly. By the way, all other combinations of the market's structure are considered as intermediate states in the market between these two extremisms.

To sum up, industrial policy measures promote dynamic efficiency in the market or industry only if competitive pressure is ensured. The structure of the oligopolistic market may constitute an obstacle to greater dynamic efficiency in the revised market.

5. CONCLUSIONS

Many models of the new trade theory are inevitably confronted with the changing structure of the market and the resulting competitive processes between companies.

Industry organization and new business theories provide many incentives for the development of market structure, including investments, competition and innovation activities. Although the discussions are still ongoing, there is a need for the theoretical and methodological information.

Without detailed theoretical revision, there are difficulties for researchers to correctly identify econometric models of structural market equilibrium that describe the imperfect competition cases between companies. Therefore, the data modelling technique is most often used. The modelling methodology makes it possible to obtain easily verifiable results. This can be especially important for analysing the proposed theoretical model.

Recent studies have presented that enterprises can be different in various parameters. Our model, which allows the market structure to evolve, allows multiple companies with different donation factors and capabilities to influence demand. On the other hand, however, changes in demand preferences affect the ability to compete with companies to make profits and continue to invest in demand accumulation. Under Bertrand's competitive conditions, companies are not only exposed to other companies and market structures (or industries), but also the companies themselves (at least the largest) can influence the market for their benefit.

The authors presented an interesting study of competition in an oligopolistic market. The scientific novelty of the study is the accounting of heterogeneous firms for competition in the oligopolistic market.

In our model, time is very important for competitors: after changing the balance of preferences, the market leader changes quickly. As a result, other companies operating in the market may lose incentives over time, especially in innovations to reduce marginal costs. Our model clearly shows that the market structure can be an obstacle to greater dynamic efficiency in the long term. The proposed model is extremely promising both in theoretical positions and in the development of applied econometric models.

The paper has limitations. In particular, the market simulation deals only with companies that produce and sell a single product. This is not a completely realistic condition. Secondly, the simulation does not take into account the theory of games in oligopolistic markets. Finally, the model provides that companies make decisions about demanding investments and find the necessary technologies and competences without restrictions. This is not entirely realistic either.

Further research could be developed into directions as follows: the proposed model can be further developed including more products per company; international trade decisions such as export or FDI might be included, and some improvements into preferences equations might be offered too.

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