WARSAW SCHOOL OF ECONOMICSS

COLLEGIUM OF ECONOMIC ANALYSIS

Decision support for the regulator of local oligopolistic markets with participants of bounded rationality

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1 Introduction

The oligopolistic market is characterized by a small number of dominating firms, called oligopolists, see Varian (1993), Mas-Colell, et al. (1995), Vives (2001). The ubiquitousness of this market structure results from high entry barriers, see Bain (1956), present in many industries. Unlike perfect competition, where firms are price-takers, oligopolists can usually set – profitably – a price above marginal cost, see Tirole (1988). It results from – as in monopoly – the downward slopping demand curve faced by companies, see Varian (1997). Moreover, the oligopolistic market structure facilitates explicit or tacit price collusion, which may result in even higher prices – even up to the monopoly level, see Chamberlin (1929), Hall and Hitch (1939), Sweezy (1939). Consequently, higher prices result in lowering the consumer surplus, allocation inefficiency and the associated social loss, as well as production inefficiency, see Cabral (2017).

Due to the above threats to consumers' interests and market competitiveness, in oligopolistic markets, regulators[1] are often designated - and play a crucial role - to protect consumer interests and competitiveness through, inter alia, combating practices consisting in the abuse of a dominant position and restricting competition, strengthening the position of the consumer, policy-making evaluation, concentration control and monitoring of state aid, see Dz.U. 2007 Nr 50 poz. 331 (2007), Dz.U. 2014 Nr 214 poz. 827 (2014), Dz.U. 2014 Nr poz. 945 (2014), UOKiK (2015). Regulators create regulations that help maintain a balance between the interests of consumers and companies. To assess these regulations, economic analysis tools are used, see Viscusi, et al. (2018), including models, e.g., analytical, numerical or simulation, see Law, et al. (2007), Kamiński (2012). They allow experiments with the system model and the effect evaluation of regulatory solutions. This way of experimenting is sometimes the only acceptable way in economic practice due to the high social costs of conducting actual experiments on the real economic system. Hence the need for a regulator

[1] In the dissertation, a broad definition of a regulator was adopted, encompassing all institutions shaping the rules of a given market. In this sense, the role of the regulator in Poland is played by, inter alia, antimonopoly agency – the Office of Competition and Consumer Protection (UOKIK), industry regulators, e.g., the Office of Electronic Communications (UKE), the Energy Regulatory Office (URE), legislative bodies, e.g., Seym, Senate, government.

to use economic models, and their precision in mapping the actual decision-making mechanisms of companies and consumers will determine the quality of regulatory solutions recommended based on these tools.

Classic models of oligopolistic competition assume perfect rationality of all market participants, i.e., consumers and companies, see Cournot (1838), Bertrand (1883), Hotelling (1929). At the same time, the bounded rationality of economic agents is an empirical phenomenon documented by numerous studies, see Kahneman and Tversky (1979, 1981, 1986), Kahneman, et al. (1991), Rubinstein (1998), Gigerenzer and Selten (2002), Camerer and Loewenstein (2003), Thaler and Sunstein (2003), Camerer, et al. (2011). In particular, the bounded rationality of consumers makes them more exploitable to oligopolists' strategies, see Ellison (2006), Armstrong (2008), Spiegler (2011). Economic models assuming the perfect rationality of participants are prone to the risk that their predictions of the behaviour of economic agents, i.e., companies and consumers, may too much - in relation to models considering bounded rationality - differ from the modelled reality. As a result, such models will not constitute a reliable tool for monitoring and intervention evaluation conducted by market regulators.

The aim of the dissertation is to develop methods of modelling markets with participants of bounded rationality, which will allow the regulator to better understand the behaviour of both consumers and companies as well as support its decision-making process. The dissertation examines the following three traits of the limited rationality of the participants of the oligopolistic market: (1) consumer switching cost, (2) consumer limited price sensitivity and (3) time inconsistency of companies.

The first characteristic of bounded rationality examined in the dissertation is the consumer switching cost, understood as the reluctance to change their current supplier of services or products from the previous period. The strength of this reluctance is measured in the dissertation by the switching cost parameter, see Farrell and Klemperer (2007), Klemperer (1987A, 1987B, 1987C, 1988). Depending on the sources of the switching cost, its occurrence can be considered as rational or of bounded rationality. For example, if the reluctance to

change comes from the bias of the decision-maker or a subjectively motivated desire to keep the status quo, then such a behaviour is an example of the consumer's bounded rationality.

The second symptom of the limited rationality of consumers examined in the dissertation is a limited consumer price consciousness, which results in suboptimal consumer decisions. The standard method used in the literature of incorporating limited price sensitivity into the economic model is add the random noise to actual prices, see Perloff and Salop (1985), Gabaix and Laibson (2004), Kamiński and Łatek (2016). Additionally, the strength of the consumer price consciousness will be measured in the dissertation by the price consciousness parameter δ.

The third source of bounded rationality - examined in the dissertation - is the time inconsistency of companies, called myopic. A comparison of myopic companies with those of a long, i.e., infinite, planning horizon, will allow the assessment of this trait on the market price equilibrium, see Hausman (1979), Thaler (1981), Loewenstein and Prelec (1992), Frederick, et al. (2002), Czakon (2020).

Each of the three above traits of bounded rationality, i.e., consumer switching cost, consumer limited price consciousness and myopic companies, was separately the subject of numerous theoretical and empirical research studies in which the impact of each of these factors on the decisions of market participants was documented. This is confirmed by the extensive literature review presented in the dissertation. At the same time - based on the literature review - a research gap was identified consisting in the lack of studies that would comprehensively address the subject of all three discussed traits of bounded rationality and examine the interdependencies between the influence of factors on the decisions of companies and consumers. This dissertation is an attempt to fulfil this research gap.

Despite globalization and internationalization of the world economy, competition for end customers often takes place in smaller regional markets - referred to in the dissertation as local markets, see Heggestad and Rhoades (1978), Rossi-Hansberg, et al. (2021). Firms typically compete in more than one local market. Research on multicontact competition shows that such market structures facilitate tacit price collusion, see Bernheim and Whinston (1990). It is a consequence of the so-called the mutual forbearance hypothesis,

see Edwards (1955). According to this hypothesis, companies do not engage in intense competition for clients in individual local markets, fearing retaliation by their competitors in other local markets. Such behaviour of companies does not have to be the result of an explicit collusion and may result from the optimal reactions of companies to price movements of their competitors, see Evans and Kessides (1994). It, in turn, makes monitoring competition and preventing monopoly practices in local markets by antitrust agencies particularly challenging, see Edwards (1955), Heggestad and Rhoades (1978), Parker and Röller (1997).

Due to the risk of limited competition on local markets, they require special attention from antitrust agencies. For example, the Office of Competition and Consumer Protection (UOKIK) – which is the Polish antitrust agency – declares that "special attention will be paid to local markets where the largest number of entrepreneurs with a monopoly operates. More emphasis will be placed on detecting and eliminating exploitation practices" in these markets, see UOKiK (2015). On the other hand, the Office of Electronic Communications (UKE) – the industry regulator of telecommunications markets in Poland – applies the following strategic directions: (1) "market analysis using a local approach" and (2) "implementation of analytics considering local competition", see UKE (2017).

In the dissertation, the basic model of oligopolistic price competition with clients of bounded rationality is extended to include local markets. It is used to assess the ability to predict the behaviour of companies by commonly used market concentration measures such as, for example, the Herfindahl-Hirschman index, see Tirole (1988), Peppal, et al. (2014), Cabral (2017). Moreover, the extended model makes it possible to evaluate the regulation prohibiting regional price discrimination, see Dz.U. 2007 Nr 50 poz. 331 (2007).

2 The purpose of the dissertation and research hypotheses

The purpose of the dissertation is to develop methods of modelling local oligopolistic markets and supporting regulatory decisions made by antitrust agencies in these markets. A special feature of oligopolistic markets, which is studied and modelled in the dissertation, is the bounded rationality of the participants, i.e., consumers and companies, of these

markets. Among the many traits of bounded rationality of decision-makers, three were selected, which are considered ubiquitous and important. The selected traits of bounded rationality are: (1) consumer switching cost, (2) consumer limited price consciousness, and (3) myopic companies. The dissertation discusses in detail and presents a detailed justification for the choice of these three traits.

Achieving the goal set out in the dissertation requires testing following hypothesises:

1. **About the need to consider bounded rationality in models of strategic interactions between players** – there is a need to consider the phenomenon of bounded rationality in models of strategic interactions between players due to ontological premises and the resulting disturbance of decision-making processes. Verification of the second premise is possible on theoretical, simulation and experimental grounds.
2. **On the interdependencies of the traits of the bounded rationality of oligopolistic market participants** – the direction and shape of switching cost on equilibrium price is dependent on the remaining traits of bounded rationality examined in the dissertation, i.e.: limited consumer price consciousness and the length of the planning horizon of companies.
3. **On the possibility of accurate prediction of the price level on regulated local markets** – equilibrium prices set by companies operating simultaneously on many oligopolistic markets with regulations prohibiting regional price discrimination will depend on the structure of these markets and the role of companies on these markets. Prices can be effectively predicted by aggregating the Herfindahl-Hirschman indices.
4. **On the effects of the regulation prohibiting regional price discrimination** – both the regulation prohibiting regional price differentiation and the lack of this regulation are Pareto optimal solutions, i.e., not dominated. It means that some consumers experience a surplus at the expense of other consumers. Regulation results in lower prices in monopolized local markets and higher in highly competitive markets.

5. **About the possibility of evaluating the local markets structure in terms of market competitiveness** - the structure of local markets and their competitiveness can be assessed by means of a ranking with the use of multi-criteria optimization methods. Assessment can be used to monitor competitiveness by the regulator, as well as to identify its determinants and try to influence them.

The interconnection of research theses and elements of the dissertation problem is presented in Figure 1. The diagram presents three market participants of the decision problem being undertaken, i.e., companies, consumers, and the regulator.

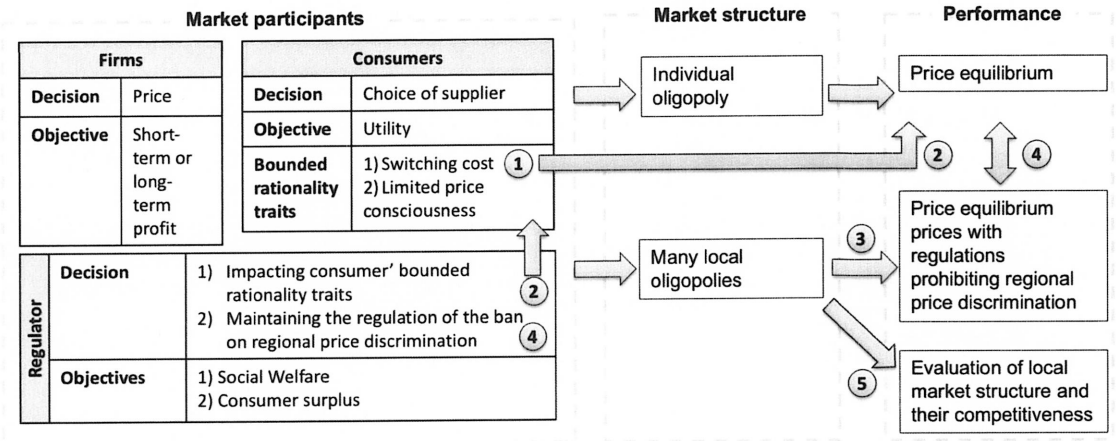

Figure 1 Diagram of the dependence of research theses marked with numbers from 1 to 5.

Source: own study

Based on the literature review of the industrial organization, behavioral and experimental economics, as well as operational research, the need to take into account the traits of bounded rationality of participants in oligopolistic markets, i.e., consumer switching cost and consumer price consciousness and myopic firms, was justified in modelling these markets (thesis 1). The dissertation distinguishes two types of oligopolistic market structures: (1) individual oligopolistic market and (2) many local oligopolistic markets. The identification of price equilibria in an individual oligopolistic market will allow to determine the impact of the characteristics of bounded rationality on price level (thesis 2). Knowledge of the structures

of local markets and their concentration measures will allow for effective prediction of equilibrium prices in these markets (thesis 3). The comparison of equilibrium prices between the individual market and local markets will allow for the effects' evaluation of the regulation prohibiting regional price discrimination (thesis 4). The empirical part of the dissertation shows the possibility of assessing the competitiveness of local markets and identification its determinants (thesis 5).

3 Results

The main result of the dissertation is the development of modelling methods for local oligopolistic markets with participants of bounded rationality. The proposed tools can be used to support regulatory decisions made by antitrust agencies in these markets. Moreover, during the dissertation, all five research hypotheses were positively verified.

The first hypothesis about the need to consider bounded rationality in strategic interaction models based on the conducted literature review was confirmed. As part of the literature review, two studies by the author of the thesis on the significance of switching cost, see Zawisza and Kamiński (2011), Zawisza (2013), were also cited.

The second research hypothesis about the interdependence of the characteristics of the bounded rationality of the participants in the oligopolistic market has also been positively verified. According to this hypothesis, the direction and shape of the impact of the consumer switching cost – SC – is conditioned by the features of oligopolistic market participants with bounded rationality, such as: (1) limited price consciousness – δ, (2) the length of the companies' planning horizon: short or long, or (3) market renewal rate - r - denoting the percentage of existing consumers replaced from period to period with new clients not burdened by the switching cost, see Zawisza, et al. (2011), Zawisza and Kamiński (2013A, 2013B).

The impact of the three discussed factors on the price equilibrium is presented in Table 1. According to it, the direction of the impact of switching cost and the price sensitivity of consumers on the price level is determined by the companies' planning horizon. Both factors negatively affect the price in the long-term planning horizon of companies. Their impact can

be reversed and positive in the case of companies with a short planning horizon. For these companies, the effect of the market renewal rate on the price was determined to be negative provided that the switching cost is positive. In the absence of switching cost, i.e., $SC = 0$, the difference between new and existing customers disappears, and, consequently, the factor of the market renewal rate - r is no longer relevant.

Direction of price impact: negative (-) or positive (+)	**Planning horizon**	
Czynnik wpływu na cenę	**Long**	**Short**
Switching cost (SC)	−	+
Price consciousness (δ)	−	−/+
Marekt renewal rate (r)	N.A.	− for positive switching cost
Prioritization of recommendations for the regulator aimed at lowering prices for consumers	1) Efforts to increase the customer price consciousness. 2) In the case of zero or low switching cost, a slight increase in it will lower the price level, but this impact (marginal effect) fades out for higher values of the switching cost.	1) Striving to switching cost especially in markets with: (a) low growth rates and/or (b) high switching costs; 2) Coordinating actions to reduce the switching cost with increasing price consciousness, e.g., by defining price display standards that facilitate the comparison of offers.

Table 1 *Summary of the impact of: consumer switching cost, price consciousness and the rate of market renewal on price equilibrium for companies with long and short planning horizons.*

Source: Own study based on Zawisza, et al. (2011), Zawisza i Kamiński (2013A i 2013B)

The third research hypothesis was also positively verified. It concerns the ability to predict the average price in local markets by means of aggregating local Herfindahl-Hirschman indices. At the same time, it has been shown that the alternative method of calculating this

index - based on market shares aggregated at a higher level - does not have the ability to predict the average price level in local markets, see Zawisza and Kamiński (2012). This means that the use of aggregated market shares at too high a level of granularity, e.g., of the entire country, may not carry significant information about the level of average prices and, as a result, provide erroneous or random recommendations. It was argued in the dissertation that a lower level of aggregation of the Herfindahl-Hirschman index does not deteriorate (and in practice usually improve) its ability to predict price equilibrium. This is because even artificially dividing a homogeneous market into smaller market segments does not change the value of the Herfindahl-Hirschman index, and therefore cannot weaken its predictive power.

The fourth positively verified research hypothesis concerns the possibility of multi-criteria evaluation of regulation prohibiting regional price differentiation. The presented regulatory impact assessment is an exemplary analysis based on the theoretical simulation model. A similar analysis could be performed by a regulator based on a model calibrated to real data. The considered regulation was evaluated through the following economic criteria: average price, average sales volume, level of social inequalities, and price changes in markets with different levels of competitiveness. In the space of the above objectives, none of the regulations Pareto-dominates the other - which was consistent with fourth research hypothesis. This means that the final recommendation depends on the decision-maker's preferences.

The last - fifth - research hypothesis verified in the dissertation concerns the possibility of making multi-criteria evaluation of the competitiveness of local markets and identifying the determinants of this evaluation. For this purpose, a proprietary two-stage analytical procedure was proposed, consisting of: (1) Data Envelopment Analysis (DEA), see Charnes, et al. (1979), and (2) methods of statistical supervised learning, see Hastie, et al. (2009), Kamiński and Zawisza (2012). The proposed procedure was applied to the actual analytical need of the telecommunications regulator, i.e., the Office of Electronic Communications, in terms of measuring and identifying the determinants of the competitiveness of communes in access to broadband Internet. For this purpose, data characterizing communes in 2010

and 2011 were used, obtained in cooperation with the Office of Electronic Communications, see Zawisza, et al. (2013).

4 Concluding remarks

The research hypotheses verified in the dissertation, together with additional results, provide antitrust agencies with specific recommendations, and offer tools that can support their decision-making processes. The main conclusions for the regulator are presented below, as well as potential directions for further research.

As part of the verification of the second research hypothesis, it was shown that the impact on the price level of two factors, i.e., consumer switching cost and limited price consciousness, depends on the planning horizon of companies, i.e., long, or short, see Table 1. This differentiation of the impact of these factors translates into also the differentiation of recommendations for the regulator, which depend on the planning horizon of companies. For companies with a long planning horizon, the regulator is recommended to first make efforts to increase consumer price sensitivity, e.g., by requiring prices to be quoted in a standardized manner that facilitates price comparisons. At the same time, the regulator may refrain from efforts to reduce the switching cost, as they increase the price level. On the other hand, for markets with a short planning horizon, the regulator is recommended to lower the switching cost, for mature markets, with a low rate of market renewal and an already high level of switching cost. Parallel efforts to increase price sensitivity can be beneficial if coordinated with the simultaneous reduction in switching cost.

Another important effect of the verification of the second research hypothesis is the generalization of the undercut-proof equilibrium, see Shy (2002). The need to use a concept other than the pure strategy Nash equilibrium (NE) results from the non-existence of pure strategy NE for a certain subspace of high values of the switching cost and price sensitivity. At the same time, the proposed concept is consistent with the prediction of the NE in the parameter subspace in which it exists. This means that the new concept inherits all the positive properties of the NE, and at the same time can make reliable predictions of the company behaviour in situations where there is no pure strategy NE. The new concept may

constitute an additional tool in the repertoire of the regulator's analytical methods and allow for solving game theory models with consumer switching cost for which there is no classical pure strategy NE.

As part of the verification of the third research hypothesis, it was proved that a better explanatory variable at predicting the average price level is the Herfindahl-Hirschman index, which uses market shares calculated at a lower granularity level, e.g., of an apartment block or a commune, rather than the same index calculated based on market shares from a higher level of aggregation, e.g., by province or country. On this basis, regulators can be recommended to monitor local markets from a data perspective at the lowest possible level of granularity allowed by the cost-effective technology. For example, in the case of fixed-line Internet access services analysed in the dissertation, the granularity level may be a single apartment block. At the same time, it is discouraged to use aggregate market shares, e.g., at the country level, especially if local structures are not homogeneous, which is usually the case in economic practice. The use of such highly market aggregated shares usually present a false and overly optimistic picture of market concentration as measured by the Herfindahl-Hirschman index.

Also, as part of the verification of the third research hypothesis, a positive impact of the percentage of monopolized local markets on the average price level was demonstrated. This means that local monopolies are a source of negative externalities, resulting in higher average prices in all local markets, not only in a given monopolized local market. It has been shown that the lifting of a single local monopoly by the appearance of a second player on it lowers the average price in all local markets to a greater extent than, for example, the appearance of a third, fourth and subsequent players on it. This means that the greatest benefit for the entire market comes from promoting competition in local monopoly markets. On this basis, it is recommended that the policy evaluation performed by the regulator should include the measurement of externalities.

The verification of the fourth research hypothesis confirmed that the prohibition of regional differentiation is beneficial for some consumers, but not for all. As a result of its introduction, it can be expected that consumers from the local monopolized markets will experience lower prices. In turn, consumers in the more competitive local oligopolistic

markets will pay a higher price. This conclusion alone does not provide the regulator with a strong basis for introducing or withdrawing from such regulation. To offer the regulator a more specific recommendation, an additional rather soft assumption was made about its preferences. The assumption is to make 1 currency unit of equal importance over all consumers, irrespective of the local market to which they belong. This means, for example, that 1 currency unit of consumer surplus from a large, high-income city will be as important to the regulator as 1 currency unit of consumer surplus from a small town with lower incomes. This soft assumption allows for a simple aggregation of changes in surpluses of various consumer groups and the evaluation of the total effect of the regulation under consideration. As a result of adopting this assumption, it was shown that the analysed regulation contributes to a reduction in the average price, an increase in the sales volume and reduces social inequalities. This positive effect is achieved even though most consumers lose from the implementation of this regulation. This is because the aggregate loss of consumer surplus for most consumers is less than the corresponding benefit for a minority of consumers. This is an example of socio-economically beneficial regulation that would have little chance of being elected by popular vote, such as a referendum. This is due to the heterogeneous distribution of the effects of this regulation, see Zawisza and Kamiński (2012).

As a result of the verification of the fifth research hypothesis, the analytical procedure proposed in the dissertation was applied to the data obtained from the regulator of the fixed-line Internet access market. The use of this tool made it possible to: (1) create a ranking of communes in terms of the level of competitiveness of the broadband Internet market and (2) identify the determinants of this level. One of the identified positive determinants of Internet market competitiveness is the number of computers with Internet access per student in rural schools. This means that investments of public institutions in equipping rural schools with computers with Internet access contribute to the improvement of the competitiveness of the Internet access market in a given rural commune.

The results presented in the dissertation still leave many open questions, which makes it possible to continue the outlined direction of research. The author of this dissertation sees

at least three potential directions for the continuation of the initiated research, which are presented below. Firstly, due to the qualitatively different results of the impact of switching cost and price sensitivity between companies with two different planning horizons, the impact of these factors for companies with a middle-term planning horizon, e.g., those whose objective function is a discounted sum of profits, remains an interesting research question. Such a study may also include an analysis of the sensitivity of the obtained results due to the discounting factor adopted. Secondly, an important research question is the sensitivity analysis of the obtained results of the Bertrand model with consumer switching cost and limited price consciousness driven by the assumed logistic function, which determines the probability of the consumer choosing a specific supplier. An exemplary modification of the supplier selection probability function may refer to: (1) the adopted functional form or (2) "removing" the switching cost (SC) parameter from the impact of the limited price consciousness parameter (δ). Thirdly, with regard to the results concerning the identified determinants of the competitiveness of broadband Internet markets in municipalities, it would be reasonable to use the methods of causal inference, see Angrist and Pischke (2008), Imbens and Rubin (2015), e.g., Bayesian additive regression trees, see Hill (2011), causal trees, see Athey and Imbens (2016), causal forests, see Wager and Athey (2018), or generalized random forests, see. Athey, et al. (2019), in order to confirm or negate the cause-and-effect impact of initially identified potential determinants of competitiveness of the Internet access market, e.g. the average number of computers with Internet access in rural schools.

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