Econometric Models of Car Market Entry Games

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Abstract. The paper presents empirical models based on game theory for assessing the car market concentration. The analysis of games with simultaneous moves is carried out, the specifications of econometric models of discrete games are developed. Binary probit models with external and internal factors that determine the activity of auto dealers are formalized. Points of break-even demand for monopoly and duopoly are defined. The experimental sample accounted for 81 markets with a population from 5 thousand to 150 thousand people, 55 of which are monopolistic, and 26 consist of two dealers. As a result of the analysis the best model was chosen, the factors influencing the dealers entry into the market were revealed. It was found that the choice of auto dealers is mostly influenced by the number of people in the isolated market and the level of average per capita income. The model with internal factors turned out inadequate, which indicates a low quality of the information provided by companies to accountancy statistics agencies.

Keywords: game theory, car market concentration, binary probit models, decision-making strategy, point of break-even demand, computer modelling

1 Introduction

The entrance to the car market is associated with significant costs. This is due to the presence of entry barriers from competitors and specific features of the commercial environment, which include the concentration of consumers, the volume of the market, infrastructure, etc. That accounts for the need for the tools for assessing the consequences of entering the market of auto dealers. Bresnahan and Reiss [8] thoroughly investigate this problem. However, significant differences between the countries do not allow a direct application of the results obtained. The Russian car market is characterized by extensive development. Growth is due to territorial distribution. There is consolidation of the industry, formats differentiation taking into account various consumer groups. In regions with a relatively high level of well-being and high population density, there is an increase in competition, a decrease in the degree of asymmetry in information [6]. Also, the isolated local markets of the USA and the Russian Federation, which are explored in this work, differ substantially. In the American retail industry across the country Bresnahan and Reiss [8] identified 202 such car markets with

a population of 500-75,000 people (for 20 miles there is no other city with a population of more than 1,000 people). Throughout Russia there are 81 isolated local markets with a population of 5,000-1,500 people (for 20 miles there is no other city with a population of more than 20,000 people). The differences mentioned convincingly prove the topicality of developing analytical tools for assessing the concentration of the domestic car market.

When assessing situations of alternatives, binary choice models, formalizing two decision-making strategies of whether to enter into the market or not, are traditionally used [1]. However, there has recently been a growing interest in the econometrics of games, which has obvious advantages of the game-theoretic concept. The identification of the most preferred strategy among the players enhances the efficiency of the research. At the same time, it is possible to ignore such key economic indicators as price and sales volume. Besides, it is possible to estimate the constant costs from the moment the agent enters the market. Games econometrics allows us to select models as well as to use a situational approach to the research.

In practical application of the game-theoretic concept Bresnahan and Reiss [1] discovered the following features. Monopolists do not interfere with other dealers market entry, the consequence will not cause a significant drop in profits. A second dealer only increases approximately 2-2.5 times the market volume necessary to support one dealer. The entry cannot be realized if the market volume is more than 2 times higher than the break-even point of demand for the monopoly [1].However, models of entering the market differ in different markets. For example, in the works of following authors: Aradillas-Lopez [5], Grieco [12], Bajari et al [7], Aumann [6], Fudenberg and Tirol [10], Harsanyi [13], Heckman [14], Katz and Shapiro [15], Maddala and Lee [16], Milgrom and Roberts [18], Milgrom and Weber [17], Stigler [19]. In the works of Russian authors on game econometrics, only models of binary or multiple choice are analyzed, without going into theoretical-game forms, which significantly lowers the quality of research. Examples include following works: Gladysheva and Ratnikova [11], Zakharova [20], Fedorova et al [9] in which the problems of investment in the food industry of the Russian Federation, the satisfaction of consumers with the quality of services and forecasts of enterprises bankruptcy are investigated.

This study of the activity of auto dealers in domestic markets is based on the methods proposed by Bresnahan and Reiss [8]. In accordance with the proposed methodology, it is necessary to formalize a game with simultaneous moves, develop specifications, evaluate the probit models with external and internal factors, determine the points of break-even demand for a monopoly and a duopoly.

2 Methodology

The economic basis for computer modeling the market entry for an equilibrium number of firms has the following features. In the car market, winnings depend on the number of operating firms. Most consumers buy new cars in local dealerships.

Dealers work independently of the manufacturer, although manufacturers spend significant amounts on the organization and location choices of car dealers. Both manufacturers and dealers argue that the success of the dealership is critically dependent on the number of closest dealers [1].

The empirical basis was made up by the following provisions. Winnings depend on the number of firms on the market. Entering the market is equivalent to the activity of a certain number of firms on the market. The state of equilibrium is described by the ratio of winnings for market participants:

$$\Pi_m(n_m) \geq 0, \quad \Pi_m(n_m + 1) < 0, \tag{1}$$

where Π_m stands for the winnings of m-th firm; n_m is number of firms in market. The winning function is determined by the formula:

$$\Pi_m(n) = V_m(n) - F_m(n) = s_m \nu_m(n) - F_m(n). \tag{2}$$

Taking into account the random components, we have

$$\Pi_m(n) = s_m(x_m^\nu \beta - \alpha(n)) - (x_m^f \gamma + \delta(n) + \varepsilon_m), \tag{3}$$

where V_m is the income of the m-th firm; F_m is expenses of the m-th firm; s_m is the market volume; x_m stands for the characteristics of the market; $\alpha(n)$, $\delta(n)$, ε_m are residues of regression that go up as the number of firms increases. The break-even point, according to formula (1), is calculated by the formula:

$$S(n) = \frac{x_m^f \gamma + \delta(n)}{x_m^\nu \beta - \alpha(n)}. \tag{4}$$

3 Variables and Data

We use the economic and empirical bases for researching the retail car market in Russia. The data for 2010–2015 were used. Since it is not possible to clearly define the boundaries of the market in urban areas, data on dealers in isolated areas were collected. In each constituent entity of the Russian Federation, we defined cities or stand-alone centers of population concentration. They met the following criteria: the absence of another city with a population of more than 20,000 people within a distance of 50 km from the core city; the absence of a large city within 50 km with more than two dealers. The study identified 81 markets or cities with a population from 5 thousand to 150 thousand people. Since the residents of core cities have to overcome more than 50 km to reach the next city, the dealers have a considerable market power. Due to data gaps, the sample size has significantly decreased (from 150 to 81). The study showed that 55 out of the 81 markets have one dealer (i.e., represent monopolies), and 26 have two dealers (represent duopolies). For example, in the Krasnodar Territory, two monopoly markets and four duopoly markets were identified, corresponding to the above conditions.

As an evaluation tool, a sample of indicators characterizing isolated markets was used. These are external indicators that characterize the business environment of companies: the population density of the region, the population density of a certain settlement (the factors affect the revenue side), the distance between the given settlement and another one whose population is more than 20,000 people, per capita income of the population, the share of farmland (factors affect the expenditure side). The resulting indicator of the model is a second dealer's market entry or their absence on the market. The description of the environmental data is presented in Table 1.

Table 1. Unobservable car market factors

Indicators	Description	Reference
sred_dush_doh_nas	per capita income of the population	[1]
nas_raion	the regional population density	[2]
nas_centr	the population density of the given settlement (the dealer location)	[2]
dolya_selhoz_ugod	the share of farmland	[2]
rasstoyanie	the distance between the given settlement and another one with the population of more than 20,000 people (5,000 people for the Magadan Region and the Chukotka Autonomous District)	[4]

4 Experiment

Various specifications of binary probit models with external and internal factors of enterprises were evaluated. The criteria for assessing the adequacy of the models selection were the McFadden coefficient of determination (the higher the value, the better the quality of the model), the information criteria (the lower the value of the criteria, the higher the relative quality of the model) and the value of the logarithm of the maximum likelihood function (the higher the value, the higher the quality of the model). The results of the assessment of the model with internal factors (data for 5 years from the financial statements of companies) proved inadequate. This is due to the low quality of information provided by companies, with numerous missing or erroneous data [3]. The most efficient specifications for models with environmental factors (models (1), (2)) are presented in Table 2.

Based on the research findings, the following conclusions can be made. The best model is (1), since the value of the logarithm of the maximum likelihood function for it is minimal. The marginal effects on the specifications were calculated on the basis of Table 2 and are presented in Table 3. The marginal effect of per capita income of the population turned out to be 0.033, and the marginal effect of the population of the region is 0.054. This means that with an increase

Table 2. Binary probit models evaluation results

Indicators	Specifications	
	(1)	(2)
nas_raion	1.369^{***}	1.376^{***}
sred_dush_doh	0.829^{***}	0.672^{***}
dola_selhoz_ugod		-0.004^{*}
rasstoyanie		-0.002^{**}
intercept	-23.497^{***}	-21.589^{***}
log likelihood	−287.810	−285.080
McFadden R-squared	0.623	0.531

***, ** and * indicate the parameter estimates are significant at the 1%, 5% and 10% levels, respectively

in per capita income of the population by 1%, the probability of a second dealer entering the market, i.e. the probability of a duopoly increases by 3.3%. With an increase in the population by 1%, the probability of a duopoly increases by 5.4%. For model (2), with an average rise of the regional population density by 1%, the probability of a duopoly in the region increases by 5.4%. A growth of average per capita income of the population by 1% leads to an increase in the likelihood of a second dealer entering the market by 2.7%. Marginal effects for the indicators of the distance from the nearest settlement with a population of more than 20,000 people and the share of farmland are insignificant.

Table 3. Marginal effects

Indicators	Marginal effects values according to specifications	
	(1)	(2)
nas_raion	0.054	0.054
rasstoyanie		−0.001
dola_selhoz_ugod		−0.002
sred_dush_doh	0.033	0.027

The level of break-even demand calculated for model (2) is presented in Table 4. The data were obtained from formula (2) from the ratio of costs and incomes for monopolies and duopolies. The demand for a duopoly products is about 2 times higher than the demand for monopoly products. To interpret this value, let us represent it in the form of the ratio of the incomes of a monopoly and a duopoly. This ratio determines the amount by which the company's profit falls when a second dealer enters the market. When duopolists sell the same products, the ratio of incomes is less than or equal to 0.5. This ratio is equal to 0.5, when the duopolists conspire and evenly divide the profits. If the firms

do not agree, the ratio falls below 0.5. Finally, if the products of the companies differ significantly, this value will exceed 0.5. In this case, it can be assumed that most companies collude and the differentiation of products increases the profit of the duopoly, while competition reduces it. The third ratio shows that the costs of a second dealer are almost 2 times higher than the monopoly costs, this is explained by the entry barriers.

Table 4. Break-even demand points and other ratios

Specification	Monopoly break-even demand point	Duopoly break-even demand point	Monopoly and duopoly break-even demand points ratio	Monopoly and duopoly profits ratio	Monopoly and duopoly expenditure ratio
Model (1)	41083	81272	0.505	0.505	0.45

Let's compare the ratio of breakeven points, incomes and expenditure of US firms (according to the data proposed by Bresnahan and Reiss [1]) and Russian firms. The results of the comparison are presented in Table 5. The values of the break-even points of demand and other ratios are generally comparable, the deviations are 10–15%. The indicators identified reflect country differences.

Table 5. Comparison of break-even demand points

	Russian dealers	US dealers
Monopoly and duopoly break-even demand points ratio	0.505	0.397
Monopoly and duopoly profits ratio	0.505	0.651
Monopoly and duopoly expenditure ratio	0.45	0.619

5 Conclusion

Game-theoretic methods let us evaluate the decision-making strategy of choosing car market players only on the basis of external data. On this ground it is possible to analyze break-even points, without taking into account the unobservable economic indicators of companies. These models are only a prelude to entering oligopolistic markets. Many interesting concepts and solutions to enter-market games were not considered here. For example, the dealer's solutions for the sale of certain models or the complexities that arise when more than two dealers go into the market have not been simulated. These topics will become the subject of further research.

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