DEFINITION OF ENTREPRENEURSHIP STRATEGIES IN THE IT INDUSTRY BASED ON GAME THEORY

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ABSTRACT

Tools were developed to automate the modeling and optimization of entrepreneurship distribution processes in the retail computer hardware market. The choice of appropriate software environments for the implementation of the proposed methods for building mathematical models were substantiated, namely: MathCad environment for building a discrete dynamic model and MS Excel environment for building game-theoretic models and implementing optimization procedures. This made it possible to apply modern information technologies to solve relevant modeling problems and to simplify procedures for practical application of models. The developed methods and complex of mathematical models were tested for forecasting the dynamics of distribution of the retail computer hardware market and optimizing the behavior of enterprises present in this market, in particular, those related to the B2B sector.

Keywords: Entrepreneurship Strategy, Information Technologies, Network Economy, Game Theory, Dynamic Model.

JEL Classifications: M5, Q2.

INTRODUCTION

Information technology (IT) is now playing a significant role in the modern world. Without them, no important, well-grounded decisions are made now, whether in business, politics, science or any other area of public life. Undoubtedly, modern computerized IT is the basis of information communication both between individuals and between different groups of people, which are, in particular, connected by the production relations. This impact of IT causes a large-scale change in forms, methods and tools in the economy and other areas.

As a result, the modification of the existing business is occurring, its transformation into other forms, and absolutely new forms of it are emerging. A clear illustration of this is the emergence of such a business as e-commerce or the operation of electronic exchanges.

The information technology industry is now a leading industry in the world economy, which stimulates the economic development of the country and technological progress of society as a whole. An integral part of this industry is the computer hardware market, most of which is the retail market. For the further successful development of the entire IT industry and its individual components, it is necessary to use modern methods of market management, which involve the use of the latest methods of scientific research, which, in particular, are based on the application of economic and mathematical models.

Dynamic processes occurring in the retail computer hardware market (RRKT) are consistent with the behavior of a complex system with many different factors. Therefore, for their modeling, it is necessary to apply formal dynamic mathematical models, which are developed using the methods of mathematical systems theory.

Nowadays, research into the retail markets of many countries in the world is largely reduced to general analysis or simulation or marketing modeling. Economic and mathematical modeling of dynamic processes in these markets is usually limited to the construction of duopoly continuous dynamic and linear regression models.

And the mathematical models regarding the national RRKT as a separate component of the IT industry are underresearched today. In particular, there are not enough publications that take into account the influence of market structure and its dynamics on the effectiveness of management decisions of its entities.

The purpose of the dissertation is the development of approaches and the complex of mathematical models for display and optimization of distribution processes of RRKT.

REVIEW OF PREVIOUS STUDIES

As a result of computerization and mediation, modern society as a whole, and therefore the world economy, have become network structures. Such structures are characterized by parallelism, high density of logistical ways of information transfer, and multitrunking. Other characteristics of network structures are: openness, decentralization, self-development, dominance of horizontal links, autonomy of the nodes included in them.

Network structures that are developing in the economy displace pre-formed industrial hierarchical market forms of economic relations servicing and replace these forms with horizontal links. As a consequence, a branchless network economy emerges.

The following characteristics are distinguished in a network economy:

In a network economy the value of a product is determined by the level of its mass character, and the value of participation in a network economy is exponentially dependent on the number of entities of joint economic activity (Elena, S. (2018); Dalevska, et al. (2019));

Low constant expenses, which are typical of a network economy, as well as fast distribution of production accelerate the onset of the stage of rapid growth, and in a network economy, an increase in benefit from the results of the work is provided by a whole network and is distributed between all its components (Tetiana, et al. (2019); Lakhno, et al. (2018));

In a network economy, the value of the production is growing in proportion to increasing its volumes, increasing the needs while reducing its value (Drobyazko, et al. (2019a); Drobyazko et al. (2019b)).

Mechanisms of a network economy result in refocusing the interests of participants in the joint activity from a desire to maximize their own profit to maximizing the efficiency of the entire network infrastructure (Hilorme, et al. (2019)).

Diverse, interactive and highly flexible network economy objectively creates the preconditions for continuous change in the organization of the system (Altinoglu, (2020));

In the conditions of a network economy an intensive replacement of "*Heavy*" and material elements of the system with "light" and information ones is taking place with simultaneous growth of the intellectual component of production (Koch & Windsperger, (2017));

Similar to biological systems, a network economy has mechanisms of self-organization and self-renewal, the extinction of old forms and the birth of new ones (Kucharska & Confente (2017)).

METHODOLOGY

General scientific and special research methods were applied to solve these problems. The methods of general systems theory and game-theoretic methods are decisive for achieving the purpose of the dissertation. The system method and the method of structuring were used to analyze the distribution processes of RRKT, to determine its structure and the factors that influence it.

Methods for building and identifying discrete dynamic models, structural programming were used to build the distribution models of RRKT, and linear programming methods were used to optimize these models. To determine the strategies of behavior of major sellers on RRKT, there was used the method of solving the problem of the completed antagonistic game of two players with a zero sum. And in the case of modeling the behavior of sellers in the conditions of insufficient information, methods of fuzzy linear programming were used. Computer modeling methods were used to programmatically implement the problems of building and studying mathematical models.

The information base of the paper is the scientific works of scientists concerning methods of mathematical modeling of complex dynamic systems and conflict situations, as well as statistics on the functioning of RRKT.

RESULTS AND DISCUSSIONS

It is reasonable to consider RRKT as an environment where there is a conflict situation between categories of sellers. In a conflict situation, several of its participants have to interact in circumstances where each of them tries to achieve his goal in the ways available to him, but none of them completely influences the course of events. That is, the consequences of resolving a conflict situation are only partially dependent on the behavior of a separate participant. So, in a conflict situation there are several stakeholders, and each of them is trying to get the most out of it.

Between such participants of RRKT as different categories a competition is taking place, in particular, for the shares of this market in different segments. In this competition, which can be considered as a way of achieving a benefit in a corresponding conflict of interest, each of the categories operates on the basis of their own capabilities and understanding of the situation. At the same time, the action of each category has its share in the process of resolving the above conflict of interest. It is appropriate to apply the game theory for modeling the behavior of different categories of sellers in a conflict situation in RRKT.

The game theory assumes that the elimination of contradictions, which are the basis of a conflict situation, is possible only after mathematical modeling of this situation in the form of a game. Therefore, in solving one of the problems of our study, it is necessary to create a suitable game model and apply the appropriate mathematical methods.

It should be noted that for game-theoretic modeling it is not enough to use only the classical mathematical approach of finding extremum functions. Instead, there is a need to use the latest mathematical methods for finding optimal minimum solutions. One of the objectives of our study is to adapt these methods to the problems of modeling commodity markets, in particular, RRKT.

Parties that defend their interests in a conflict situation (in the game) are known as players. In general, a player is considered to be a single game party or group of parties that share common interests that do not coincide with those of other groups. Therefore, not every single party can be considered a player. There are a lot of different sellers in RRKT.

However, each of them cannot be considered as a separate player, since his actions as a separate party do not allow him to solve the game problem. Instead, a set of sellers belonging to a certain category have common interests in the game and their joint actions influence the ways of resolving the conflict. Therefore, it is appropriate to consider players just as the categories of sellers that are present in RRKT.

Furthermore, the interests of several categories of sellers may overlap at certain points in time. For example, when a group of categories is jointly vying for a share in a market belonging to another category or to a group of other categories. In this case, a player must be considered a group of seller categories.

To achieve a certain purpose in the game, a player performs a series of actions, applies the appropriate technologies, methods, algorithms, methods, etc. that are specific to the player. In this case, it is said that a player formulates certain strategies for his behavior. Usually, a player makes strategies based on his/her capabilities and resources, his/her vision of conflict resolution. For example, under the same circumstances of the operation of RRKT the actions of different mobile phone outlets may differ from those of specialized stores of computer equipment, since for the first category the sales of computer equipment is not the only line of their business.

In RRKT each of the categories of sellers, generally, behaves differently. However, as quasi-competitive relationships are observed in this market, separate categories can agree their actions with each other. In particular, they may create communities for the purpose of jointly capturing a market share owned or released by a category that is not part of their community.

In such situation, the competition between a single category and a community of other categories should be described as a two-player game. A package of measures taken by a category that is not part of the community category, which are aimed at maintaining or systematically reducing its market share can obviously be regarded as its pure strategies. Accordingly, measures taken by a community to capture additional market share are pure strategies of that community.

In this case, the interests of a separate category and community can be viewed as opposite. On the one hand, a separate category seeks either not to reduce its market share at all or not to reduce it beyond its intended value. On the other hand, the community seeks to capture as much as possible of a market share owned by a separate category. Therefore, a game that describes this situation is antagonistic. Let us specify this game.

Suppose a certain category of sellers (first player) systematically reduce their presence in certain segments of RRKT. It should be noted that whether this player is reducing his market share, maintaining the status quo regarding it, or increasing it is not of crucial significance for our task.

The actions of a player, which are aimed at achieving any of these goals, assume that he is spending certain resources, including financial resources. These costs are calculated taking into account the final goal that the player sets for himself. If the costs are aimed at capturing a certain share of the market by a player, then capturing exactly the share that he wants to capture will be the win of the player in the game.

Let us consider a possible redistribution of RRKT in four segments, namely: PCs, laptops, monitors and MFDs. Suppose the first player plan to reduce his shares in these segments by the value of $\Delta p_i (i = \overline{1,4})$. On the other hand, the second player seeks to further increase his share in the same segments in proportion to the change in the average price of the corresponding goods by the value of $\Delta c_i (i = \overline{1,4})$. The value of the planned reduction of his shares in the market segments by the first player and the value of the change in the average price of the corresponding goods in relative terms are given in Table 1.

Table 1
PLANNED REDUCTION OF SHARES AND CHANGE IN THE AVERAGE PRICE OF A PRODUCT IN MARKET SEGMENTS (AUTHOR'S RESEARCH)

No.	Market segment	Planned share reduction Δp_i, %	Product average price change Δc_i, %
1	PCs	20	3
2	Laptops	30	4
3	Monitors	10	5
4	MFDs	15	2

Based on the data summarized in Table 1, and given that $\Delta z_i = \Delta c_i$ i, we put down the gain function in the form of a matrix of type (1), namely:

$$H_1 = \begin{pmatrix} 20\,23\,23\,23 \\ 34\,30\,34\,34 \\ 15\,15\,10\,15 \\ 17\,17\,17\,15 \end{pmatrix} \quad (1)$$

From Δp_i we select the maximum value, namely: $\Delta p_{i\max} = \Delta p_2 = 30\%$. For this value we select the coefficient k_2=0,01. After the corresponding transformations we obtain a matrix of type (2) in this form:

$$H_2 = \begin{pmatrix} 0 & 0.045 & 0.045 & 0.045 \\ 0.04 & 0 & 0.04 & 0.04 \\ 0.15 & 0.15 & 0 & 0.15 \\ 0.04 & 0.04 & 0.04 & 0 \end{pmatrix} \quad (2)$$

Based on matrices (1) and (2), we calculate the corresponding optimal mixed strategies of the first and second players. The results obtained are presented in Table 2.

Table 2
OPTIMAL MIXED STRATEGIES OF PLAYERS (AUTHOR'S RESEARCH)

i	x_i^*	y_i^*
1	0.28169	0.154493
2	0.316901	0.049296
3	0.084507	0.746479
4	0.316901	0.049296

The calculated values of the strategies indicate that, if the first player adheres to the strategies $x_i^*(i=\overline{1,4})$, the values of which are given in Table 2, it will be most advantageous for the second player to focus his attention on the segment of monitors, pay less attention to the segment of PCs and pay even less attention to the segments of laptops and MFDs. It seems obvious that the category of sellers included in the community will distribute their efforts to capturing the shares of the RRKT that the first player is going to leave,

respectively: segment of monitors - 75%, segment of PCs - 15%, segment of laptops - 5%, segment of MFDs - 5%, and will gain a competitive edge over other sellers in this community.

For the first player, the result obtained means the following. If the second player adheres to the calculated strategies $y_i^*(i=\overline{1,4})$, then for the first player to achieve the best possible result of his activity, with the planned decrease in the shares of RRKT segments, it will be necessary for him to distribute his efforts between these segments, respectively: segment of PCs - 29%, segment of laptops - 32%, segment of monitors - 8%, segment of MFDs -31%.

The price of the game means that, with the pure strategies selected that match the calculated optimal mixed strategies, the first player will leave in each segment an additional share that is proportional to that value in relative terms. Considering that v = 0,03803, R = 0,3, k_1=0,015, k_2=0,01, k_3=0,03, k_4 =0,02, and Δp_i is set in Table 1, after corresponding calculations we obtain the values $\Delta\tilde{t}_i$ and $\Delta\tilde{t}_2$, which are presented in Table 3.

Table 3
FINAL REDUCTION OF THE SHARES OF THE FIRST PLAYER AND ADDITIONAL SHARES OF THE SECOND PLAYER IN THE SEGMENTS OF RRKT (AUTHOR'S RESEARCH)

No.	Market segment	First player share final reduction $\Delta\tilde{t}_i$,%	Second player additional share $\Delta\tilde{t}_2$,%
1	PCs	22.5	2.5
2	Laptops	33.8	3.8
3	Monitors	11.3	1.3
4	MFDs	16.9	1.9

Based on the calculated values, $\Delta\tilde{t}_i(i=\overline{1,4})$ we calculate the absolute values of the shares that each player will own in the respective segment of RRKT, if they adhere to the optimal mixed strategies defined by them.

And depending on which category is the first player and which of the categories form the community that is the second player, we further determine the overall market distribution in the selected segments.

Let us consider the distribution of RRKT that is forecasted with the help of the dynamic model. The results of forecasting are presented in Table 4. We will consider this forecast as the initial situation that exists until a certain category of sellers decides to systematically reduce its presence in the market.

Table 4
INITIAL DISTRIBUTION OF RRKT BY SEGMENTS (AUTHOR'S RESEARCH)

Seller category	Share in market segments			
	PCs	Laptops	Monitors	MFDs
Chains of consumer electronics stores	0.34	0.58	0.384	0.561
Specialized stores	0.078	0.21	0.238	0.212
Mobile phone stores	0.001	0.107	0.016	0.054
B2B sector	0.581	0.103	0.362	0.173

We will select the chains of consumer electronics stores as the first player. Accordingly, a community of such categories will be the second player: specialized stores, mobile phone stores, B2B sector.

For further calculations we will use the data from the Tables 3 & 4. The results of the calculations are presented in Table 5.

Table 5
FINAL RATIO OF SHARES IN THE SEGMENTS OF THE FIRST AND SECOND PLAYERS

Player	Share in market segments			
	PCs	Laptops	Monitors	MFDs
1st player	0.26	0.38	0.34	0.47
2nd player	0.74	0.62	0.66	0.54

The results of modeling enable the managers of corresponding business structures to evaluate the effectiveness of their management decisions when planning their trading activities in certain segments of RRKT. Relying on these evaluations, the managers of separate trading companies are able to adjust their previous plans, which can provide them with a certain competitive advantage over other trading structures that sell similar types of goods in a particular region.

At the macro level, managers of trading structures that form a certain category of sellers, based on the results of modeling, can make an agreed decision on the directions of competition with other categories of sellers.

For wholesale suppliers, the results of modeling can be useful, given that their knowledge of market sharing prospects enables them to select the right priorities for collaboration with seller categories. Thanks to this knowledge, suppliers can adjust supply volumes for certain categories of sellers, market other types of goods, adjust pricing policies in RRKT segments, which are critical for them, or in all segments as a whole, etc.

RECOMMENDATIONS

As in the case of well-defined operating conditions of RRKT, the optimal mixed strategies of the first and second players, considering (1) and (2) and the proportionality of distribution of the share of the second-player are the basis for determining the final optimal distribution of PPKT among all seller categories.

Based on the calculated optimal mixed strategies, we determine the optimal distribution of resources among market segments for sellers of the categories that form the appropriate player.

We formulate the obtained results of modeling in a form that is acceptable for making management decisions.

MS Excel was used for software implementation of the proposed methods of game-theoretic modeling. It has a convenient method for implementing simple single-type arithmetic operations on data arrays, and with the help of the add-in “Solver” we can use the simplex method to solve linear optimization problems, provided for by the procedure of modeling.

CONCLUSIONS

Using the methods of the game theory for a matrix game of two players, the optimal mixed strategies of both players and the price of a game are calculated. Based on the optimal mixed strategies, they define the optimal distribution of resources for each player that he

directs to those segments of the market where he is seeking to get a guaranteed competitive advantage.

By interpreting the price of a game as the share of RRKT that a player loses or gains as a result of competition, determining the value of the price of a game makes it possible to forecast how the market will be distributed among players when each of them applies the optimal mixed strategies.

The non-transparency of the PPKT creates uncertainty in the behavior of its entities, in the course of processes, which are characteristic of it, including its redistribution among categories of sellers. In such uncertain conditions, fuzzy modeling methods must be used to describe the market.

According to this method, the uncertainty of certain characteristics of the market operation is described by the measure of membership in the form of a set of corresponding functions. For the case of considering two entities of a conflict situation in RRKT, the task of modeling in the form of an antagonistic game of two players is reduced to the dual task of linear programming with fuzzy restrictions. The use of membership functions allows reducing this task to crisp linear programming.

Fuzzy modeling of a conflict situation between two players-antagonists allows determining their optimal mixed strategies and the price of a game under fuzzy conditions of game formulation. And this means that this approach should be applied to determine the parameters of rational behavior of categories of sellers who distribute RRKT among them under uncertain conditions of its operation.

Building the proposed game-theoretic models and their use for the purpose of solving the corresponding game tasks involves performing a number of elementary arithmetic operations and carrying out optimization procedures using linear programming methods.

To automate the corresponding calculations, you should use the standard tools that are present in MS Excel.

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