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USING THE APPARATUS OF SIMULATION MODELING IN THE PROCESS OF DEVELOPING ADVERTISING STRATEGIES OF ENTERPRISES

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ABSTRACT

The main problems in the field of advertising strategies development of enterprises, as one of the important factors in increasing the efficiency of their marketing, production and economic activity, are determined. The peculiarities of the formation of advertising strategies in the market of pharmaceutical goods are considered. The expediency of using a flexible mathematical apparatus in the process of developing and approbation strategies and their consequences for the future is substantiated. The model-simulator of the advertising strategies formation of the enterprises is offered, that developed on the software platform of the integrated system of multilevel imitative modeling - AnyLogic. The developed model-simulator is intended for daily application in the process of making managerial decisions regarding the formation and adjustment of the advertising strategy of enterprises in commodity markets. The model is quite typical and can be easily adapted to the specifics of not only concrete pharmaceutical companies, but also for enterprises in other industries.

Keywords: *advertising strategy, AnyLogic, enterprise, pharmaceutical model-simulator, simulation modeling*

1. INTRODUCTION

Advertising activity of domestic enterprises is gaining momentum today as a result of marketing processes activation in the conditions of consumer-oriented economy formation. First of all, it concerns the formation of an advertising strategy, as one of the determining factors of the advertising effectiveness, and also marketing and production and economic activities of enterprises in general. Pharmaceutical industry is one of the most complexes in developing effective advertising management strategies. In today's Ukrainian pharmaceutical market, the process of using advertising funds is shifting to a qualitatively new stage in its development, due to the significant segmentation and diversification of the pharmaceutical goods market; high level of competition; import dependence; significant state control; creation of new information and communication technologies that cause the emergence users of a new type with complicated behavior and dynamic change in the benefits. In the given context, the use of special models-simulator in practice for the preliminarily working off of various advertising strategies and their possible consequences becomes significant. The development and application of such a management tool requires the use of highly flexible mathematical research methods on modern software platforms. One of the ways to solve the problem is using simulation modeling apparatus. A significant contribution to the study in the problems of advertising strategies formation of enterprises in commodity markets has been such scientific

works as [2, 5, 13, 17, 19, 20, 23, 26, 32-36, 39]. In particular, in the case of pharmaceutical companies should be emphasized works [1, 6-8, 25, 42]. Thus, a review of analytical decision support tools for marketers (including *SWOT* analysis) is considered in [1, 6, 13, 25, 34, 39]. Research and improvement of customer feedback to increase sales is highlighted in [5, 7, 13, 35]. In recent years, it has become popular to promote products and services in the global Internet network, especially in social networks. A great deal of research is devoted to the development of marketing strategies using on-line video advertising [19, 20], communication "Word of mouth" (*WOM*) [26], viral advertising [35], promotion of products in Instagram [17] and Twitter [32], etc. The structural equations modeling (*SEM*) and mathematical modeling (including the use of spreadsheets) are studied in detail in works [1, 2, 7, 23, 33, 35, 42]. Scientific developments [7, 8, 17, 19, 20, 23, 26, 35] emphasize the need to create dynamic models and identify the most effective indicators of advertising, external and internal factors of influence on potential buyers. The theoretical and applied questions of using simulation modeling as a device for conducting research in various fields of economics are considered in numerous literary sources, for example [11, 27, 32, 36]. There is a specific range of model applications in the field of socio-economic systems management at the micro level [3, 27], in particular, in the management of marketing activities of enterprises various industry directions [18, 30]. With regard to the simulation of various aspects of advertising, it need note the achievements, the results of which are covered in [9, 21, 30]. Models by the study field are regularly submitted at the international forums of the simulation models development: Winter Simulation Conference (*WSC*) [41], International System Dynamics Conference [38], *ASIM* (German-language simulation community) [4], *IMMOD* ("Imitation Modeling, Theory and Practice") [40], European Congress of *EUROSIM* [31]; webinars and publications by one of the world's leading corporations in the simulation industry - The AnyLogic Company [28]. Despite the existing developments of scientists and practitioners, the problem of the formation of effective advertising strategies for enterprises, in particular the pharmaceutical industry, based on the use of modern mathematical tools remains unexplained. On the one hand, this is due to the specifics of advertising companies in this area, on the other hand - with difficulties in the process of creating and implementing model applications. When developing a marketing strategy, it is necessary to consider the possibility of emerging new information and the need to change the taken decisions; the initial objectives of the strategy may varied, be corrected [24]. The development of a marketing strategy from the beginning to the end should be cyclical [5]. This process may be accompanied by difficulties associated with translating into the digital indicators of the utility of the taken decisions. Therefore, it is necessary to involve specific means to support decision-making and reduce potential risks. With regard to the mathematical basis of research, then, of course, the simulation apparatus has advantages along with the analytical approach due to the possibility of taking into account the dynamic nature of the development of processes, the influences of various stochastic factors, many inverse relationships, nonlinearity. In the course of an analytical decision it is often impossible to obtain an unambiguous result due to the lack of corresponding equations or the presence of recursiveness formulas. At the same time, for tasks arising in the process of advertising strategies development, as a rule, it is enough to provide a numerical solution and visual representation of the results based on a series of numerical experiments. Exactly method of simulation modeling is allows it. The limited application of the method in the activity of economic systems at the micro level is due to the presence of a number problems and "bottlenecks" in the industry. For example, the means of production, implementation of models and planning of simulation experiments are need to improve. The further development of software platforms for the implementation of simulation by creating a single research space within specific integrated systems is topical. This will lead to the transition from the outdated classical concept of organization and simulation to the practical implementation a system

approach of simulation research. With regard this, it is expedient to develop model applications using multi-approach paradigms of simulation on the corresponding software platforms of integrated systems, as well as the involvement of modern Internet technologies for the exploitation of ready-made models. The paper goal is revealing the possibilities of applying simulation modeling methods on the software platforms of integrated systems in the process of advertising strategies formation of pharmaceutical enterprises.

2. THE MAIN RESULTS OF THE RESEARCH

Pharmaceutical advertising goals do not differ from the advertising goals of any product group and consist in the purchase of the advertised product. However, the specifics of the industry affect advertising processes and the advertising strategy formation for pharmaceutical companies in different regions of the country. Currently, according to the Law of Ukraine "On Advertising" there are restrictions on advertising of prescription medicines. Advertising of prescription medicines can be used taking into account the basic principles of advertising, all legislative requirements regarding its form and content, but only among a limited number of subjects - it is placed in specialist publications intended for medical institutions and doctors, and also distributed at seminars, conferences, symposia on medical topics. Therefore, the study considers the advertising activities of enterprises in relation to non-prescription medicines. Any company is interested in increasing sales and expanding its customer base, but the means to achieve these goals are not always obvious. Professionals need to analyze a huge number of factors that influence success to select the most rational marketing and sales strategy, for example: income levels, product features, competitors' actions, trends in the development of modern technologies, market and customer requirements, production capacity, market segmentation, national peculiarities of potential buyers. In addition, most of the factors need to be considered in dynamics [22]. The simulation models offer many advantages over the implementation of experiments on a real system and the use of other methods, namely: cost, time, accuracy, visibility, universality, etc. Within the framework of the creation the model complex of the production and marketing system of the pharmaceutical enterprise, a module is developed, that studies the influence of certain factors in different regions of the country on the level of income, sales volume and number of customers in the context of various strategies for the marketing of medicines. The software platform for the implementation of the model is the system of multilevel simulayion modeling AnyLogic, which supports on a single platform all existing approaches for discrete-event and continuous simulation (flowcharts of processes, system dynamics, agent modeling, condition maps, equation systems, etc). A fragment of the model is shown in Figure 1.

Figure following on the next page

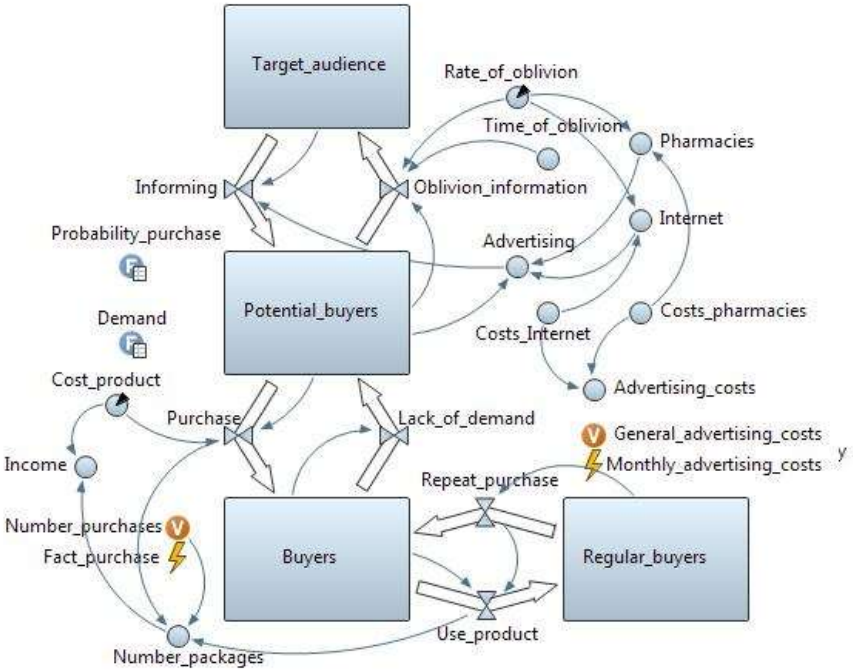

Figure 1 - Model fragment of the advertising strategy formation of the enterprise (developed by authors)

The content of the flows is formed through parameters, variables or table functions. The demand function may be formed by different algorithms depending on the particular market situation that simulated. Imitation experiments can be performed at different time periods with different duration of the simulation step. Time periods are determined by the user in the process of directly configuring the experiment. The work of the module allows adjusting the necessary amount of expenses for advertising tools; determining the reasonable cost of pharmaceutical products; optimizing the efficiency of marketing costs, maximizing income from advertising campaign and the number of regular buyers; calculate the sales volume in kind. The simulation model provides the possibility of conducting computer experiments in order to make variations of significant environmental factors for choosing the optimal level of prices, revenues, number of buyers in the analysis of different regions of the country provided that the costs of advertising campaigns are minimized. Model-simulator of marketing activity of the pharmaceutical company allows analyzing in a short time the current state of affairs, optimizing the current activity of the enterprise, reducing advertising costs and developing a plan for further action. Quite typical for the enterprises of the studied area, the model-simulator allows creating the basis for making grounded decisions. This is facilitated by the large number of types of experiments that offer modern platforms of multilevel simulation modeling. AnyLogic tools allow conducting various experiments by type of analysis: Standard (simple) experiment; Optimization; Variation of parameters; Comparison of "runs"; Sensitivity analysis; Calibration; Monte-Carlo; Non-standard. Farther, the results of the implementation of three types simulation experiments are shown in a fragmentary way: Standard Experiment, Comparison of "Runs", Sensitivity Analysis. Performing a Standard experiment allows adjusting the required amount of expenses for advertising tools; determine the reasonable period for advertising campaign of pharmaceutical products; optimize the effectiveness of marketing costs; maximize income from advertising campaigns. The simulation model provides the possibility of conducting computer experiments in order to select the optimal combination of advertising strategies to minimize the costs of their implementation, provided income from sales is maximize. With the help of a Standard experiment, it was held the analysis of the advertising activity results of the

pharmaceutical company *OJSC* "Farmak" - one of the largest pharmaceutical manufacturers of various pharmacotherapeutic groups in Ukraine. According to [16], the company's advertising costs for the first half of 2017 amounted to 28,725.8 thousand dollars. The company holds 6.5% of the market for pharmaceuticals among all producers (including foreign producers) and 16.8% of the medicines market among Ukrainian producers [29]. Approbation of the model was carried out on the indicators of the group "Cold remedies". Seasonal fluctuations for demand are typical for this group. The main sources of informing potential buyers about the medicines of this group with the corresponding rating are viewed in [37]. The process of informing the target audience is described by the model of Nerlow-Errow (N-A model), which has the form of differential equation of the 1st order:

$$\frac{dA}{dt} = b \cdot q(t) - k \cdot A, \text{ where} \tag{1}$$

A(t) – awareness about product (number of informed people about product in period t);
q(t) – advertising activity (advertising costs in period t);
b – advertising effectiveness (rating of the source of advertising);
k – the speed of oblivion of information. In the simulation model this coefficient is defined as a random variable of 10% to 80%, which is due to the forgetting curve of Ebbinghaus.

An important parameter for making a decision on the purchase of a medicinal product is the cost of the product. The monthly costs of advertising and product cost are the variables when performing experiments on the simulation model. Here are specific examples. The results of three experiments that investigate the change in time of such parameters as Target_Audience, Potential_Buyers and Buyers under different conditions for the cost of advertising the product are shown in Figure 2.

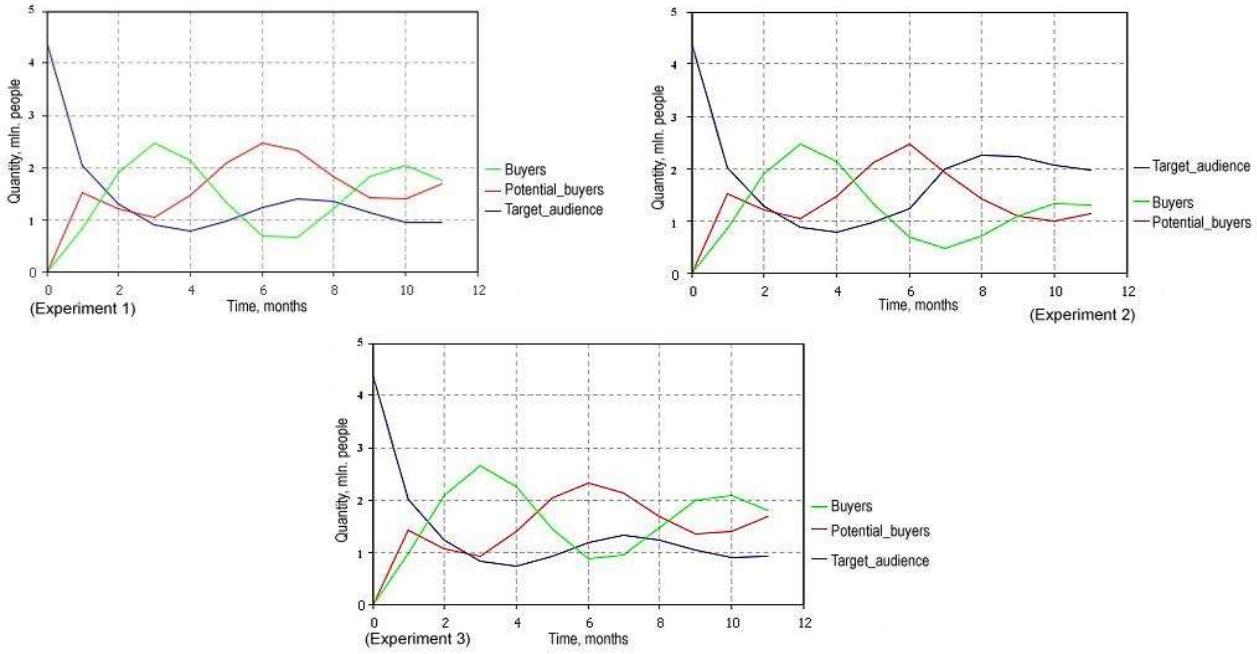

Figure 2 − Time charts of parameters Target_Audience, Potential_Buyers and Buyers

- Experiment 1. The costs of product advertising are evenly distributed over the entire simulation period.

- Experiment 2. The costs on product advertising are implementation only for the first 6 months (evenly distributed), starting from the 7th month they cease.
- Experiment 3. During the first six months, the advertising costs amount to 80% of the total, and starting from the 7th month the remaining 20% are distributed.

Experiment 1 shows that the first 6 months of advertising is quite effective, but starting from the 7th month, advertising costs are unreasonable and do not have the expected response of the target audience. Experiment 2 shows that after the cessation of advertising, the number of users, as well as the number of information carriers, has rapidly decreased. Experiment 3 shows that the strategy of uneven distribution advertising budget between the first and last months of advertising keeps the number of users at a fairly high level. The number of purchases in the first months has increased significantly, with a high proportion of target audiences being carriers of information. For large pharmaceutical enterprises operating throughout Ukraine and abroad, the conditions analysis of specific regions for determining the optimal plan of an advertising strategy is a prerequisite for successful business conduct. For example, in different regions of Ukraine vary greatly the levels of morbidity, existence pharmacies and special stores, people's incomes, medicines costs, age limits of the population, etc. Making decisions on setting price for medicines, distributing funds between sources of advertising, placing medicines on pharmacies depending on demand and other complex issues are priority tasks for managers of pharmaceutical companies in each region. Results of the experiment Comparison of "runs" is presented on the example of analysis the dynamics of studied parameters in the section of regions of Ukraine. Experiments were conducted for the Kharkov and Odessa regions. In them compared the behavior of variables Regular_buyers, Income, Number_packages at different values of the Cost_product parameter. The sources of incoming data are the State Statistics Service of Ukraine [14] and pharmacy sales in the regions of Ukraine [15]. Experiment results the Comparison of "runs" for the parameters Regular_buyers, Income and Number_of_packages at different values of the variable Cost_product for the Odessa and Kharkov regions are shown in Figure 3. In both regions the maximum number of regular buyers is achieved at the lowest cost of the product. The feedback between these parameters is clearly reflected. At the maximum cost of a product the number of regular buyers is kept at one level throughout the simulation period. This is the part of buyers, for which the purchase decision does not depend on the price. The obtained results prove that in Kharkov and Odessa regions the enterprise will receive the maximum income at the product cost 170 UAH. However, income in the Kharkov region is much higher due to larger population and higher level of morbidity. One of the important parameters for the pharmaceutical industry is the number of sold packages in natural expression. The graphs show that in the Odessa region residents buy in 1.5 times less medicines, with a population less in 1.1 times. The income in Kharkov region is higher than in Odessa in 1.7 times at a lower level of material maintenance of the population. Given the health status and the level of prosperity in different regions, it can be argued that in the Kharkov region the population will continue to buy medicines even with the small advertising efforts of pharmaceutical companies. Therefore, it is necessary to increase the amount of funds for an advertising campaign in the Odessa region. Due to the low level of morbidity in comparison with the Kharkov region, it is recommended to promote vitamins and biological activity supplements (*BAS*) on the pharmaceutical market [10].

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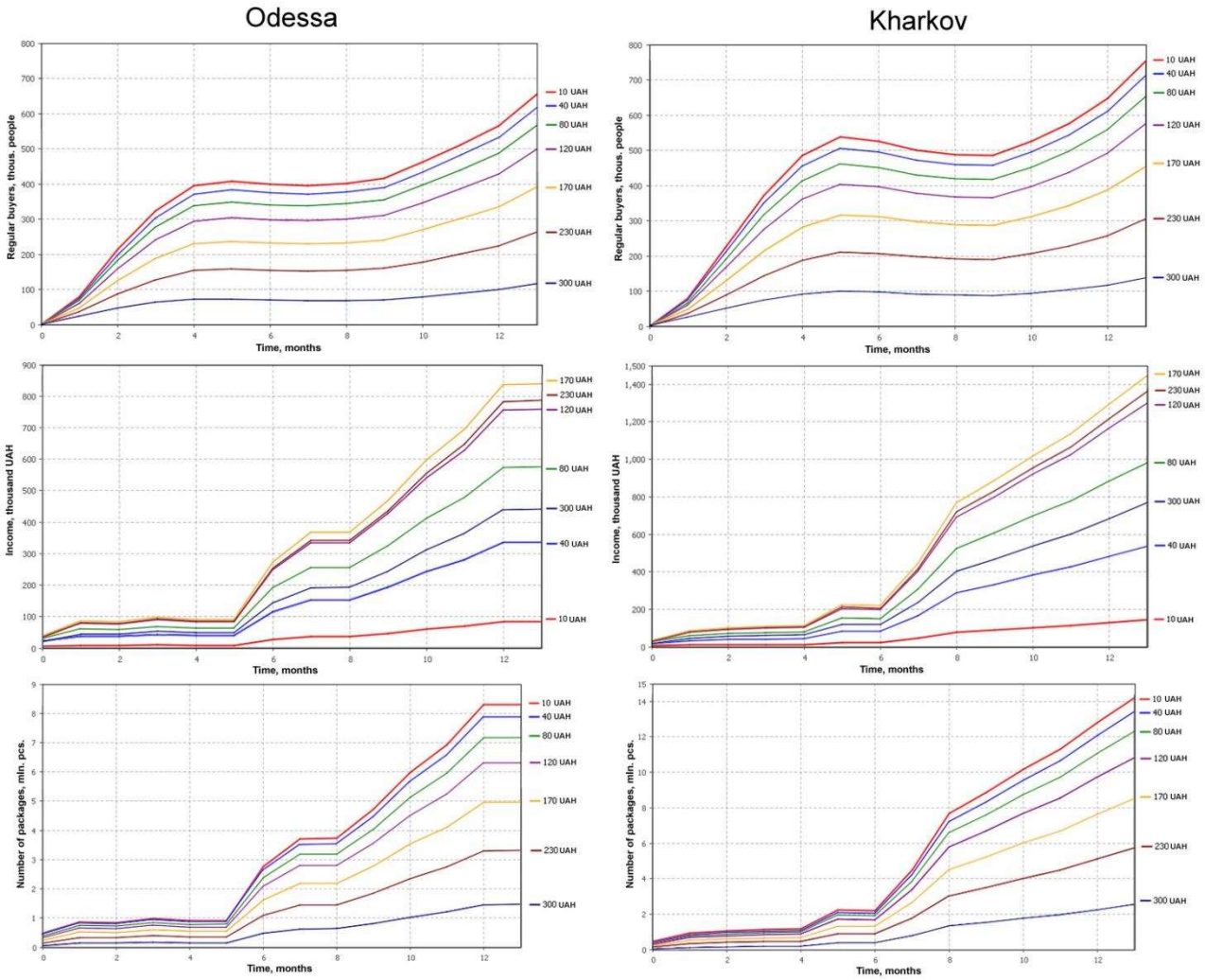

Figure 3 − Comparison of "runs" Odessa and Kharkov regions (for the parameters Regular_buyers, Income and Number_of_packages)

Experiment the Analysis of model sensitivity is a procedure for evaluating the influence of input hypotheses and the values of key factors on the model's output indicators. An experiment with variation of parameters and analysis of the model reaction helps to assess how sensitive the model's forecast from change the hypotheses underlying it. In the analysis of sensitivity the change in the values of factors is performed separately, which allows to rank their influence on the final indicators. AnyLogic has a mechanism for automatically launching a model the given number of times with a change in the value of the selected parameter. The analysis of sensitivity performs several "runs" of the model, varying the value one of the parameters and showing how the simulation results depend on these changes. The run of experiment provides opportunity to study and compare the behavior of the model at different values of the parameters using graphs. For this model the experiments Analysis of sensitivity were conducted on the following parameters: Target audience; Cost of product; Advertising costs in the pharmacies; Advertising costs on the Internet network; Rate of oblivion and other. Execution of experiments showed that:

- In the Kharkov region a greater influence has advertising on the network of pharmacies, whereas in the Odessa region preference is given to Internet advertising;
- With increasing spending on advertising and increasing the intensity of advertising decreases the rate of oblivion and increases the number of regular buyers;

- The target audience of the Odessa region is less than Kharkov, but the effectiveness of advertising in it is higher;
- In the Odessa region the sale of more expensive products prevails, whereas in Kharkov population buy cheaper goods, but considerably more in terms of the number of packages.

The presented examples of realization three types of experiments prove their informativeness for the enterprises of the investigated industry. However, in actual practice, the experimental circle can be significantly expanded according to the needs of users (a list of possible types of experiments provided by the AnyLogic platform is given above). Particular attention should be paid to the simplicity using of the finished model-simulator, as a daily apparatus to support managerial decisions making, and the possibilities of its adaptation to the specifics of certain enterprises and situations in the pharmaceutical market. In addition to the traditional advantages of simulation modeling - the modularity and openness of the model, the user interface of the high level, service support of the application, etc. - this is facilitated by the use of modern cloud technologies (AnyLogic platform provides an instrumental base for the implementation of cloud service). Migration of the imitation model-simulator into the cloud significantly increases its efficiency in the following directions [12]:

1. There are appears additional computing power. The browser provides a new approach to working with the created model. According to the developers of the AnyLogic platform, the typical scenario for such exploitation is to work with model versions; setting / changing input parameters; observation the animated run and on-line interactive with it; planning complex experiments; configurating the control panel (dashboard) with inputs and outputs of the model; performing experiments; viewing, analyzing (for example, comparing) and exporting results.
2. The scheme of interaction with customers is changing. If, for example, it is necessary to adapt the developed model to the specifics of the certain object, make the corresponding changes, etc, it is enough to download the model with the data and the configuration of concrete experiments in the cloud and send the appropriate link to the customer. The user will be able to download the model, run the submitted experiments or generate their own, change the parameters, make the necessary model runs and, on this basis, formulate proposals and requirements for its further setting. All work is done in the browser and takes a few seconds.
3. New opportunities for teamwork are creating. In AnyLogic the following principle is realized: the single base stores the input parameters and the corresponding results of all anytime user launches of the model by anyone user. Then, if new startup options are found in the database, simulation isn't performed. In addition, the cloud with the model is a social network. Thus, any enterprise-user can use the results obtained by colleagues in the presence of access to the model in the cloud, as well as make in their composition appropriate enhancements. This can be convenient for large pharmaceutical companies with a developed network of subdivisions, affiliates.

3. CONCLUSION

Summing up all the above, it should be noted that the processes of advertising strategies formation of enterprises in the conditions of the increased entropy of modern commodity markets, the emergence of new trends in the consumer-oriented economy and the development of digital marketing technologies are not only local application tasks, but require the creation of a single theoretical and instrumental basis for their implementation. The presented model-simulator for the development scripting of advertising strategies clearly reflects the general tendency to involve the mathematical apparatus of simulation modeling to create a base of models of decision support systems (DSS) on the micro-level.

The proposed model application and plans for simulation experiments demonstrate the application of a system-dynamic approach to provide a quantitative assessment of the components of advertising strategies for a diverse time perspective with a significant degree of aggregation. Due to the high level of structuring, the flexible user interface and the ability to implement the cloud service on the software platform AnyLogic, model can be deepened and expanded in order to increase its functionality and adaptability to specific situations of concrete enterprises. Further research is aimed at increasing the detail of the components of advertising strategies with the expansion of the range factors of external environment influence. In particular, it is about reproducing the dynamic behavior of products consumers, which is being promoted to the market. This is achieved through the use of the hybrid simulation paradigm in the AnyLogic environment as a base for providing various levels of aggregation of processes and conducting various types of simulation experiments. The main task of these improvements should be considered the creation of a convenient and parametric-tuned support device for making managerial decisions in the field of advertising.

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