SIMULATION TECHNOLOGIES IN THE STRATEGIC MANAGEMENT OF ADVERTISING PROCESSES OF PHARMACEUTICAL ENTERPRISES

Zoya Sokolovska,
Doctor of Economics, Professor,
Head of the Department of Economical Cybernetics and Informatics Technologies,
Larysa Frolova,
Doctor of Economics, Professor,
Head of Entrepreneurship and Trade Department,
Irene Kapustyan,
Post-graduate student of the Department of
Economical Cybernetics and Informatics Technologies,
Odessa National Polytechnic University

Annotation. *The development of modern information and communication technologies contributes to the improvement of advertising strategies, as effective tools of pharmaceutical marketing. The feasibility of attracting methods of simulation as tools of making strategic advertising decisions is substantiated. The simulation model-simulator is proposed, developed using the combination of agent and system-dynamic approaches on the AnyLogic software platform. The decision-making process is illustrated by the results of various types of simulation experiments.*

Key words: *advertising strategy, pharmaceutical enterprise, simulation modeling, model-simulator, simulation experiments.*

Introduction. The pharmaceutical industry is one of the domestic economy sectors, which demonstrates a positive dynamics of development, despite existing problems: imperfect state legislation; lack of funding; low solvency of the population; significant import dependence, increased competition in the pharmaceutical market.

Pharmaceutical companies belong to one of the most high-tech industrial sectors, which characterized by a fast-updating product line. Accordingly, there is an increase in their interest in such business development strategies as research and development (in particular, the development of innovative products), which is accompanied by deepening the localization of production with the active search for strategies for optimizing costs and marketing strategies for market research and product promotion.

An important component and effective tool for pharmaceutical marketing is advertising that moves to a qualitatively new level with the advent of modern information and communication technologies, aimed at users with complicated behavior, prone to interactive communication and change of benefits. Considerable segmentation of the pharmaceutical market, caused by diversification of the nomenclature series, sets forth special requirements for formation the advertising strategies and establishes their close relationship with the commodity strategies of pharmaceutical enterprises.

Decision-making in the field of strategic advertising involves careful study the target audiences (potential users) of products, timely prediction the dynamics of their changes. The parallel process is tracking the life cycle of each product from the range of enterprise from the stages of research and development to release on the market and duration of stay on it. Advertising can prolong or reduce the age of the product's presence on the market. In turn, market trends determine the expediency of increasing or decreasing the advertising budget and the technology of its use (or termination of use). The above processes occur under the influence of many stochastic factors of internal and external environment of operation the pharmaceutical companies. Therefore, it is necessary to forecast dynamics the relevant sectors of the pharmaceutical market (target audiences, commodity flows) in conditions of risk and uncertainty in order to make informed decisions in the course of defining and implementing both the marketing and accompanying advertising strategy. The instrumental base of forecasting requires the use variety flexible research methods that take into account the qualitative and quantitative character of the problem. Based on this, one of the modern paradigms of quantitative modeling is proposed - multiapproach simulation on the platform of AnyLogic system.

In this study, it is put forward the hypothesis of expediency the formation advertising strategy of the company based on predicting duration the life cycle stages of product and the dynamics of target audiences (commodity flows) by means of simulation in connection with the impossibility of obtaining an unambiguous analytical solution.

The possibilities of making the strategic advertising solutions using a model-simulator, taking into account the nonlinear character of the investigated processes and numerous feedbacks, are proving.

Analysis of recent research and publications. From the point of view the given problem, an overview of the existing research results was made in the following areas:

− Analysis of commodity (assortment) policy of pharmaceutical enterprises.

− Research of target audiences (sectors of the market) for which advertising of pharmaceutical products is directed.

− Investigation the effectiveness of advertising: its impact on the current demand for products, reputation, the final results of the companies works.

− Modeling advertising strategies for pharmaceutical companies. In particular, existing applied imitations in this area.

A significant range of domestic and foreign studies are devoted to various aspects of formation the commodity policy of pharmaceutical enterprises.

The questions of classification the pharmaceutical products and management of its assortment are raised in the works [1, 2]. In [1] within the framework of research the models of marketing-oriented management of pharmaceutical enterprises, it is offered model of classification a dynamic assortment of pharmaceutical products and considered the certain aspects of commodity portfolio management. In [2] the classification of products by commodity-market characteristics got the improvement; investigated the features of pharmaceutical products as an object of commodity innovation policy. A separate emphasis in the work is made on the differences in product advertising

specifically in the pharmaceutical market.

The process of making managerial decisions during the formation of product portfolio is explored in the work [3]. Attention is paid to the processes of passing through the stages of the life cycle, especially the stages of research and development. The author stresses, that the ideal structure of the product line is determined by the cost of developing medicines, the likelihood of their survival during the testing and approval processes, the duration of the market and expected profitability. The use of optimization methods in determining the composition and structure of a pharmaceutical company's product portfolio is proposed. The minimizing the level of risk and maximizing the return on the portfolio are quite widespread and offered as target functions. However, in addition to formally analytical ones, it is emphasized the need to further involve fuzzy methods based on the use of available information from previous precedents. Although there are references to only some aspects of pharmaceutical advertising in the work, the dynamic, interactive approach to formation the product portfolio due to the prism of assessing the life cycle stages of individual products is interest.

The research, conducted on the basis of the University of Georgia (USA), are devoted to objectives of the formation and management the commodity portfolios of pharmaceutical companies [4]. The work is focuses on the peculiarities and complexity of formation the portfolios in context of merger; the integrations of portfolio management processes. The results of extensive empirical studies lead to the conclusion that it is necessary to attract a special mathematical base for predicting the sales outcomes of commodity portfolios in conditions of a dynamic pharmaceutical market.

A modern approach to managing a pharmaceutical portfolio in conditions of limited resource is proposed in [5]. Developments are based on the implementation of a hybrid approach that combines several simulation methods and creates a complex environment for reflecting the dynamic behavior of the market. According to the authors, it is expedient to use both purely analytical and simulation methods with different degrees of processes aggregation. The main hypothesis put forward in the work - the desire to optimize the pharmaceutical portfolio (in particular, from the point of view of the distribution and use limited resources of companies) - is realized only subject to the creation of a single object-oriented modeling complex, which can be adapted to the specifics of concrete enterprises in the industry.

One of the most time-consuming and regular studies in strategic advertising is the study of target groups. For the pharmaceutical market, this process is complicated by the high level of segmentation and dynamism. Pharmaceutical products have a huge assortment and significant differences in organizing processes of production, control, legal support, promotion, etc. In addition, progress in pharmacology field promotes the emergence of new innovative medicines; the market is replenished also with many related goods.

Pharmaceutical companies all over the world spend a lot of money on conducting research the target audiences. Thus, in [6] the results of analysis the relationship of marketing strategies of a number the leading companies with the specifics of target groups

of users pharmaceutical products, in particular, its innovative segments, are given. In [7] the results of studying the target audience behavior of users the unpatented medicines are presented. The constructed behavior model takes into account the benefits of Italian consumers groups, which differ in numerous features: demographic, self-identification, previous behavior, risk sensitivity, preferences for specific brands, etc.

The geography of such studies is great. As presentative examples of "field" experiments to assess the effect of responding target groups of users on pharmaceutical advertising (direct and contact) can lead [8-10].

One of the most problematic and ambiguous aspects of strategic decision-making is determining its effectiveness. The following sources are illustrative examples of research in this area.

In [11] are presented empirical studies of 25 large "field" experiments with aggregate spending on digital advertising of over $ 2.8 million, conducted with major American retailers, that covering millions of customers. The results proved the impossibility of unambiguous determination the impact of advertising costs on the resulting end-points. In the course of the researches, economic and statistical methods were applied and, in general, more than 10 million man-weeks were used to ensure the informativeness of the advertising experiments.

An analysis of impact the advertising in terms of attracting investment is given in [12]. The promotion of products, focused on stock investors, was in the focus of this empirical study. An experiment was conducted with a representative sample of real investors to test the effect and study the main advertising mechanisms. The results proved that accentuation of product characteristics in advertising for investors increasing their subjective assessment of concrete products and interest of investing in shares of the company. In this case, the effect is manifested independently of existence the factors associated with the previous perception of brands. The authors came to the conclusion that the obtained data identifies and confirms various mechanisms of advertising influence on investors, however, the relative magnitude of influence can not be generalized.

An attempt to obtain an analytical solution to one of the specific tasks of evaluating the effectiveness of advertising in [13] deserves to attention. In work the dynamical, continuous-time model of optimal management of advertising costs is analyzes. It takes into account the lateness of users' reaction and the advertising influences on purchases, which made earlier. It take into account the effects of past sales and advertising (accumulated from specific intervals) to determine the impact of advertising. The solution of the optimization problem is reduced to the solution the system of non-linear integral equations of Volterra type and integral functional of quality. The authors prove the existence of a solution the problem of maximizing company profits in the planned period with restrictions on the advertising budget and the availability of functional dependence, which reproduces the reaction of the target audience. The authors discuss the issues of functional dependence of current demand on the accumulated reputation of the company and the accumulated effect of advertising. However, the applied results of application the proposed model are not presented.

A detailed analysis of existing mathematical apparatus for the study of dynamic advertising is given in [14], where authors made a reference to a significant number of literary sources (134 references). As example of using model applications in the field of pharmaceutical advertising can bring works [15-18] and other.

The using simulation methods of research aimed at advertising is sufficiently limited to date. The range of model simulation applications devoted to the reproduction of various aspects of advertising processes can be represented by follow sources.

In [19] the simulation model is proposed, focused on research the using of advertising funds in process promoting the products of Internet enterprise. The result of experiments is the choice an optimal set of advertising methods in conditions of minimizes costs. The model is implemented in AnyLogic system environment. The questions of advertising and pricing policy of Internet providers are raised in work [20], in which the model of reproduction thr users' behavior on the market of Internet services is offered. Modeling advertising budgets in the framework of general advertising strategies of enterprises presented in [21].

Although the presented model applications do not relate exactly to the pharmaceutical industry, the specific blocks and technology of simulation experiments can be adapted to its specificity.

International platforms, which regularly present the model applications with using various simulation paradigms, aimed at solving a wide range of tasks, in particular, in the context of the considered problem, are the following: Winter Simulation Conference [22], International System Dynamics Conference [23], German-language simulation community ASIM [24], IMMOD "Imitation Modeling, Theory and Practice" [25], European Congress of EUROSIM [26], webinars and publications by one of the world's leading corporations in the simulation industry – The AnyLogic Company [27].

Unsettled issues which are part of a common problem. Researches the various aspects of the formation and implementation advertising strategies, as a rule, are carried out separately, that violates the complex perception of the problem and reduces the validity and reliability of the results. On the other hand, the mediation of advertising actions and the dependence on components of the company's overall strategy (production, commodity, innovation, marketing, financial, investment, marketing) stipulate to take into account their specificity when making strategic advertising decisions. Practice proves that set tasks are relevant, and their final solution is far from complete - this is confirmed by the results of many empirical, "field" experiments.

In the context of this work, we are talking about the need to focus on complex consideration the processes of dynamic strategic advertising and the formation commodity portfolio of the pharmaceutical enterprise (taking into account the peculiarities of life cycle stages of individual nomenclature positions). At the same time, it is need to reduce the cost of experiments to make them accessible to a wide range of enterprises. According to this, not only the concept of research is important, but also mathematical tools, which are used.

The above review proves that in most cases the mathematical basis of decision-

making in the advertising field consists of economic-statistical, optimization methods and model applications based on them. But this greatly limits the possibility of obtaining adequate results in the absence of stable, equilibrium tendencies, clear algorithmic dependencies; the presence of recursive formulas; lack of required retrospective information.

Therefore, it is expedient to use modern paradigms of simulation on the corresponding software platforms to create model-simulators for the development the management solutions in a dynamic uncertain environment. Although improvement the means of setting up and implementing simulation models as well as the plans for carrying out experiments is a permanent process, the simulation tools will contribute to expanding the scope of the problem, reducing the duration and cost of conducting research. The use of multiapproach simulation paradigms on the software platforms of integrated systems as well as Internet technologies for the application of ready-made models create a single research space and carry out the system approach of conducting simulation studies. Today one of the most effective world-class software platforms supporting the main modern paradigms of simulation (discrete-event, agent and system dynamics) and their combinations is the AnyLogic system.

The purpose of the article is studying processes of decision-making in the field of strategic advertising of pharmaceutical enterprises using the multilevel paradigm of simulation on the software platform of the AnyLogic system.

The main material. 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 (original and generic) medicines. Considering medicines as a market product category, the understanding of the terms "original" and "generic" (reproduced) medication is also important. The original (innovative) medicinal product is the product, first introduced to the pharmaceutical market, containing a new synthesized or received other way active pharmaceutical ingredient, authorized for medical use and patented for a certain period of time. A reproduced medicinal product (generic) is a copy, which correspond to an innovative (original) medicinal product by therapeutic efficacy and safety. It’s manufactured by a pharmaceutical company after expiration of the patent protection period [28].

In the framework of creation the model complex of marketing activities of the pharmaceutical company, it was conducted an analysis the advertising strategies of OJSC "Farmak" - a leader in the pharmaceutical manufacturers of various pharmacotherapeutic groups in Ukraine. The basic sources of incoming data are the State Statistics Service of Ukraine [29] and the official website of "Farmak" [30].

Developed within the complex, the simulation model-simulator aimed at working

out the following solutions in the field of strategic advertising:

− Investigation the optimal level of prices for the product assortment in order to maximize revenue from sales.

− Minimize advertising budget and its distribution to promote original and generic medicines.

− Monitoring the effectiveness of research new and re-production of existing medications, depending on the duration of the life cycle.

− Determining the preferences of potential buyers depending on the level of demand and prices for assortment.

− Monitoring and forecasting the reaction of the target audience to product advertising, tracking the level of information about the product, etc.

The financial elements of the model are presented fragmentarily on Figure 1.

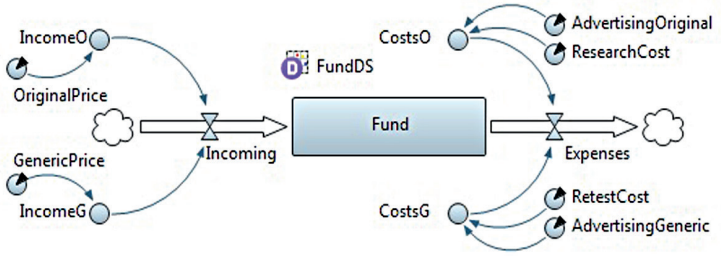

Fig. 1. Block of continuous simulation.
Source: developed by authors.

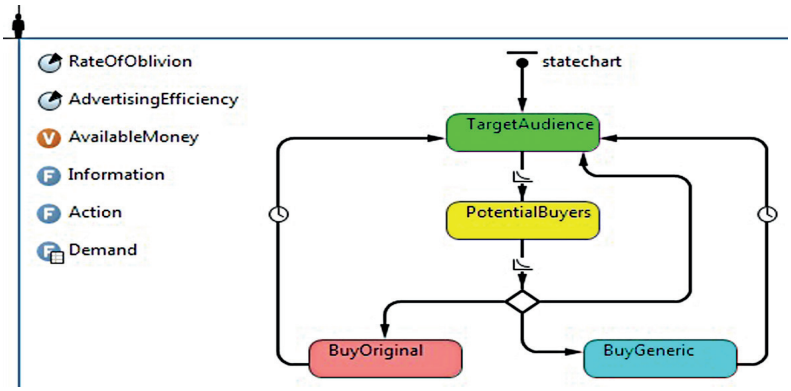

Fig. 2. Buyers State Diagram.
Source: developed by authors.

The system-dynamic block, shown in Figure 1, is designed to simulate the company's capital in real time (in the limits of the task), the movement analysis of which allows to make conclusions about the intensity of sales processes and investment in specific areas. According to this, the contents of storage devise "Fund" are replenished with incomes

from the sales of original and generic medicines and reduced with costs of their research and advertising.

Factors affecting the level of income are directly related to the behavior of the user - potential buyer. The buyer in the system can be in four states: TargetAudience, PotentialBuyers, BuyOriginal and BuyGeneric (Figure 2).

The built-in graphic tools AnyLogic are used in the course of dynamic simulation objects - the schematic representation of elements and the change of colors for tracking states.

The process of buying medicines and switching to appropriate states occurs depending on the stages life cycle of preparats. So, if there will be no necessary preparat on the market at the time of purchase, the buyer choosed an analogue or completely refuse to buy. Life cycle stages of generic and original medicines are presented in system in the form of corresponding diagrams of states using agent modeling (Figure 3 and Figure 4).

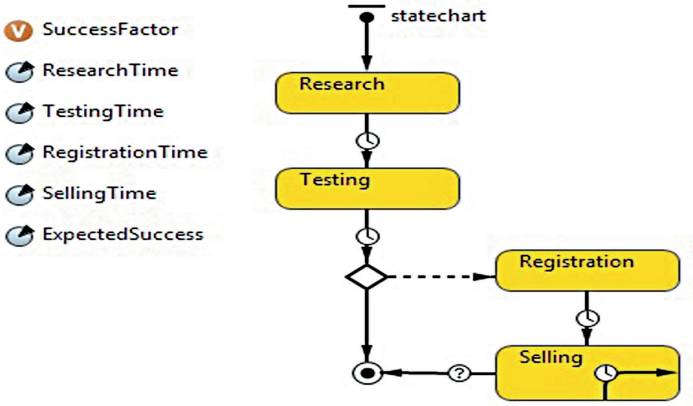

Fig. 3. State Diagram of original medicines.
Source: developed by authors.

Original medicines in the system can be in four states: Research, Testing, Registration and Selling, while generic medicines - only in two states: Retest and Selling. This is due to the fact that original preparat pass a complete cycle of preclinical and clinical researches and mandatory registration.

All blocks of the model are interconnected, allows to adjusting the required amount of expenses for advertising tools; determining the reasonable cost of pharmaceutical products; optimizing the effectiveness of marketing costs; maximizing revenue from advertising campaigns and the number of regular buyers; calculating 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 values in conditions of minimizing costs of advertising campaigns. The model-simulator of marketing activity of pharmaceutical enterprise allows analyzed in a short time the

current state of affairs, optimized the current activity of enterprise, reduced advertising costs, and also developed a plan for further action.

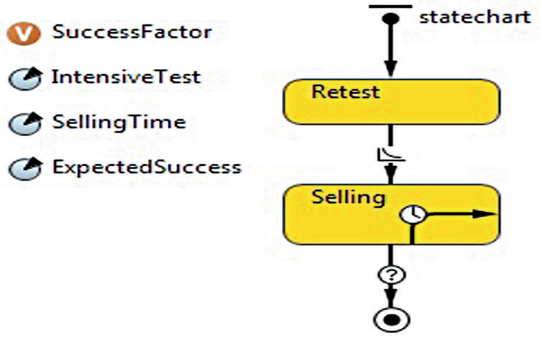

Fig. 4. State Diagram of generic medicines.
Source: developed by authors.

The process of decision-making support is due to realising different types of experiments on the model. AnyLogic tools allows to conduct the following experiments by type of analysis: Standard (simple) experiment; Optimization; Variation of parameters; Comparison of "runs"; Sensitivity analysis; Calibration; Monte Carlo; Non-standard. The first three types of experiments are considered in this study.

A Simple experiment launches a model with specified parameters values, supports virtual and real time modes, animation, debugging of the model. So, change in the level of capital during the simulation period (1 year) is shown in Figure 5.

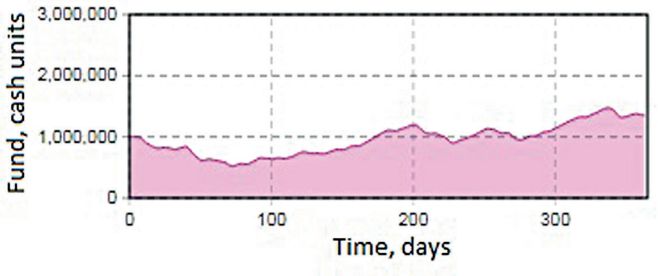

Fig. 5. Fund level during model time.
Source: compiled by authors based on simulation results.

Figure 5 shows that in the first half of the year the company suffers losses, while in the second it begins to make a profit. Because significant costs on research and advertising carried out, when new preparat introduction into the market, and only after a while buyers are beginning to recognize and actively buy the product.

The activity of the target audience and the transition to the state of buyers at execution of Simple experiment during model time (1 year) is shown in Figure 6. This fragment presents a generalized situation in the context of Ukraine regions.

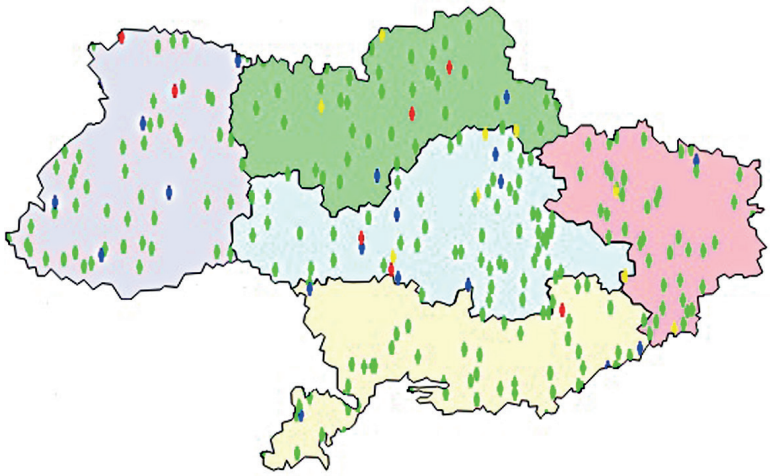

Fig. 6. Buyer activity during model time.
Source: compiled by authors based on simulation results.

So, in state TargetAudience agent is marked in green, in state PotentialBuyers - in yellow, in BuyOriginal and BuyGeneric states - in red and blue respectively. With the built-in "Time schedule" tool, it can be graphically monitored the level of buyers original and generic medicines (Figure 7). This allows in a timely manner to respond on changes in the situation, make decisions about increasing or reducing the intensity of advertising the certain type of preparat.

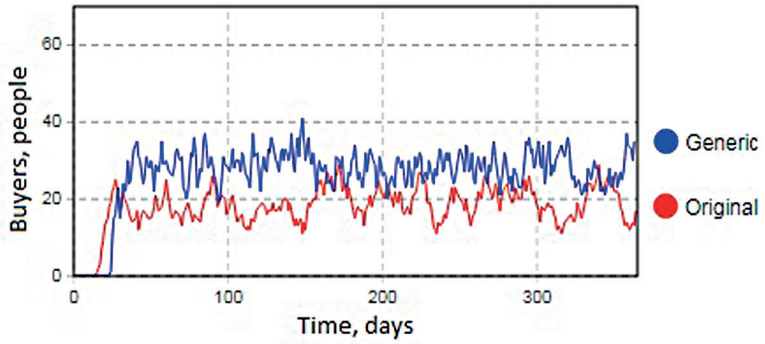

Fig. 7. The level of buyers of original and generic medicines.
Source: compiled by authors based on simulation results.

As Figure 7 shows, the sales number of generic medicines in kind prevails over the original. This is explained by a much lower price and a larger assortment.

The Optimization experiment looks for the value of the parameters at which the optimal value of the given target function is achieved. There may be a number of constraints on the values of the parameters and variables of the model. The optimization progress schedule is displayed. For this model, the target function of minimizing the advertising costs for both types of medicines was set. The result of the Optimization experiment is shown in Figure 8.

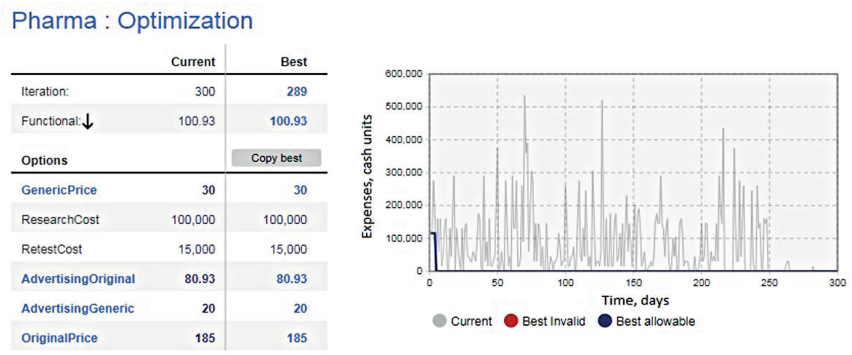

Fig. 8. Optimization experiment of minimizing advertising costs.
Source: compiled by authors based on simulation results.

Similarly, the system allows conducting Optimization experiment of maximizing revenues from sales of medicines, and also considering separately each type of preparat. Due to this type of experiment, the pharmaceutical company can quickly find the parameters in which the necessary market situation will be realized - increase or decrease of strategically important factors.

Experiment Variation of parameters performs several "runs" of a model with variations of one or more parameters. For the constructed model it was decided to conduct two experiments with change of only one parameter. The Fund serves as a factor, which changes under the influence of the chosen parameter.

The first experiment. The advertising costs of original medicines are acting as a parameter, which changes (Figure 9).

The second experiment. The advertising costs of generic medicines are acting as a parameter, which changes (Figure 10).

This type of experiment involves fluctuations of the main factor from the changing parameter. These predictive values help to make strategically important decisions to achieve certain goals about setting the level of advertising costs for each type of preparat, the level of medicines prices, etc.

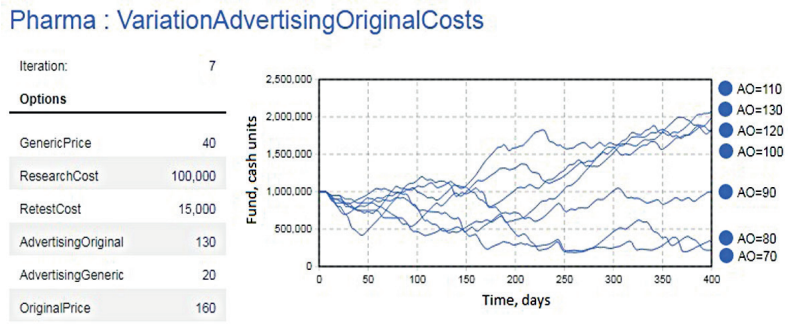

Fig. 9. First experiment of parameters variation.
Source: compiled by authors based on simulation results.

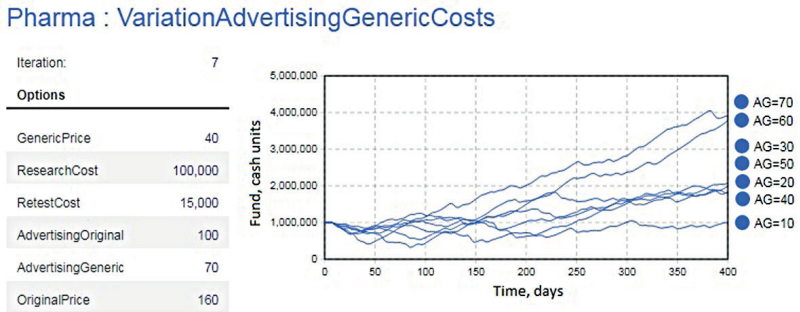

Fig. 10. Second experiment of parameters variation.
Source: compiled by authors based on simulation results.

Conclusions. Summarizing the foregoing, it can be argued that the simulation model-simulator is an effective basis for supporting decision-making in the formation advertising strategies of pharmaceutical companies. With the help of this model, it is possible to track real-time consumer behavior and the life cycle stages of medicines, taking into account the variability and instability of pharmaceutical market. Reproduction by means of simulation the stochastic nature of investigated processes and the dynamics of their changes provides a sufficient level of adequacy the developed model application, increases the reliability of the results.

The presence different types of experiments allows to getting statistical and predictive values in a variety of situations with the ability to configure specific parameters.

The model application is intended to repeatedly work out situational experiments for monitoring the saturation of the commodity market, promotion products in the regions of the country (which is especially interesting for innovative medicines), level of awareness the target audience, assess the impact of advertising efforts and a significant numbers of other parameters presented in the system. In general, it contributes to optimizing the budgets of advertising companies and the technology of their distribution in time,

especially on a strategic perspective.

Due to the openness and modularity of the model-simulator, the conditions for its adaptation to the specifics of the work of concrete industry enterprises are created.

Further research is planned to be conducted in the following areas:

− Take into account changes in the reputation of the company (by introducing into the model dynamic parameters-indicators of market situations) and competitor's actions (reproduction on the model of competitors' generalized advertising strategies with prediction of their impact on the results of product promotion of investigated enterprise) in the process of making strategic decisions.

− Detail forecast of financial results and risks of implementation the specific advertising strategies.

− Focusing on advertising strategies for innovative types of pharmaceutical products.

− Increasing the visibility of dynamic simulation experiments by using the HTML5 animation display mechanism.

− Development and testing of technology for embedding developed models-simulators into existing information flows of pharmaceutical companies, that is, integration with operating in enterprises CRM or ERP systems.

− Strengthening of the instrumental platform for experimentation through the use of cloud technologies, which will integrating the processes of making strategic advertising decisions of pharmaceutical companies at the sectoral level.

The general direction of research is the increase of the experimental base by expanding the range of investigated pharmaceutical industry enterprises in Ukraine.

References:

1. Shabelnyk,T.V. (2016). Modeli marketynho-orientovanoho upravlinnia farmatsevtychnym pidpryemstvom [Models of marketing-oriented management of the pharmaceutical enterprise]. Doctor's thesis. Poltava, 383p. [in Ukrainian].

2. Melnik, I. M. & Holysheva, E. O. (2017). Osoblyvosti kompleksu marketynhu v systemi innovatsiinoho rozvytku farmatsevtychnyh pidpryemstv [Features of marketing complex in the system of innovative development of pharmaceutical enterprises]. Marketynh i menedzhment innovatsii – Marketing and Management of Innovations, 4, 27-40 [in Ukrainian].https://doi.org/10.21272/mmi.2017.4-02

3. Jekunen, A. (2014). Decision-making in product portfolios of pharmaceutical research and development – managing streams of innovation in highly regulated markets. Drug Design, Development and Therapy, 8, 2009-2016. https://doi.org/10.2147/DDDT.S68579

4. Jones, C. M. (2016). Managing Pharmaceutical Research And Development Portfolios: An Empirical Inquiry Into Managerial Decision Making In The Context Of A Merger. Doctor's thesis. Georgia State University, 150p.

5. Solo, K. & Paich, M. A. (2003). Modern Simulation Approach for Pharmaceutical Portfolio Management. SimNexus LLC. URL: https://www.anylogic.ru/upload/

iblock/6d4/ 6d45074aefb2d023be20115ec9c77301.pdf (Last accessed: 23.02.2019).

6. Kalotra, A. (2014). Marketing strategies of different pharmaceutical companies. Journal of Drug Delivery & Therapeutics, 4 (2), 64-71.

7. Zerbini, C., Luceri, B. & Vergura, D. (2017). Leveraging consumer's behaviour to promote generic drugs in Italy. Health Policy, 121 (4), 397-406. https://doi.org/10.1016/j.healthpol.2017.01.008

8. Pujari, N. M., Sachan, A. K., Kumari, P. & Dubey, P. (2016). Study of Consumer's Pharmaceutical Buying Behavior Towards Prescription and Non-Prescription Drugs. Journal of Medical and Health Research, 1 (3), 10-18.

9. Biswas, K. & Ferdousy, U. K. (2016). Influence of Pharmaceutical Marketing on Prescription Behavior of Physicians: A Cross-sectional Study in Bangladesh. Journal of Accounting & Marketing, 5 (2), 1-4. http://dx.doi.org/10.4172/2168-9601.1000160

10. Costea, D., Carter, F., Chou, S.-Y. & King, A. (2012). Is Advertising Effective or Not? Evidence from the Pharmaceutical Market. NMIMS Management Review, 12, 9-28.

11. Lewis, A. & Rao, J. M. (2015). The unfavorable economics of measuring the returns to advertising. The Quarterly Journal of Economics, 1941–1973.

12. Aspara, J. & Chakravarti, A. (2015). Investors' reactions to company advertisements: the persuasive effect of product-featuring ads. European Journal of Marketing, 49 (5/6), 943-967. https://doi.org/10.1108/EJM-11-2013-0661

13. Lutoshkin, I. V. & Iamaltdinova, N. R. (2016). Sushchestvovanie resheniia zadachi upravleniia reklamnymi rashodami s raspredelennym zapazdyvaniem [The existence of a solution to the problem of managing advertising expenses with distributed delay]. Izvestiia Irkutskoho hosudarstvennoho universiteta - News of Irkutsk State University, 18, 48−59 [in Russian].

14. Huang, J., Leng, M. & Liang, L. (2012). Recent Developments in Dynamic Advertising. European Journal of Operational Research, 220 (3), 591–609. https://doi.org/10.1016/j.ejor.2012.02.031

15. Ahmed, R. R., Vveinhardt, J., Streimikiene, D. & Awais, M. (2016). Mediating and marketing factors influence the prescription behavior of physicians: An empirical investigation. Amfiteatru Economic, 18 (41), 153-167.

16. Avagyan, V., Landsman, V. & Stremersch, S. (2017). Marketing models for the life sciences industry. International Series in Operations Research and Management Science, 254, 385-430. https://doi.org/10.1007/978-3-319-56941-3_13

17. Bardey, D., Bommier, A. & Jullien, B. (2010). Retail price regulation and innovation: Reference pricing in the pharmaceutical industry. Journal of Health Economics, 29 (2), 303-316. https://doi.org/10.1016/j.jhealeco.2009.11.015

18. Leeflang, P. S. H. & Wieringa, J. E. (2010). Modeling the effects of pharmaceutical marketing. Marketing Letters, 21 (2), 121-133. https://doi.org/10.1007/s11002-009-9092-3

19. Berezovskaia, E. A., & Plotnikov, C. A. (2015). Imitatsyonnoe modelirovanie reklamnoi kampanii internet-predpriiatiia v srede AnyLogic [Simulation of an advertising campaign the Internet-enterprise in the environment of AnyLogic]. Mezhdunarodnyi nauchnyi zhurnal - International Scientific Journal, 9, 86-90 [in Russian].

20. Katalevskii, D. Y., Solodov, V. V, & Kravchenko, K. K. (2012). Modelirovanie povedeniia potrebitelei [Modeling of consumer behavior]. Iskusstvennye obshchestva - Artificial societies, 7 (1/4), 34-59 [in Russian].

21. Pesikov, E. B. (2003). Otsenka effektivnosti i stepeni riska marketinhovykh stratehii predpriiatiia na osnove imitatsionnoho modelirovaniia [Estimation of efficiency and degree of marketing strategies risk of the enterprise on the simulation modeling basis]. Praktika imitatsionnoho modelirovaniia (IMMOD-2003) – The Practice of Simulation Modeling (IMMOD-2003), 2: 110-115 [in Russian].

22. Winter Simulation Conference. URL: http://meetings2.informs.org/wordpress/wsc2018/ (Last accessed 11.02.2019).

23. The 36th International Conference of the System Dynamics Society. URL: https://www.systemdynamics.org/past-conference-2018 (Last accessed 13.02.2019).

24. Arbeitsgemeinschaft Simulation. URL: https://www.asim-gi.org/asim/ (Last accessed 12.02.2019).

25. Vosmaia Vserossiiskaia nauchno-prakticheskaia konferentsiia “Imitatsionnoie modelirovanie. Teoriia i praktika” IMMOD-2017 [Eighth All-Russian Scientific and Practical Conference "Simulation modeling. Theory and practice" IMMOD-2017]. URL: http://simulation.su/static/ru-immod-2017.html (Last accessed 11.02.2019) [in Russian].

26. Proceedings from «The Federation of European Simulation Societies». URL: https://www.eurosim.info/eurosim/ (Last accessed 15.02.2019).

27. Offical Site of AnyLogic Company URL: http://www.anylogic.com/ (Last accessed 11.12.2018).

28. Levytska O. Likarski zasoby iak obekty farmatsevtychnoho rynku (chastyna 2) [Medicinal products as objects of the pharmaceutical market (part 2)]. Farmatsevt Praktyk – Pharmacist Practitioner, 2016, 2. URL: http://fp.com.ua/articles/likarski-zasobi-yak-ob-yekti-farmatsevtichnogo-rinku-chastina-2/ (Last accessed 20.01.2019) [in Ukrainian].

29. Derzhavna sluzhba statystyky Ukrainy [State Statistics Service of Ukraine]. URL: http://www.ukrstat.gov.ua/ (Last accessed 21.12.2018) [in Ukrainian].

30. Offical Site of OJSC “Farmak”.URL: http://www.farmak.ua/ (Last accessed 05.12.2018) [in Ukrainian].