DEVELOPMENT OF A MANAGEMENT MODEL FOR THE MARKETING ACTIVITIES OF AN INDUSTRIAL ENTERPRISE BASED ON INCOMING CONTROLLED AND UNCONTROLLED VARIABLES

DESENVOLVIMENTO DE UM MODELO DE GESTÃO PARA AS ATIVIDADES DE MARKETING DE UMA EMPRESA INDUSTRIAL BASEADO NA ENTRADA DE VARIÁVEIS CONTROLADAS E NÃO CONTROLADAS

DESARROLLO DE UN MODELO DE GESTIÓN DE LAS ACTIVIDADES DE COMERCIALIZACIÓN DE UNA EMPRESA INDUSTRIAL BASADO EN VARIABLES CONTROLADAS Y NO CONTROLADAS ENTRADAS

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Abstract

Fundamental changes are taking place in the work of markets, and new market institutions are being formed in the context of the development of information and communication technologies. Accordingly, the interaction between enterprises and consumers of their products is changing; therefore, classical marketing models are losing their relevance. Thus, there is a need for such a model of management of marketing activities of an enterprise, with the help of which it is possible to predict the activities of specific enterprises, considering various factors of consumer behavior and effects arising under the influence of various marketing tools. In connection with the above, the purpose of the study is to build a model for managing the marketing activities of an industrial enterprise to improve the accuracy of forecasting the value of the target indicator of an advertising campaign. The authors of the study have analyzed the cybernetic management system, synthesized the cybernetic system and the McKinsey model, and built a generalized model for managing the marketing activities of the enterprise based on them. It has been concluded that the constructed model is able, with certain limitations, to predict the value of the target indicator of an advertising campaign based on incoming controlled and uncontrolled variables.

Keywords: marketing activity management model, consumer behavior, cybernetic system, McKinsey model, neural networks.

Resumo

Mudanças fundamentais estão ocorrendo no funcionamento dos mercados e novas instituições de mercado estão sendo formadas no contexto do desenvolvimento das tecnologias de informação e comunicação. Assim, a interação entre empresas e consumidores de seus produtos está mudando; portanto, os modelos clássicos de marketing estão perdendo sua relevância. Assim, há a necessidade de tal modelo de gestão das atividades de marketing de uma empresa, com a ajuda do qual é possível prever as atividades de empresas específicas, considerando vários fatores de comportamento do consumidor e efeitos decorrentes da influência de vários Marketing Ferramentas. Em conexão com o exposto, o objetivo do estudo é construir um modelo para gerenciar as atividades de marketing de uma empresa industrial para melhorar a precisão da previsão do valor do indicador de destino de uma campanha publicitária. Os autores do estudo analisaram o sistema de gestão cibernética, sintetizaram o sistema cibernético e o modelo McKinsey e construíram um modelo generalizado para gerenciar as atividades de marketing da empresa com base neles. Concluiu-se que o modelo construído é capaz, com certas limitações, de prever o valor do indicador alvo de uma campanha publicitária com base em variáveis de entrada controladas e não controladas.

Palavras-chave: modelo de gestão da atividade de marketing, comportamento do consumidor, sistema cibernético, modelo McKinsey, redes neurais.

Resumen

Se están produciendo cambios fundamentales en el funcionamiento de los mercados y se están formando nuevas instituciones de mercado en el contexto del desarrollo de las tecnologías de la información y la comunicación. En consecuencia, la interacción entre las empresas y los consumidores de sus productos está cambiando; por lo tanto, los modelos de marketing clásicos

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están perdiendo su relevancia. Por lo tanto, existe la necesidad de un modelo de gestión de las actividades de marketing de una empresa, con la ayuda del cual sea posible predecir las actividades de empresas específicas, considerando varios factores del comportamiento del consumidor y los efectos que surgen bajo la influencia de varios marketing. instrumentos. En relación con lo anterior, el propósito del estudio es construir un modelo para gestionar las actividades de marketing de una empresa industrial para mejorar la precisión de la previsión del valor del indicador objetivo de una campaña publicitaria. Los autores del estudio analizaron el sistema de gestión cibernético, sintetizaron el sistema cibernético y el modelo de McKinsey, y construyeron un modelo generalizado para gestionar las actividades de marketing de la empresa basándose en ellos. Se ha concluido que el modelo construido es capaz, con ciertas limitaciones, de predecir el valor del indicador objetivo de una campaña publicitaria en función de variables entrantes controladas y no controladas.

Palabras clave: modelo de gestión de actividades de marketing, comportamiento del consumidor, sistema cibernético, modelo de McKinsey, redes neuronales.

1. INTRODUCTION

The development of information and communication technologies (ICT) has opened up new opportunities for the development of market structures (Piñeiro-Otero, Martínez-Rolán, 2016; Zakharov et al., 2022). For example, remote trading of a wide variety of product categories has become the norm, and now a variety of ways in which the consumer collects information about the seller, contacts them, and places an order are considered a sales channel (Panasenko et al., 2021a; 2022). An increasing number of spheres of life are moving into the virtual dimension, new user habits of consumers are being formed, and hence their expectations from the ways of interacting with sellers of goods and services (Afanasev, 2017; Kiseleva et al., 2017). The excess of information and its availability causes the emergence of new approaches to working with information and attitudes toward it among consumers, and in all spheres: professional, personal, and, of course, the sphere of purchases of goods and services (Karashchuk et al., 2019; Panasenko et al., 2021b). Following this, the forms and content of information media of enterprises are changing: advertising, in particular, and the transfer of information about the enterprise to other market participants in general (Hernández de Velazco et al., 2009; Lochan et al., 2021).

Newmarket institutions are also emerging, for example, digital platforms that simplify the establishment of links between the two sides of the exchange (Schallmo, Williams, 2018; Ramazanov et al., 2021). A new value proposition appears along with the platforms – access to

the platform, providing up-to-date and complete information about the market and its participants for a fee (Artamonova, 2017).

The enterprise has the opportunity to integrate all previously available data into a single linked array (Peres, Muller, 2010) and build personalized portraits of consumers with the transition of the market to the Internet and the development of web technologies (Kozhushko, 2015).

Given the above, previous marketing models, such as the classic sales funnel, cease to be relevant, since they cannot effectively convey the complexity of the exchange relationship in the digital environment (Erokhina, 2018). Instead, modern realities demonstrate many points of interaction of various kinds between the consumer and the seller. Naturally, each interaction has a certain impact on the consumer and determines their behavior at other points of interaction.

The company should consciously interact with consumers to remain an effective player in the market, considering their individuality, previous interaction, and context (Hernández García de Velazco et al., 2021). The task of an enterprise wishing to maximize its profit from the market activity is to effectively manage all available marketing tools and make decisions based on all available information. The presence of advanced information and communication systems is what distinguishes successful enterprises from unsuccessful ones. Therefore, there is an urgent need to build such a model of marketing tools management, which will make the processes of interaction with the market systematic and reasonable.

Research analysis. Various models of managing the marketing activities of enterprises in the modern conditions of digital transformation are the subject of numerous studies. Thus, M. Wouters and M. A. Kirchberger (2015) model the processes of the value proposition for customers. Models and analyses of the "word of mouth" marketing effect are proposed in the works (Li, Du, 2017; Chen, Lurei, 2013; Li et al., 2018). The study (Eelen et al., 2017) models the influence of brand loyalty, but it is noted that advertising is not the only marketing tool. The intention of making online purchases in (Lee et al., 2017) is modeled depending on the attributes of the product and engagement. P. Harrigan et al. (2018) present a model of customer interaction based on the relationship between engagement, interaction, communication with one's brand, and brand use.

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However, only models based on the specific effects of marketing tools are proposed in most works (Cosenz, Noto, 2016; Jiang et al., 2016; Walrave, Raven, 2016) without generalizing the diversity by a single model. A sales policy management system is modeled in (Alvarez-Milán et al., 2018), but this model does not consider the fact of the diversity of mechanisms of influence of various marketing tools, which are expressed by different types of functions in terms of content and level of complexity.

The purpose of the study is to build a model for managing the marketing activities of an industrial enterprise to improve the accuracy of forecasting the value of the target indicator of an advertising campaign.

Research hypothesis: the proposed model of marketing activity management of an industrial enterprise can accurately predict the value of the target indicator of an advertising campaign based on incoming controlled and uncontrolled variables.

2. RESEARCH DESIGN AND METHODS

The following research methods were used in the course of the study:

- analysis of scientific literature on the problem of modeling the management of marketing activities of an enterprise and the experience of companies (case study): ten industrial enterprises producing various household appliances and household items (power tools, household appliances, kitchen accessories) for households;

- mathematical modeling method – for creating and presenting mathematical models of various marketing management systems of an enterprise;

- graphical modeling method – for creating and presenting schematic images of various marketing management systems of an enterprise;

- the method of statistical analysis – to determine the absence of significant differences between the forecast and real values of the target indicator of the advertising company.

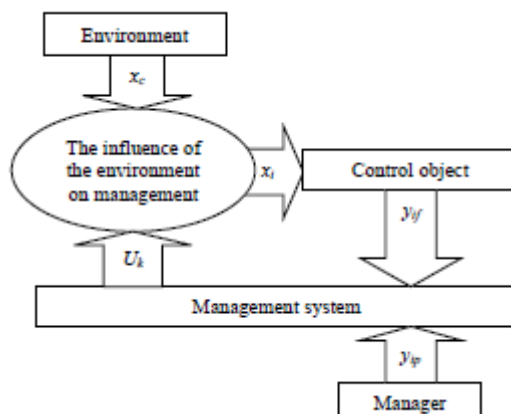The study was conducted in two stages in the period from January 11 to February 11, 2022.

A generalized model of marketing activity management of an industrial enterprise was built at the first stage of the research, based on the synthesis of the cybernetic system and the McKinsey model.

The results of a quantitative analysis of the effectiveness of advertising messages on the VKontakte social network were obtained (vk.com) at the second stage of the study using the created model on the example of ten industrial enterprises producing various household appliances and household items. The indicators of an advertising company of ten industrial enterprises producing various household appliances and household items (power tools, household appliances, kitchen accessories) for household needs were considered as an object of research.

2.1 Description of the generalized management model

First of all, we present the definition of the management model in a generalized form. Some control object is considered, the state of which is characterized by a certain set of parameters yi. Information about the actual values of these yif parameters gets to the input of a control system built on the feedback principle. That is, the system connects the output and input of the controlled object and for each yif performs a comparison with the program value of yip. Based on the information about the deviation value $Dyi. = yif - yip$ a decision is made on the formation of a certain influence of Uk on the controlled system.

The management process does not take place in an isolated system, but in interaction with the external environment: economic, social, informational, and the like. The control system, together with the control object, is exposed to the environment and itself influences this environment. The implementation of the control action often faces the influence of various kinds of disturbances. Let us denote them by the set fe. Despite their action, the controlled object is affected by the result of the activity of the control system and the influence of disturbances, the effective action of which we denote as xi. A schematic representation of the cybernetic system is shown in Fig. 1 for clarity.

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Figure 1. Schematic representation of a cybernetic system

Since we are developing a marketing activity management model, it is necessary to choose and take a marketing model as a basis that will successfully and quite generically describe the management object.

Researchers (Harrigan et al., 2018) note that the traditional metaphor of the sales funnel lost relevance, which assumes that the consumer starts by considering a certain number of brands (the wide end of the funnel) and, being directed by marketing tools, consistently reduces the number of brands (moves towards the narrow end of the funnel) and eventually makes a purchase of a product or service of one of their chosen brand (coming out of the funnel). Today, the idea of a funnel cannot describe all the points of interaction between the two sides of the market exchange and the factors of making a purchase decision through the explosive growth in the number of market offers and digital channels of interaction, as well as the formation of a fastidious and well-informed consumer. In addition, the importance of the factor of two-way communication between consumers and sellers, as well as direct communication between consumers, known as "word of mouth", is noted (Chen, Lurei, 2013).

McKinsey's cyclical model is proposed to replace the unidirectional sales funnel model, which includes four main stages: initial consideration of alternatives, collection of information about a potential purchase, purchase, and evaluation of the purchased product or service during use (Wang, Zhang, 2017). Unlike the funnel model, in which each next step is a decrease in the number of choices relative to the previous step, the cyclical model assumes that the number of brands in question may increase significantly during the transition from the initial review to the

collection of information. The second difference is the transition of the initiative from the seller to the consumer, who independently collects information in the ways available to them at the right moment: there are twice as many interaction points initiated by consumers today as there are points initiated by the seller. Another difference from classical marketing models is that the consumer continues to actively collect information about the product or service even after making a purchase and the efficiency of the enterprise at these points of interaction directly affects whether this consumer will make a repeat purchase. The authors (Lee, Han, Park, 2015) emphasize the need to choose marketing tools that will target the points of interaction relevant to consumers, and, of course, the balance of the importance of points differs for different market offers.

Let us perform a synthesis of the theory of a generalized cybernetic system and the McKinsey cyclic marketing model. Each of the four stages of the cyclic model can be considered as a controlled object to which the influence of the control Uk is applied. Uk can be understood as a wide range of marketing tools available to enterprises, which we will describe with a set of quantitative independent variables g within the framework of our generalized management model.

Nevertheless, the control is exposed to environmental disturbances fe, which are also the inputs of the control system – we denote them by a set of uncontrolled variables x. Based on the inputs of the variables g and x, the controlled object – one of the four points of interaction with consumers – demonstrates some output – a dependent variable S. Since the marketing model is cyclical and the interaction points alternately affect each other, the dependent variable S of the first interaction point (for example, the primary consideration of alternatives) will be an independent input variable for the second point (active information collection) and so on.

To organize feedback in the control system, it is necessary to set some program values of the variables Sp or the target direction of change S in order that, based on the deviation $D = S - Sp$ for cases with specified Sp or $D = S_t - S_{t-1}$ for cases with a given target direction of change S ? where t – time index, determine the desired control value g_t (Li, Du, 2017). Thus we have:

$$S_{it} = f(S_{jt}, g_t, x_t),\, i, j \in I$$

where i and j are indexes denoting the point of interaction with the consumer, I is the number of interaction points.

It should be noted that the definition of the four main points of interaction by the cyclic model is somewhat conditional since within each of these four points an enterprise can allocate more precisely defined points of interaction with consumers and apply appropriate marketing and communication tools, in particular, to each of them.

For clarity, we will depict the result of the performed synthesis schematically in Fig. 2.
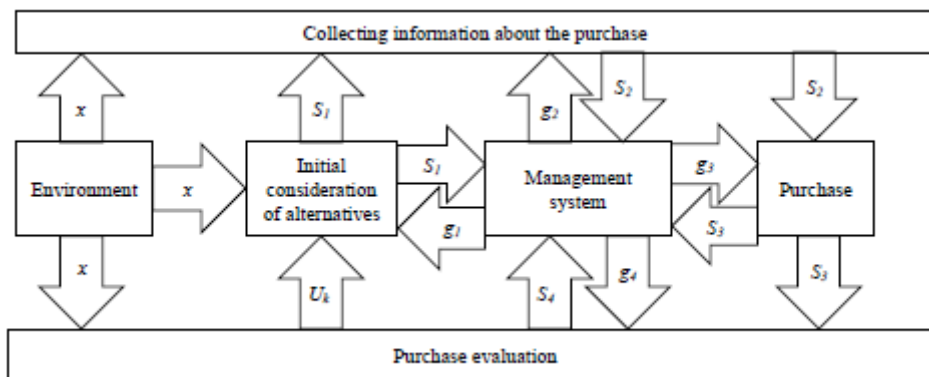
Figure 2. Schematic representation of the synthesis of the cybernetic system and the McKinsey model

Function (1) may have a different form for each interaction point, depending on which marketing tool is used, what is the nature of the product or service, and, accordingly, what effects are inherent in this interaction point and most successfully describing the nature of the influence of variables S_{jt}, g_t, x_t on S_{it}. Let us generalize this idea by the expression:

$$S_{it} = f^1(S_{jt}, f^2(g_{tk}, nn(x))),\, i, j \in I,\, k \in K$$

where $f1$ is a function describing the connection of the interaction point i from other points of interaction and influence of controlled factors of marketing activity of the enterprise and uncontrolled environmental factors;

$f2$ is a function that is selected for each interaction point i and expresses the effects that determine the influence of controlled and uncontrolled factors on consumer behavior at this interaction point,

nn(x) is a neural network.

Thus, during the implementation of a specific cybernetic system for modeling the marketing activities of a certain enterprise, it is possible to set an arbitrary relationship of inputs and outputs of interaction points *i, j* defined for the enterprise for the specific nature of marketing of this enterprise. We have a generalized model constructed (Fig. 3).
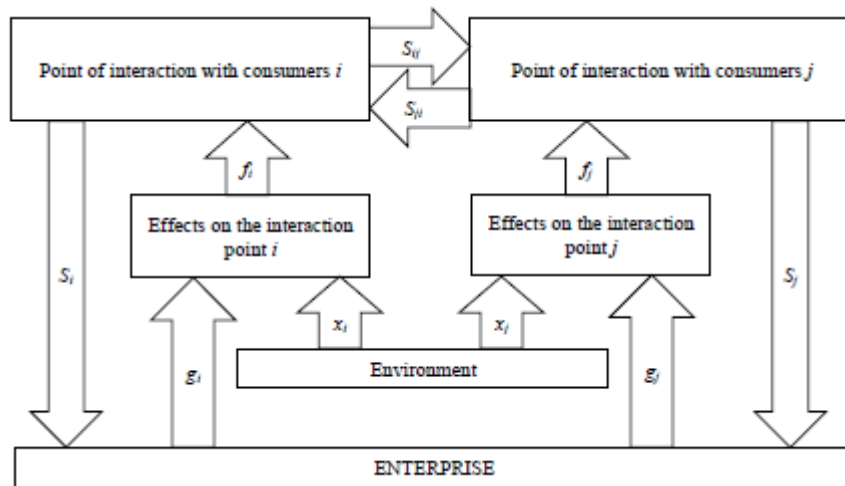
Figure 3. Block diagram of the generalized model

3. RESULTS

We investigated a marketing subsystem with one point of interaction with consumers – the display of contextual advertising on the VKontakte network (within the McKinsey model, this would be a point of interaction of the "primary consideration of alternatives" type). The output from this interaction point is the number of clicks on the link in the advertisement to the company*'s* website, that is, the next interaction point ("collection of purchase information"). The controlled impact is the amount of money spent to pay for the impressions of an advertisement on a social network. The uncontrolled impact is the characteristics describing the user who saw the advertising message. We will use the inverse exponential function as *f2*, the influence of uncontrolled factors is considered by including a neural network in the model:

$Sk\ (g,\ \alpha,\ \beta) = \alpha\ (1 - e^{-\ (nn(xk)\ +\ \beta gk)})$ (3)

where *k* is the index of a marketing tool, an advertising message,

β is the coefficient of diminishing returns on the scale, which determines the rate of saturation with advertising.

Since we are considering only one interaction point, it is not necessary to set f1.

Let us take a closer look at the neural network *nn*(*x*). It can have *n* certain input values (input neurons) that measure uncontrolled demand factors. We will have one coefficient at the output of the neural network. Since in fact, the neural network will in this case approximate some unknown function of calculating the coefficient from *n* variables, we will use the Tsybenko universal approximation theorem and apply a single-layer perceptron with three input neurons (by the number of uncontrolled variables), ten hidden neurons (experimentally verified that such a number is sufficient for a qualitative approximation of some function of three variables of unknown type) and one output neuron (an indicator of the elasticity of visits to an online store during advertising expansion).

Given that the nature of the influence of uncontrolled factors on sales is not known to us, we will suggest the existence of nonlinear effects of this influence. We apply the sigmoid activation function of neurons, which has a nonlinear form to take into account the nonlinearity.

A key element in working with neural networks is the process of training a neural network on a training dataset. As training data, we use an array of data about an advertising campaign on the VKontakte social network, the purpose of which is to attract potential consumers to visit the company's website (online store).

The array includes data on advertising messages shown to various market segments of consumers and for which various amounts of money were allocated. Each of the observations is described by the following values: Visitors – the number of consumers who saw the advertising message and visited the online store by clicking on the online link in the advertising message; Spend – the amount of money spent on the placement of this advertising message: the more money was spent, the more potential consumers were shown the advertising message on the pages social network VKontakte; Age – the age group that the advertising message was aimed at; Gender – the gender that the advertising message was aimed at; Interest – the interest group that the advertising message was aimed at.

Since the value of Spend is quantitative and it can be assumed that an increase in the amount of money spent on advertising increases the number of times an advertising message

was shown and, accordingly, the likely number of Visitors (visitors to the online store, the number of which was the target for the advertising campaign), then we will consider it appropriate to interpret Spend as a controlled variable.

Age, Gender, and Interest qualitatively describe the potential consumers to whom the advertising message was shown.

The results of a quantitative analysis of the effectiveness of advertising messages on the VKontakte social network for ten industrial enterprises producing various household appliances and household items are presented in Table 1.

Table 1
The results of a quantitative analysis of the effectiveness of advertising messages in the VKontakte social network

Enterprise	Scope of production	Controlled variables		Uncontrolled variables			Visitors*	
		Number of views	Spend, rub (1 USD = 75 rub)	Age	Gender	Interest	Forecast	Access counter
1	power tools	110,000	52,000	25-60	male	repair	1,188	1,135
2	power tools	80,000	42,000	25-60	male	repair	752	764
3	power tools	75,000	39,000	25-60	male	repair	797	742
4	appliances	150,000	55,000	30-55	female	cooking	2,113	2,084
5	appliances	125,000	48,000	30-55	female	cooking	1,923	1,986
6	appliances	140,000	53,000	30-55	female	heat treatment	2,114	2,023
7	appliances	115,000	45,000	30-55	female	heat treatment	1,697	1,768
8	appliances	55,000	31,000	25-45	female	brewing coffee	845	893
9	kitchen accessories	70,000	36,000	30-50	female	cooking	569	543
10	kitchen accessories	65,000	34,000	30-50	female	cooking	446	439

The value of the Mann–Whitney U test Uemp = 47 (Ucr = 27, p≤0.05) indicates that there are no differences between the predicted and real values of site visits. Therefore, the constructed model can accurately predict the value of the target indicator of an advertising campaign based on incoming controlled and uncontrolled variables.

4 DISCUSSION

As shown by the results of a quantitative analysis of the effectiveness of advertising messages in the VKontakte social network (Table. 1), the number of visitors depends non-linearly on the number of ad impressions: an increase in the number of advertising messages

leads to an increase in the number of visitors, but the further spread of advertising expansion has no effect after a certain level: consumers get used to advertising and stop paying attention to its further distribution.

This result is consistent with the results of the customer engagement study (Harrigan et al., 2018), according to which the relationship between engagement and the intention to use the brand also has a non-linear relationship, as well as with the study of the development of a framework for targeted marketing (Jiang et al., 2016), according to which the unlimited distribution of advertising in social networks does not lead to an increase in its effectiveness.

Therewith, it should be noted that an advertising message affects representatives of different demographic groups in different ways: the same advertisement can be effective for people of the same age group or interests and is unattractive for others (Li et al., 2018). An unsightly advertisement showed a large number of times will not have a positive effect on the target indicator of the advertising campaign (Harrigan et al., 2018).

Consequently, we concluded that the above qualitative indicators determine the elasticity of the target indicator of the advertising campaign (visitors) in terms of the volume of advertising expansion (spend). However, it is not known exactly what kind of elasticity dependence function has on qualitative indicators. Therefore, it is advisable to set this function implicitly. All of this confirms the logic of using a neural network to establish the relationship between uncontrolled variables (Age, Gender, and Interest) and the elasticity of the advertising performance model.

Investigating the limitations of this model, we concluded that the disadvantage of this model should be considered the possibility of predicting the value of the target indicator of an advertising campaign on the VKontakte social network in the absence of such an indicator as the perceived value of a marketing offer, since, according to (Harrigan et al., 2018), considering the perceived value when building marketing models of relationships with consumers increases the effectiveness of an advertising company.

Also, the proposed model does not take into account the marketing effect of "word of mouth" as uncontrolled variables with both positive and negative comments, when a positive review increases the likelihood of choosing a product (Chen, Lurei, 2013), while word of **mouth (face to face) messages** have a much lower cost and much faster spread, and this is

especially true of the popularity of social networks on the Internet (Li, Du, 2017), where online communication spreads less spontaneously and more intentionally (Eelen et al., 2017).

Thus, the article presents the disadvantages of the classical marketing model of the sales funnel, an alternative marketing model is considered, and a generalized marketing activity management model is obtained by synthesizing this model and the theory of cybernetic systems, based on which it is possible to build models of specific marketing systems of industrial enterprises. The study of the experience of using the proposed compiled model of the dependence of the target indicator of an advertising campaign on controlled and uncontrolled variables. The parameters of the model were evaluated based on a set of data about the advertising campaign.

4. CONCLUSION

The study proves that the constructed model can accurately predict the value of the target indicator of an advertising campaign based on incoming controlled and uncontrolled variables. The expediency of using a neural network was justified and the advantages of using such an approach and its combination with the previously used nonlinear model were demonstrated.

The prospect of further research may be their expansion by considering the perceived value of the marketing offer and the effects of word-of-mouth (face-to-face) communication.

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