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IMPROVING THE INFORMATION SYSTEM OF THE ENTERPRISE THROUGH THE USE OF NEURAL NETWORKS

Abstract. It is offered to consider practical aspects of application of neural networks (NN) in the marketing information system (MIS) of the enterprise. The aim of the research is to improve the information system of the enterprise by introducing an intellectual decision support system (IDSS) with the use of the neural network and considering its capabilities in forecasting the state of the marketing environment. As a result of the study, recommendations for the use of such an improved system have been developed and testing has been carried out in three directions. The first direction is the forecasting of the indicators of the macro environment of the company as the main factor of the marketing environment, by developing an appropriate mathematical model, in order to implement appropriate exit strategies for external markets. The second direction is the use of NN in forecasting the state of the elements of the internal environment of the enterprise, for example, an enterprise providing engineering services. The third direction the approbation proved the effectiveness of the application of NN for the forecast of macroeconomic indicators.

Consequently, the proposed subsystem of analysis and forecasting on the basis of the IDSS with the use of NN will enable to predict the indicators of the marketing environment of the enterprise. On this basis, managers will be able to make informed decisions based on the information foundation, adequate actions, skilled performance and, as a result, to ensure the success of the entire enterprise.

The specificity of the IDSS with the neural network proposed in the study is that decision

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support from different functional areas of the enterprise is supported on the basis of predictive results obtained through neural networks. The development of the proposed method is due to the need for training artificial neural networks for intelligent decision support systems, in order to process more information.

Keywords: *marketing environment, information system, neural network, decision making, forecasting*

Introduction. The urgency of the work is that the basis of the successful market activity of a modern enterprise is the marketing and MIS, which covers all functional areas of its activity, and which becomes an important foundation in making strategic and tactical marketing decisions. The use of artificial intelligence capabilities through the implementation of the IDSS in the MIS of the enterprise will provide management with high-quality information to make effective management decisions, which, in turn, will increase the competitiveness of the firm in the market. However, the use of neural network capabilities has not yet been sufficiently studied and has not become widely used in Ukrainian enterprises. At the same time, the possibilities of neural networks are gaining more and more sectors of the economy, precisely because of the relative ease of application and quality of results in modeling and forecasting of economic processes and market situation.

The specificity of the IDSS with the neural network proposed in the study is that decision support from different functional areas of the enterprise is supported on the basis of predictive results obtained through neural networks. Such an MIS will ensure the adaptation of the enterprise to changes in the environment, will enable, through the introduction of a subsystem of analysis and forecasting with embedded IDSS based on the NN to monitor, accumulate information for further training NN. Trained NN will allow IDSS to analyze the status of the marketing environment, assess the extent, nature and direction of its impact on the company's position in the strategic perspective. Ultimately, the functioning of a full-fledged marketing information system should orient the management of the company to choose the most optimal marketing strategy (from the list of strategic alternatives), and will enable the systematic tracking of marketing positions and provide options for making the necessary corrective measures in case of changes. At the same time, such an MIS will allow to accumulate insufficient data and provide continuous monitoring, training and provision of already prepared information to managers of all levels for decision making, taking into account changes in the main environmental factors in the dynamics.

Analysis of recent research and publications. The research of the use of neural networks was carried out by domestic and foreign scientists: S. Kalantaievska, H. Pievtsov, O. Kuvshynov, A. Shyshatskyi, S. Yarosh, S. Gatsenko (2018), N. Kuchuk, A. Mohammed, A. Shyshatskyi, O. Nalapko (2019), J. Zhang, W. Ding (2017), L. Katranzhy, O. Podskrebko, V. Krasko (2018), E. Manea, D. Di Carlo, D. Depellegrin, T. Agardy, E. Gissi (2019), A. Çavdar, N. Ferhatosmanoğlu (2018), G. Kachayeva, A. Mustafayev (2018) et al.

The questions of application of informational-analytical decision-making systems were investigated both by foreign and domestic scientists: S. Bratushka, M. Demydenko, V. Sytnyk, S. Subbotin, L. Shchavelov, Yu. Synytsina (2019), O. Kaut, T. Fonareva and others.

The problems of building the MIS of the company are covered in works O. Frolenko (2014), Ya. Panukhnyk, O. Sokhatska (2005), but the improvement of the MIS precisely with the use of IDSS based on neural networks is not highlighted. In 2017, a study was carried out on the mathematical model of forecasting macroeconomic indicators of the economy of Ukraine, but The questions of the role of neural networks for forecasting processes of the internal environment of the enterprise are not covered.

Therefore, improvement of the information system of the enterprise through the implementation of the IDSS on the basis of the NN will solve the problems that cover all aspects of the enterprise. The analysis showed that the main difficulties in the way of even more widespread neurotechnology are the lack of practical developments and recommendations for using their capabilities in marketing and personnel management, the inability of a wide range of professional managers to use the NN and formulate their problems in terms of understandable for systems with artificial intelligence.

The purpose of this work is improvement of the information system of the enterprise through the implementation of the IDSS on the basis of the NN.

Formulation of the main material. Rigid statistical requirements for the characteristics of time series limit the possibilities of methods of mathematical statistics, the theory of image recognition, theories of random processes, etc. The fact is that most real processes can not be adequately described using traditional statistical models, since they are essentially nonlinear and have either a chaotic or quasi-periodic or a mixed basis. In this case, special artificial networks can serve as an adequate apparatus for solving problems of diagnostics and forecasting, implementing the ideas of forecasting and classification in the presence of learning sequences.

Neural Network (NN) – a collection of neural elements and connections between them. The main element of the neural network is the formal neuron, which performs the operation of non-linear transformation of the sum of the inputs of the input signals into weight coefficients. Different learning algorithms and their modifications are used to teach the network. It is very difficult to determine which learning algorithm will be the fastest in solving a particular task. The most interesting for us is the algorithm of reverse error propagation, as it is an effective means for teaching multilayer neural networks of direct distribution.

It is also known to use the algorithm of error backpropagation for automatic analysis of electrocardiograms in the diagnosis of cardiovascular diseases in the works of the authors G. Kachayeva, A. Mustafayev (2018) and to detect the occurrence of avalanches by V. Zhdanov (2016).

The algorithm minimizes the mean square error of the neural network. To do this, in order to set up synoptic bonds, the method of gradient descent in the space of weight coefficients and thresholds of the neural network is used. In order to accelerate the learning process, instead of the constant learning step, it is suggested to use the adaptive learning step α (t). The algorithm with an adaptive learning step works 4 times faster. At each stage of the network learning, it is selected in such a way as to minimize the square root of the network error (Sokhatska & Romanchukevych, 2005).

For prediction of systems based on NN, the best quality is shown by a

heterogeneous network consisting of hidden layers with a nonlinear activation function of the neuronal elements and the output or linear neuron. The disadvantage of most of the considered nonlinear activation functions is that the range of their initial values is limited by the segment [0,1] or [-1,1]. This leads to the need to scale the data, if they do not belong to the above range of values. In the paper, we propose to use a logarithmic activation function for solving prediction problems, which allows obtaining a forecast much more accurately than using a sigmoid function.

The architecture of the neural network plays an important role for the network learning efficiency. We used a three-layer neural network, which allows to approximate any function with arbitrarily given accuracy. Accuracy is determined by the number of neurons in the hidden layer, but with too much dimension of the hidden layer may occur a phenomenon called redistribution of the network. To eliminate this disadvantage it is necessary that the number of neurons in the intermediate layer is significantly less than the number of training images. On the other hand, with a very small dimension of a hidden layer, you can get into an undesirable local minimum (Sokhatska & Romanchukevych, 2005).

This study is aimed specifically at the development of specific recommendations for the application of NN in the enterprise information system.

In a changing economic environment, it is very important not only to analyze the state of macroeconomic indicators but also to be able to predict their state for the future. Therefore, forecasting of macroeconomic indicators with the help of models becomes an integral part of the strategic planning of the development of any organization or state in general. The modeling of economics based on the LAM (Long-run Adjustment Model) has been developed to model and forecast the economies of Eastern European countries during the transition period. The research used the LAM 3 model. This model is considered as a small model whose purpose is to analyze and short-term (quarterly) forecast of the main macroeconomic indicators: GDP, imports, exports, consumer price index, income and consumption indicators, investments, average income per capita and employment, unemployment, demand for money and others. The model is easy to manage and easy enough to accompany. There is an opportunity for quick access to the correction of the model when new data is available. The structure of the model for different national economies does not change, it differs only in the input parameters. The model itself consists of 25 equations: four of them describe long-term dependencies, twenty one is short-term. The basis of the LAM-3 model is the bilinear autoregression vector (Bilinear Vector AutoRegressive model – BiVAR).

Thus, the authors developed an econometric macromodel for analysis and short-term forecasting of aggregate demand in Ukraine, including endogenous and exogenous variables.

Endogenous variables are GDP; final consumption of households and non-profit organizations that serve them; final consumption of government institutions; gross accumulation; export of goods; import of goods; export of services; import of services; foreign trade balance; cash income of the population; labor remuneration of employees; balance of purchase and sale of foreign

currency.

The exogenous variables in the macro model are the nominal exchange rate of the UAH relative to the US dollar; nominal tariff rate of the first category; average number of employees employed in the economy; nominal average wage of one employee; labor productivity (Synytsina & Kaut et al., 2019, Savchuk & Bushuyev, 2017).

These interconnections are of crucial importance for choosing key policy orientations in Ukraine, therefore, they are represented in a macro model by a system that includes autoregressive equations of GDP deflator, money supply (M2). The macro model is also supplemented by the regression equation for the foreign exchange purchase and sale balance indicator (Synytsina & Kaut et al., 2019, Savchuk & Bushuyev 2017).

The basis of the macro model was the well-known Keynes equation, according to which GDP can be obtained by the end-use method (Synytsina & Kaut et al., 2019, Savchuk & Bushuyev 2017):

$$gdp_t = fchn_t + fcg_t + gcf_t + saldo_t \quad (1)$$

where: gdp_t – GDP;

$fchn_t$ – final consumption of state farms and non-profit organizations that serve them;

fcg_t – final consumption of government institutions;

gcf_t – gross accumulation;

$saldo_t$ – net exports of goods and services.

When constructing an econometric model of final consumption of households and non-profit organizations serving them, factors are taken into account cash income of the population and accumulation of savings in deposits, securities, balance of sale of foreign currency by banks, (Savchuk, L., & Bushuyev, K., 2017), that is:

$$fchn_t = f_1(MINC_t, ASAV_t) \quad (2)$$

In the standard version of the macromodel, this equation also took into account the influence of the nominal UAH against the US dollar (EU_t). Since cash foreign currency in hands and on accounts with banks is one of the forms of saving of the population of Ukraine, it is necessary to take into account the influence of the nominal exchange rate during the modeling except for the previously mentioned nominal UAH against the US dollar, affect the cash income of the population (Savchuk, L., & Bushuyev, K., 2017):

$$ASAV_t = f_2(MINC_t, EU_t) \quad (3)$$

A separate element of the macro model is the regression dependence of real cash income of the population on its level in the previous period and the payment of employees (Synytsina, Yu., & Kaut, O. et al., 2019, Savchuk, L., & Bushuyev, K., 2017):

$$MINC_t = f_3(CE_t, MINC_{t-1}) \quad (4)$$

The most significant factors determining the payment of labor are productivity (p_t), tariff rate of the first category (***WRt***) and the average number of employed employees (***anet***). Taking into account the above model will look (Synytsina & Kaut et al., 2019, Savchuk & Bushuyev, 2017):

$$CE_t = f_4(p_t, WR_t, ane_t) \quad (5)$$

Another component of aggregate demand is the final consumption of state institutions. For this indicator, the following econometric models were developed: a model from tax revenues to the budget; model of consolidated budget expenditures; model from the tariff rate of the first category; model of the number of employed in the public sector of the economy (Synytsina & Kaut, et al., 2019, Savchuk & Bushuyev, 2017).

Neural network programming was used to perform practical calculations and further analysis of the results. This is due to the fact that the rigid statistical requirements for the characteristics of time series limit the possibilities of methods of mathematical statistics, the theory of pattern recognition, theories of random processes, etc. The fact is that most real processes can not be adequately described using traditional statistical models, since they are essentially nonlinear and have either a chaotic or quasi-periodic or a mixed basis.

In this case, an adequate device for solving problems of diagnosis and forecasting is the special artificial networks implementing the ideas of forecasting and classification in the presence of learning sequences, and, as a very promising, it is worthwhile to note the radial-basic structure, the distinguishing factor of which is high learning speed and universal approximating capabilities (Sokhatska & Romanchukevych, 2005).

Investigating the MIS of Ukrainian enterprises for some time, the authors came to the conclusion that they mostly have a marketing information system of open architecture and support a strategy for gradually increasing its functional capabilities. As a rule, the company's MIS model has a standard appearance, i.e. information is provided on the input from the external and internal environment of the enterprise, from it the database is formed, further through the means of information processing, namely software and hardware, are submitted to the output and used for the adoption of appropriate management making decisions. The analysis of the MIS of the enterprises revealed a number of shortcomings that the company inevitably encounters, namely: deficit of the necessary or excess of unnecessary information; dispersal of information in different divisions of the enterprise, which makes it difficult to find it; concealing information by employees, which may indicate disadvantages in their work; late arrival of important information; the impossibility of determining the completeness of information, accuracy, etc.; Output information is not prepared, i.e. not grouped and not systematized properly for making marketing decisions (Synytsina & Kaut et al., 2019, Savchuk & Bushuyev, 2017).

To enhance the system's capabilities, the authors proposed to improve its subsystem of analysis and forecasting by creating an intellectual decision support system (IDSS). The authors propose a schematic diagram of such an IDSS using neural networks.

Proceeding from the priorities of the company, the software product created will allow modeling and forecasting macroeconomic indicators of both

the internal and external market on which the firm plans to work. Also, one of the main tasks of the enterprise is to take part in tenders for automation of production at large industrial enterprises. Therefore, the problem of calculating the projected cost of the project for the provision of engineering services for automation and adjustment of equipment becomes acute.

The specificity of the IDSS with the neural network, which is proposed in the work, is that the analysis and selection of marketing decisions is carried out on the basis of the predictive results obtained with the help of neural networks. The user interface is a software suite, which should provide a simple and convenient interaction between the system and the end user. It includes various scripts (menus) of work.

At the same time, the work of the user, in the role of which is an manager, is to enter the necessary input data to get the predictive value using the IDSS, based on which will be made a managerial decision.

Approbation of the proposed improvement was carried out in two directions:

– firstly, the possibility of analyzing the macroeconomic environment of the enterprise and forecasting macroeconomic indicators were carried out on the example of Ukraine, for this purpose the data of the State Statistics Committee and the corresponding econometric model were used;

– secondly, one of the complex tasks for engineering services companies was solved, namely, the projected cost of the project on the automation of the cotton pressing line for the enterprise of Uzbekistan was calculated, which will provide access to the foreign market.

Let’s consider in more detail the results of approbation in three directions.

The implementation of the model experiment and the analysis of the results of the experiment was carried out on an example of the analysis of the macro environment of the enterprise. The model of the LAM-3 series based on international trade equations was used in the work. The model is easy to manage and easy enough to accompany. There is an opportunity for quick access to the correction of the model when new data is available. The structure of the model for different national economies does not change, it differs only in the input parameters. The model itself consists of 25 equations: four of them describe long-term dependencies, twenty-one short-term. The basis of the LAM-3 model is the bilinear vector auto regression model (BiVAR).

The statistics were compiled on the basis of selected indicators of the model for the period from 1991 to 2020. To perform practical calculations and further analysis of the results, the following software was used:

1. The EXCEL package, for statistical analysis and calculation of parameters and criteria of the simplified macroeconomic model of the Ukrainian economy.

2. Own software product developed, which allowed obtaining the forecast value of Ukraine's Gross Domestic Product (GDP) for a certain year, and analyze various algorithms of training neural networks for predictive quality, to investigate various structures of neural networks and compare results (Synytsina, Yu., & Kaut, O. et al., 2019, Savchuk, L., & Bushuyev, K., 2017). The software interface is shown in Figures 1, 2, 3.

The prognostic value of the macroindicator is shown in Figure 3, where the red line is the projected value of GDP, and the blue is the real GDP.

Thus, with the help of neural networks, the forecast value of GDP was obtained. For each structural equation, the neural network was used for the corresponding statistical data for the period of 28 years. To teach neural networks, as already noted, the user can use two learning algorithms: genetic and reverse error propagation, and different types of neural networks: based on radial-basic functions, multilayer perceptron with sigmoid activation function.

Here are some important parameters for setting up training algorithms and neural networks in general:

1. For the genetic algorithm, the following probabilistic parameters were chosen: probability of mutation , and we perform crossover of random individuals at every step, because our statistics have a limited number, then there is no need for a longer study. Number of individuals in the population 50.Training continues until the error of the most adapted individuals will not provide the necessary accuracy.

2. In the algorithm BP error rate of learning is 0.01. The training is a given number of iterations (200 iterations).

3. In the radial-basic neural network, we use the Gaussian function as an activation function.

4. In a multilayer perception, we use the activation function of the hyperbolic tangent.

In order to determine the structure of the neural network conducted test tests. So, for the input of the neural network, we always have the number of independent variables of the corresponding structural equation.

gdp=fchn+fcg+gcf+saldo
1. fchn = f1(MINC,ASAV)
2. ASAV = f2(MINC, EU)
3. MINC = f3(CE,MINC(t-1))
4. CE=f4(p,WR,ane)
5. gcf = f5(gdp(t-1))
6. saldo = f6(XG, XS, MG, MS)

Figure 1 – Structural form of the developed macroeconomic model of Ukraine

Figure 1 presents the structural form of the developed macroeconomic model of Ukraine (for the corresponding notations and formulas see above).

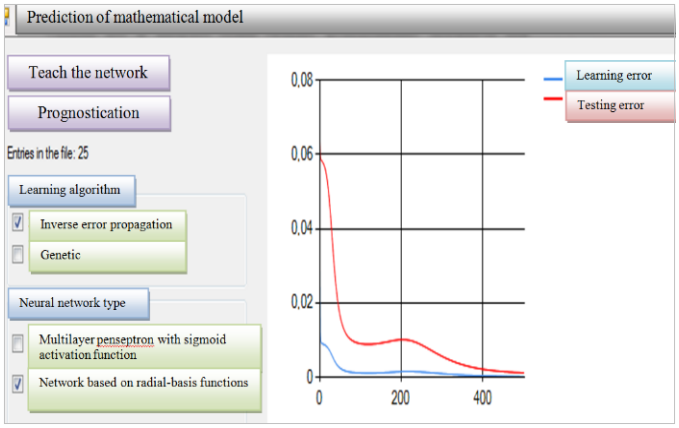

Figure 2 – Neural Network Training Schedule (Synytsina, Yu., Kaut, O.,

& Bushuiev, K., 2019)

But to determine the number of neurons in the hidden layer, test runs were performed and given for each pair (algorithm, type of network.

For each pair (algorithm, type of network) training was performed and the results recorded. Analyzing them, we arrive at the conclusion that the best predictive properties for a constructed mathematical model of macroeconomics of Ukraine demonstrate a genetic algorithm using radial-basic functions of the algorithm Back propagation. The obtained percentage error for our statistical sample based on the constructed mathematical model can be considered acceptable.

The developed software product, based on neural networks based on statistical data, allows to predict macroeconomic indicators not only of Ukraine and other countries when the company leaves the relevant foreign markets.

Consider approbation of the developed software product in the second direction of research. Consequently, the definition of the project price, that is, the calculation of the cost of engineering services is one of the most difficult issues that is agreed upon between the customer and the executor (consultant) at the stage of contracting. This is due to the variety of services provided and their non-standard, impossibility to pre-set the final amount of work required and the total amount of costs associated with their implementation. Therefore, the cost of services, which was determined at the stage of contracting, can be adjusted in accordance with actual costs at the end of the work.

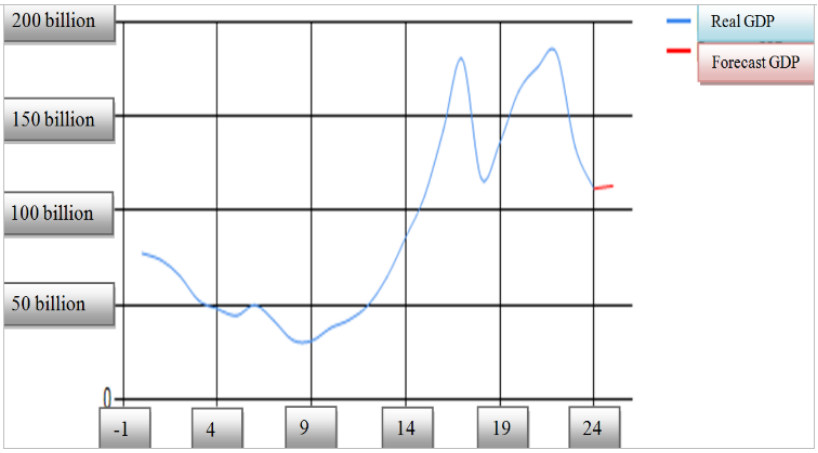

Figure 3 – Forecast value of the macroeconomic indicator (Synytsina, Yu., Kaut, O., & Bushuiev, K., 2019)

Consequently, we will calculate the forecast value for the provided engineering and consulting services for the automation of the cotton pressing line for enterprises in Uzbekistan. In order to successfully enter this foreign market, the company must submit a project with a predetermined forecast value, which would ensure the competitiveness of the company in obtaining a tender for the execution of works. To do this, we use the method of calculating the remuneration for the provided engineering and consulting services at actual costs plus a fixed remuneration.

The manager has the projected cost of equipment, the cost of installation work, equipment adjustments, the number of workers who will carry out installation and adjustment, the expected amount of wages for workers, all taking into account the projected UAH exchange rate. So, in the end, we received the projected cost of the project, which is 396 448 UAH.

Stages of such accounting using NN are presented in Figure 4.

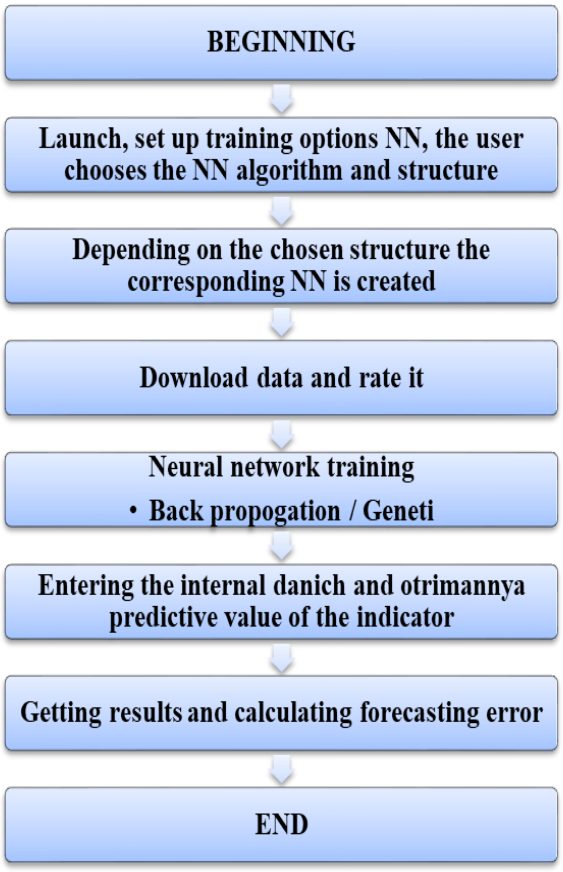

Figure 4 – Stages of the work of the software product .

Conclusions.

1. The marketing information system of the enterprise, which includes the subsystem of observation and research and the subsystem of analysis and forecasting, is developed. Such a MIS will ensure the adoption of more informed marketing decisions and obtain on this basis more profits of the company.

2. The introduction of IDSS based on NN, which allows to take the most important decisions in an interactive mode, will allow to analyze, plan and control various marketing actions and design them on the basis of "what if". As a result, a large range of rather complex tasks, which previously could only be performed by skilled professionals in the field of marketing and management, with the help of IDSS can also be implemented by specialists of related divisions.

3. The created software provides training of the neural network based on

the input data for previous years and allows the trained neural network to make a forecast of the indicators of the enterprise.

4. Verification of the developed software product is carried out. The results of the approbation proved the effectiveness of the application of NN for the forecast of macroeconomic indicators.

5. The capabilities of a software product based on NN tested in the enterprise to provide engineering services, namely, the cost of the automation project was predicted to participate in the tender for the receipt of an order. The results prove the effectiveness of using such a product in the enterprise.

The obtained results prove the necessity of continuous updating of the marketing information system of the enterprise in accordance with the modern development of information technologies and their introduction in order to make more informed marketing decisions and obtaining on this basis a greater profit of the company, which will ensure sustainable development of the company.

Conflict of Interest and other Ethics Statements

The authors declare no conflict of interest.

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УДОСКОНАЛЕННЯ ІНФОРМАЦІЙНОЇ СИСТЕМИ ПІДПРИЄМСТВА ШЛЯХОМ ВИКОРИСТАННЯ НЕЙРОМЕРЕЖІ

Анотація. У статті проведено дослідження використання нейронних мереж у інтелектуальній системі підтримки прийняття рішень на підприємстві та сформульовано модель аналізу, а також дослідження можливостей нейромережевих методів прогнозування в інтелектуальній системі підтримки прийняття рішень у процесі управління підприємством. Запропоновано розглянути практичні аспекти застосування нейронних мереж (НС) у маркетинговій інформаційній системі (МІС) підприємства. Метою дослідження є удосконалення інформаційної системи підприємства шляхом впровадження інтелектуальної системи підтримки прийняття рішень (IDSS) з використанням нейронної мережі та врахуванням її можливостей у прогнозуванні стану маркетингового середовища. За результатами дослідження розроблено рекомендації щодо використання такої вдосконаленої системи та проведено випробування за трьома напрямками. Перший напрям – прогнозування показників макросередовища компанії як основного фактора маркетингового середовища шляхом розробки відповідної математичної моделі, з метою реалізації відповідних стратегій виходу на зовнішні ринки. Другий напрямок – використання НН при прогнозуванні стану елементів внутрішнього середовища підприємства, наприклад, підприємства, що надає інженерні послуги. Третій напрямок апробації довів ефективність застосування НН для прогнозу макроекономічних показників.

Отже, запропонована підсистема аналізу та прогнозування на основі ІСС з використанням НН дозволить прогнозувати показники маркетингового середовища підприємства. На цій основі керівники зможуть приймати виважені рішення на основі інформаційної основи, адекватних дій, кваліфікованого виконання і, як наслідок, забезпечити успіх всього підприємства. Специфіка IDSS із запропонованою в дослідженні нейронною мережею полягає в тому, що підтримка прийняття рішень з різних функціональних областей підприємства підтримується на основі прогнозних результатів, отриманих за допомогою нейронних мереж.

Ключові слова: *маркетингове середовище, інформаційна система, нейронна мережа, прийняття рішень, прогнозування*