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STOCHASTIC METHODS OF MACHINERY ENTERPRISE ENDOGENOUS INNOVATIVE POTENTIAL REALIZATION MANAGEMENT

The article deals with ways to determine management of the machine-building enterprise endogenous innovative potential (EIP) realizing through gross profit forecasting based on its EIP reserves values. Methods of the statistical analysis and economic-mathematical modeling are used to forecast dependent variable (gross profit). The offered models enable to make decisions concerning realization of enterprise reserves through innovative implementations and to predict values of enterprise gross profit. Unlike existing models, the offered model operates with factors which are more connected with enterprise potentiality category.

Keywords: neural network, support vectors model, reserves of enterprise, endogenous innovative potential, machinery enterprise.

Problem statement. Implementation of innovative decisions is closely connected with operating activity at machine-building enterprise and considerably influences its results. Therefore research of approaches to machinery enterprise innovative potential realization management is an urgent task for scientists-economists.

Analysis of recent researches and publications. In scientific sources the questions of innovations implementation management, choice of innovative development alternatives, estimation of innovative projects are deeply investigated by N.I. Chuhray [7], T.V. Grinko [2], I.V. Fedulova [4], N.O. Shkvyirya [8], V.F. Kolesnichenko [3], I.V. Feofanova [5], N.V. Bondarchuk [1], V.M. Chubay [6], X. Chang [9], Márquez-Ramos L. [10].

However nowadays there is no special approach which enables to manage directly realization of an internal component of enterprise innovative capacity. This approach has to be aimed not at the development of innovative potential, as this category isn't an ultimate goal of enterprise activity, but at its realization to receive commercial results.

The aim of article is to define effective stochastic methods to manage realization of the endogenous innovative potential (EIP) at machine-building enterprise through forecasting enterprise gross profit level, based on EIP values reserves. In order to solve this aim it is necessary to realize such tasks: to study EIP essence; to model by support vectors method and neural network to forecast gross profit of machine-building enterprise; check of reliability results concerning economic-mathematical model through the residuals function.

Main material. N.I. Chuhray claims that innovative potential is formed by two main components: innovative potential of material resources and intellectual potential [7, p. 17]. I.V. Fedulova considers innovative potential as set of the intellectual, physical, financial resources and innovative products organized in certain social and economic forms [4, p. 8]. T.V. Grinko understands the resources necessary to realize the planned innovation as innovative potential [2, p. 19]. V.M. Chubay estimates innovative potential due to such spheres: personnel, research, material, financial and economic, organizational and administrative [6, p. 184-185]. N.V. Bondarchuk notes need in information, personnel and financial security of innovative activity; suggests to consider innovative development process of the economic activity subject in interaction with competitors [1, p. 65]. As V. F. Kolesnichenko states innovative potential of the enterprise can be estimated by indicators of fixed assets change index, capital productivity, profitability of the investment capital [3, p. 10]. I. V. Feofanova provides plurality of innovative strategy resources at the enterprise which include information, qualified personnel and finance [5, p. 8].

Effective method of stochastic economic-mathematical modeling is the method of support vectors which belongs to machine learning methods. The method of support vectors is method of statistical study which enables to solve regression problems by means of study, based on observations. According to training observations approximation of function minimizing a model error is carried out.

Creation of neural networks models belongs to data mining methods which enables to model high efficiency dynamic stochastic processes with nonlinear links between variables. A task of the neural network is to forecast dependant variable (gross profit of machine-building enterprise) on the basis of independent variables (process, product, marketing and organizational reserves of machine-building enterprise which constitute its endogenous innovative potential).

Multilayered perceptron to solve the objective of regression will have one input layer which consists of four inputs (process, product, marketing and organizational reserves of machine-building enterprise), of one hidden layer and one output layer which has one output (gross profit of machine-building enterprise).

By experimental studies it is necessary to establish optimum amount of the hidden layer neurons which will enable to minimize the sum of model errors. Multilayered perceptron with such optimum structure will show the best results in approximation of machine-building enterprise gross profit function. It will allow predicting value of a dependant variable with the maximum accuracy depending on independent variables change.

For the purpose of cross-checking training observations are divided into three parts: training, test and validation. Training observations are directly used for neural network education and establishment of weight values. Test observations are not applied in the course of study and do not serve for establishment of weight values. Test set of observations play role of establishing that the neural network is capable to show good result both on educational data, and on new data that means lack of data excessive adjustment which is called overfitting. The validation set of observations are used to check the overall possibility of a neural network to predict the values of the dependant variable.

The statistical model of a neural network can be described by function in compliance to (form. 1):

$$y = f\left(\sum_{i=1}^{n} w_i x_i\right), \tag{1}$$

where w_i – weights values, $i = \overline{1,n}$; x_i – inputs values, $i = \overline{1,n}$.

Function $f\left(\sum_{i=1}^{n} w_i x_i\right)$ is applied as function of neurons activation. To activate neurons of the hidden layer in suggested neural network tanh transfer function is used in compliance to (form. 2):

$$th\ x = \frac{e^{2x} - 1}{e^{2x} + 1}. \tag{2}$$

To activate neuron of an output layer in suggested neural network identity transfer function is used according to (form. 3):

$$id_x(x) = x. \quad (3)$$

Objective function of MLP is the task to minimize the number of neural network errors according to (form 4):

$$E = \sum_{j=1}^{m} (y_j - t_j)^2 \to min, \quad (4)$$

where t_j – true j's value of output layer's neuron, $j = \overline{1,m}$.

T.V. Grinko considers essence of innovative potential of the enterprise as the solution of urgent tasks of innovative development, a choice of concrete innovative strategy. The author notes that innovations differ due to resources which are necessary for their realization. It is suggested to coordinate implementation of innovations for the enterprise purpose, and to assess the innovative potential [2, p. 6]. The author's opinion is close to the suggested approach.

Let us investigate connection between variables by linear model of support vectors. During calculations observations are divided into parts: for training (54 observations) and for testing (18 observations).

Correlation coefficient due to the model of support vectors equals 0,81, which means that statistical connection between predictors and a dependent variable is close. The descriptive statistics of support vectors model (SVM) is given in Table 1.

Table 1 – **Descriptive statistics of SVM**, (author's calculations)

Observed mean	4 319 919,74
Predictions mean	4 057 649,47
Observed standard deviation	3 090 237,80
Predictions standard deviation	2 720 088,42
Sum of squared error	3 323 646 110 269,49
Error mean	262 270,26
Error standard deviation	1 816 783,84
Absolute error mean	1 372 724,49
Error standard deviation to predictions standard deviation ratio	0,59
R	0,81

Suggested SVM (C = 10,000, epsilon = 0,100) uses radial basic function (gamma = 0,250), quantity of support vectors is 35 (26 are bounded).

As N.O. Shkvyirya marks out, the enterprises aspiring to fix the positions in the market have to improve the goods continuously, enhance production and administrative processes, thus to be engaged in innovative activity [8, p. 8]. Therefore, the endogenous innovative potential is existence of reserves for improvement in process, product, marketing and organizational spheres.

Neural network modeling of economic processes is more difficult method of stochastic economic-mathematical modeling which enables to display better the nonlinear links between variables.

Suggested neural network has architecture of a multilayered perceptron (MLP). In order to calculate MLP a BFGS method of back propagation is used.

Experiments to select optimum structure of a neural network enable to allocate five best options of neural networks. Their descriptive statistics are presented in Table 2.

Table 2 – **Descriptive statistics of the best neural network options**, (author's calculations)

Neural network structure	Correlation coefficients		
	Training R	Test R	Validation R
MLP 4-37-1	0,82	0,79	0,94
MLP 4-89-1	0,82	0,85	0,95
MLP 4-6-1	0,81	0,80	0,94
MLP 4-41-1	0,82	0,79	0,95
MLP 4-11-1	0,82	0,74	0,95
Neural network structure	Sum of squared error		
	Training SOS	Test SOS	Validation SOS
MLP 4-37-1	1 621 252 049 052,18	1 682 403 296 238,65	787 550 867 343,80
MLP 4-89-1	1 567 985 816 829,65	1 169 854 404 848,93	863 914 519 762,55
MLP 4-6-1	1 700 319 115 377,82	1 610 914 537 000,87	770 453 579 091,04
MLP 4-41-1	1 625 680 661 513,50	1 608 371 627 729,81	793 708 352 504,39
MLP 4-11-1	1 605 630 963 363,78	1 904 892 904 720,13	611 268 204 226,48

Let us consider descriptive statistics of residuals functions of MLP 4-6-1 network and SVM which are given in Table 3.

Table 3 – **Descriptive statistics of residuals of MLP 4-6-1 network and SVM**, (author's calculations)

Residuals functions of	Indexes			
	Skewness	Error	Kurtosis	Error
MLP 4-6-1	0,74	0,28	0,96	0,56
SVM	0,81	0,28	1,07	0,56

Histograms of MLP 4-6-1 network residuals functions and SVM are presented on Figures 1 and 2.

X. Chang underlines that the major advantage to apply neural networks is that they do not depend on simplified assumptions such as linear behavior [9, p. 239].

As values of skewness and kurtosis do not exceed tripled errors of their representativeness, residuals functions of MLP 4-6-1 network and model of support vectors are close to normal distribution which testifies lack of undetected regularities in educational set of observations which means the suggested models reliability.

The best results to approximate gross profit function are shown by MLP 4-6-1 network, sum of squared errors of which is 770 453 579 091,04 for validation observations.

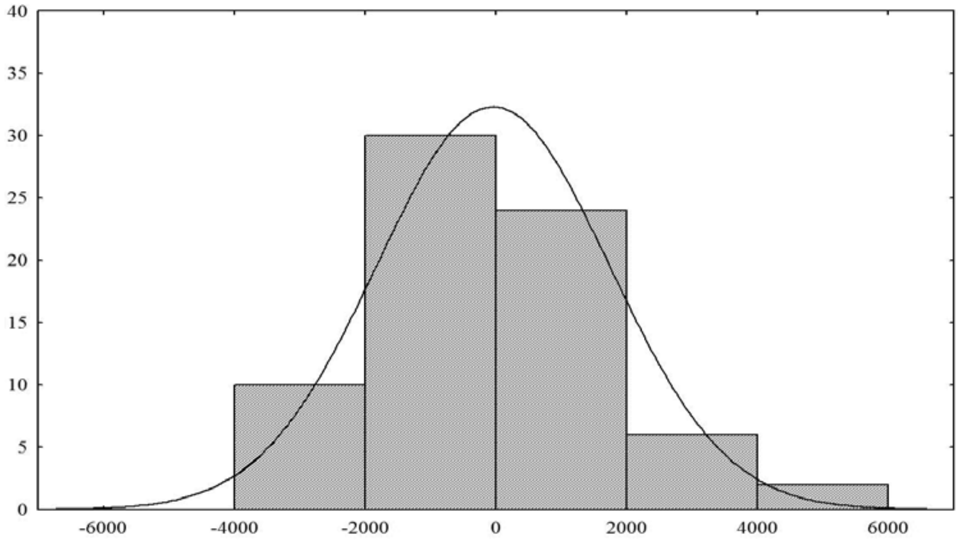

Figure 1 – **Histograms of MLP 4-6-1 network residuals functions Source,** (author's calculations)

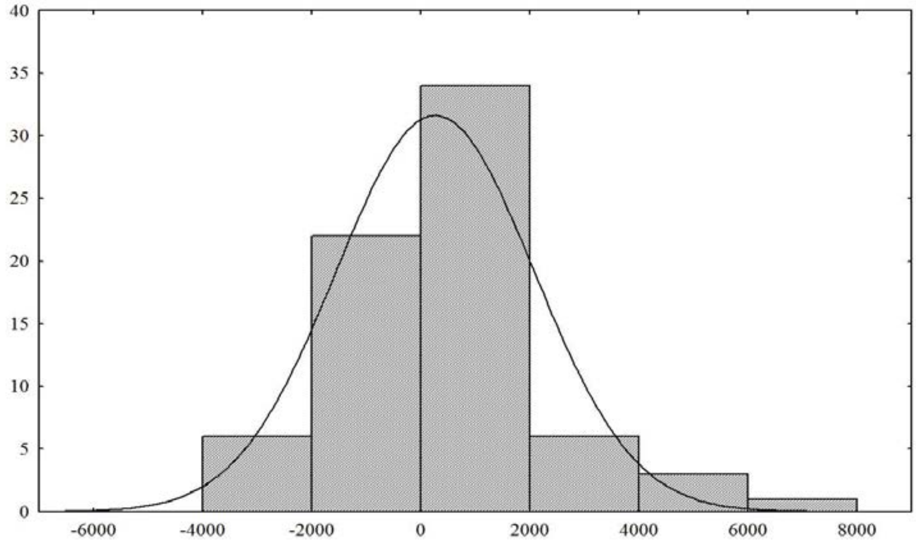

Figure 2 – **Histograms of SVM residuals functions Source,** (author's calculations)

The correlation coefficient for validation observations of MLP 4-6-1 network is 0,94. It demonstrates strong statistical link between independent and dependent variables. Sum of squared errors of the support vectors calculated model is 3 323 646 110 269,49. It is more, than value of the MLP 4-6-1 network (770 453 579 091,04) corresponding indicator, and correlation coefficient is lower (0,81 compared with 0,94). Therefore it is suggested to use

MLP 4-6-1 network which shows the best statistical results to forecast dependent variable.

Conclusions. The suggested technique to create support vectors model and neural network enables to forecast the gross profit level of machine-building enterprise depending on values, i.e. its process, product, marketing and organizational reserves, constituting its endogenous innovative potential. It makes possible to implement innovative decisions taking into account the level of innovative potential competitiveness at the enterprise and to estimate their influence on gross profit at the machinery enterprise.

Further research has to be directed to define and manage innovative decisions which are applicable for realization of endogenous innovative potential at the machinery enterprise.

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Стохастичні методи управління реалізацією ендогенного інноваційного потенціалу машинобудівного підприємства

У статті розроблені моделі опорних векторів та нейронної мережі, які дають змогу приймати рішення щодо реалізації резервів машинобудівного підприємства через інноваційні впровадження та прогнозувати значення валового прибутку підприємства. На відміну від існуючих запропоновані моделі оперують факторами, найбільш пов'язаними з категорією потенції підприємства.

Ключові слова: нейронна мережа, модель опорних векторів, резерви підприємства, ендогенний інноваційний потенціал, машинобудівне підприємство.

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Стохастические методы управления реализацией эндогенного инновационного потенциала машиностроительного предприятия

В статье разработаны модели опорных векторов и нейронной сети, позволяющие принимать решения относительно реализации резервов машиностроительного предприятия через инновационные внедрения и прогнозировать значения валовой прибыли предприятия. В отличие от существующих предложенные модели оперируют факторами, наиболее связанными с категорией потенции предприятия.

Ключевые слова: нейронная сеть, модель опорных векторов, резервы предприятия, эндогенный инновационный потенциал, машиностроительное предприятие.

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