Models and strategies for financing innovative energy saving activities

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Models and strategies for financing innovative energy saving activities

Valeriy Heyets[1], Mykhailo Voynarenko[2], Viacheslav Dzhedzhula[3], Iryna Yepifanova[3], Tadeusz Trocikowski[4]

[1]State Institution "Institute of Economics and Forecasting of the National Academy of Sciences of Ukraine", Panasa Myrnoho Str., 26, Kyiv, 01011, Ukraine
[2]Khmelnytsky National University, 11, Instytutska Str., Khmelnytskyi, 29000, Ukraine.
[3]Vinnytsia National Technical University, 95, Khmelnytsky highway, Vinnytsia, 21021, Ukraine
[4]ESFII, The European Movement Forum (FRE), Poland

E-mail epifanovairene@gmail.com

Abstract. In modern conditions, a very important issue to ensure sustainable development is the constant implementation of innovation activity. Taking into account the high cost of energy carriers, the implementation of innovative energy saving activity is a very important issue. In this paper, the authors have simulated the process of intellectual support for management decisions to determine the sources of funding for innovative energy saving activity. The proposed mathematical model allows to use the concentrated experience of experts for intellectual support of decision-making on the estimation of efficiency of financial maintenance of innovation activity. The received results show that the evaluation of priority strategic directions for machine-building enterprises in terms of efficiency of financial support of innovation activity will determine a hierarchical structured set of innovation strategies for each enterprise, taking into consideration the available financial support and external and internal environment of the enterprise. The first section in your paper

1. Introduction

The development of an enterprise in the market economy system requires the use of innovative approaches. All enterprises that plan to achieve economic growth are actively engaged in innovation activity. A significant part of innovative measures should be aimed at energy saving. Operation of any production takes place using energy resources for the manufacture and support of the life of the enterprise itself. Metallurgical, machine-building, manufacturing, light industries are the most energy-intensive productions. The basis of state policy in energy saving is a set of normative legal acts aimed at forming a certain set of actions for reducing the consumption of primary and transformed energy resources.

The energy saving policy of an enterprise should be an integral part of the general development strategy. The functioning of a modern enterprise takes place under conditions of uncertainty and risk, there is a significant influence of external and internal factors - the stability of the national currency and the political situation, the state of markets of energy consulting services and energy saving technologies, the level of qualification and motivation of the enterprise personnel, etc. The improvement of profitability, competitiveness and energy efficiency of the enterprise should take place at the expense of innovative measures. To ensure the economic stability of the enterprise it is quite important to manage energy saving actively, the first stage of which should become the formation of energy saving policy at the enterprise. The implementation of individual, local energy saving measures at the enterprise will not contribute to a qualitative increase in the energy efficiency of the enterprise. To achieve sustainable effect and significant qualitative changes, a complex of actions is required which are aimed at increasing the energy efficiency of production by implementing energy saving measures, organizational and structural changes, i.e. energy saving policy.

2. Literature review

Issues related to the definition of the essence of innovation were studied by such scientists as J. Schumpeter [1], M. Kalecki (1963) [2], G. Mensh (1979) [3], C. Freeman (1982) [4], Gierszewska E. and Nadolny K. [5].

Innovation activity requires an appropriate level of funding. The issues of finance and financing of activities were considered by Franco Modigliani, Merton H. Miller [6], Altman E.I. [7], Thorsten Beck, Asli Demirguc-Kunt [8]. Attention is also paid to the issues of financing innovation activities, in particular in the works [9-11].

A large number of scientists are investigating issues related to energy saving and management of energy saving. The efficiency of energy use is considered as one of the most cost-effective options for reducing the impact of growing demand for energy resources and achieving the goal of reducing greenhouse gas emissions [12]. Enterprises seek to identify methods to increase energy efficiency and safe energy use [13]. The world urgent needs encourage enterprises to implement both individual energy-saving measures and use a systematic approach to improving the overall energy efficiency of an enterprise and enhancing its competitiveness [14].

It is very important to understand current energy saving management issues and the factors that influence this management, because without a clear understanding of the existing difficulties, the policy may be ineffective [15].

Păunescu C. and Blid L. suggest designing a sustainable energy management system at the enterprise using the Plan-DoCheck-Act approach. The authors analyzed the efficiency of enterprises' energy goals, the quality of the energy efficiency indicator, and proposed an example of an action plan for reducing energy consumption [16].

Simulation of the process of financial support of innovation activity is most often carried out using deterministic, statistical, expert and combined methods. Modern models based on the theory of artificial neural networks [17] allow us to predict the functioning of various, including economic, objects. The main property of artificial neural networks is the ability to learn, but this requires a significant base of information resources that characterize the studied system at different ratios and parameters of input factors. The resulting signal from the neuron, which characterizes the behavior of the economic system, depends on the weighted amount of input signals, so the use of artificial neural networks to intelligent support decisions on the choice of funding sources for innovative solutions for industrial production requires a large sample of data, first of all, experimental data, which has not been accumulated yet. The theory of fuzzy logic and linguistic variable [18-19] allows the use of experimental, analytical and expert input information to study the causal relationships of the behavior of the economic system. Decisions on the financial support of enterprises' innovation activity can be carried out by evaluating the qualitative, quantitative and binary parameters of the state of the object under study. That is why further research is needed to substantiate the factors influencing the process of financial support of enterprises' innovation activity in the absence of financial resources from the standpoint of the theory of fuzzy logic.

3. Study method

Theoretical and methodological basis of scientific research is general scientific principles, dialectical method of scientific knowledge, fundamental positions of modern economic theory, modern concepts of energy saving management, laws of social development, legislative and normative documents, scientific works of domestic and foreign scientists.

For solving the tasks, there have been used abstract-logical analysis, classification-analytical analysis and comparative analysis for research of the set of factors of influence on the level of intellectual capital as a factor of efficiency of management of energy saving; methods of heuristic forecasting: expert surveys for the formation of knowledge bases of the proposed mathematical model based on the theory of fuzzy logic, linguistic variable and hybrid neural networks; pair comparison - for the construction of membership functions; logical generalizations - to formulate the conclusions of the study.

4. Results and discussion

In modern conditions, most domestic enterprises are in a rather difficult financial situation and are not able to compete with the world enterprises. That is why only those companies succeed which understand the importance of the intensive vector of development, i.e. the importance of innovation. However, not all enterprises that plan or carry out innovation activity have sufficient financial resources to ensure it. The issue of financial support of innovation activity in the conditions of deficit of financial resources and different cost of the attracted capital remains rather unresolved.

The solution of the problem of determining the effectiveness of financial support for innovation activity of an industrial enterprise is based on the formation of a mathematical model of intellectual support for decision-making to choose a priority innovation strategy from among the alternatives. If the innovation potential of the researched enterprise is in the zone of linguistic assessments “satisfactory”, “good”, “very good” and “excellent’, the task of choosing the most optimal innovation strategy arises.

When we build a mathematical model of decision-making support based on the theory of fuzzy logic and hybrid neural networks, it is necessary to choose the groups of factors that will have the greatest impact on the simulation result. It is necessary to take into account various factors of influence, which can be classified into three major groups: sources of financial resources, external factors, and internal factors. These factors are usually quantitative and qualitative in nature.

The decision-making process using the theory of hybrid neural networks is based on the system of fuzzy inference - approximation of the dependence $Ff=f(x_1,x_2,y_1,z_1 \ldots z_n)$ using fuzzy rules and fuzzy logical operations of addition, integration, intersection and implication. As a result of simulation, we have chosen an indicator of the effectiveness of financial support for innovation activity, which will allow the evaluation and ranking of alternative innovation strategies.

The linguistic variable that corresponds to the indicator of the effectiveness of financial support for innovation Ff can be represented as a function of the components:

$$Ff = f(X, Y, Z), \quad (1)$$

where Ff is an indicator of the effectiveness of financial support for innovation activity of industrial enterprises; X is a linguistic variable (LV), which describes the impact of the source of funding; Y is a linguistic variable that describes the influence of external factors that affect the formation of resources; Z is a linguistic variable that describes the influence of internal factors that affect the formation of resources.

The linguistic variable that describes the impact of sources of financial resources can be expanded into the dependence:

$$X=f(x_1, x_2, x_3, x_4), \quad (2)$$

where x_1 is LV “own funds”; x_2 is LV “investor's funds”; x_3 is LV “credit funds”; x_4 is LV “funds of international and non-governmental organizations”.

The linguistic variable, which characterizes the impact on the process of financial support of innovation activity by external factors, can be represented as follows:

$$Y=f\ (y_1, y_2, y_3, y_4, y_5, y_6), \quad (3)$$

where y_1 is LV “cost of raising financial resources”; y_2 is LV “term of resource provision”; y_3 is LV “grace period”; y_4 is LV “sanctions for late refund”; y_5 is LV “need for mortgage”; y_6 is LV “level of innovation activity in the industry”.

The linguistic variable describing the influence of internal factors on the process of financial support of innovation activity can be represented as follows:

$$Z=f\ (z_1, z_2, z_3, z_4, z_5, z_6, z_7), \quad (4)$$

where z_1 is LV “life cycle of the enterprise”; z_2 is LV “staff motivation”; z_3 is LV “level of financial stability of the enterprise”; z_4 is LV “level of business activity and reputation of the enterprise”; z_5 is LV “level of liquidity and solvency of the enterprise”; z_6 is LV “level of intellectual capital”; z_7 is LV “level of innovation activity”.

On the basis of the formed hierarchical set of factors of influence there has been developed the tree of logical conclusion which root corresponds to an indicator of efficiency of financial maintenance of innovation activity, and hanging tops - to factors of influence (Fig. 1).

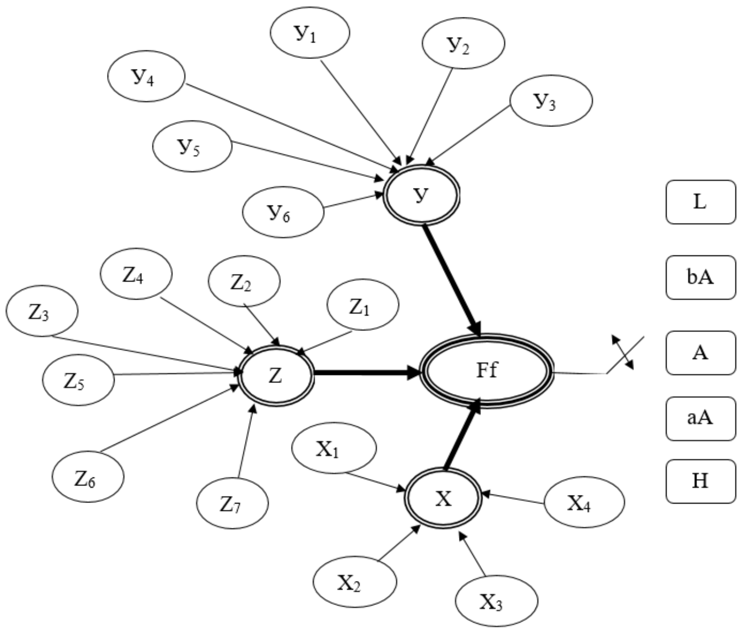

Figure 1. The tree of logical conclusion of hierarchical connections of the factors influencing decision-making process on efficiency of financial maintenance of innovation activity

For the developed mathematical model, the form of membership functions is taken to be Gaussian, which is described by equation [10; 20]:

$$\mu(x) = \exp\left(-\frac{(u-b)^2}{2\times c^2}\right), \quad (5)$$

where b is the coordinate of the maximum; c is the concentration coefficient.

This form of membership function is the most flexible, universal and allows you to describe the degree of membership of most of the processes under consideration. The parameters of this function are calculated in the software package based on the results of processing expert information.

The distribution of influence factors on the process of assessing the values of the effectiveness indicator of financial support of innovation activity is shown in Table 1.

Table 1. Influence factors described by linguistic variables

Parameter	Symbol and name of the variable	Universal set	Linguistic terms for evaluation
Sources of financial resources (X)	x_1 – LV "Own funds"	$U(x_1)$ = [1…3] (points)	deficit (d), sufficient (s), overage (o)
	x_2 – LV "Investor's funds"	$U(x_2)$ = [1…3] (points)	absent (a), deficit (d), sufficient (s)
	x_3 – LV "Credit funds"	$U(x_3)$ = [1…3] (points)	absent (a), deficit (d), sufficient (s)
	x_4 – LV "Funds of international and non-governmental organizations"	$U(x_4)$ = [1…3] (points)	absent (a), deficit (d), sufficient (s)
The impact on the process of financial support of innovation activity by external factors (Y)	y_1 – LV "Cost of raising financial resources"	$U(y_1)$ = [1…3] (points)	low (l), medium (m), high (h)
	y_2 – LV "Term of resource provision"	$U(y_2)$ = [1…10] (years)	Up to 1 year (l), 1-5 years (m), 5-10 years (h)
	y_3 – LV "Grace period"	$U(y_3)$ = [1…3] (points)	absent (a), within 1 year (m), before the start of profit (h)
	y_4 – LV "Sanctions for late refund"	$U(y_4)$ = [1…3] (points)	absent (a), in the form of interest (i), fixed amount (f)
	y_5 – LV "Need for mortgage"	$U(y_5)$ = [1…3] (points)	No (n), optional (o), yes (y)
	y_6 – LV "Level of innovation activity in the industry"	$U(y_6)$ = [1…3] (points)	low (l), medium (m), high (h)
The influence of internal factors on the process of financial support of innovation activity (Z)	z_1 –LV "Life cycle of the enterprise"	$U(z_1)$ = [1…5] (points)	development (dv), introduction (i), growth (g), maturity (m), decline (dc)
	z_2 – LV "Staff motivation"	$U(z_2)$ = [1…3] (points)	low (l), medium (m), high (h)
	z_3 – LV "Level of financial stability of the enterprise"	$U(z_3)$ = [1…4] (points)	crisis (c), pre-crisis (pc), normal (n), absolute (a)
	z_4 – LV "Level of business activity and reputation of the enterprise"	$U(z_4)$ = [1…3] (points)	low (l), medium (m), high (h)
	z_5 – LV "Level of liquidity and solvency of the enterprise"	$U(z_5)$ = [1…3] (points)	potential bankrupt (b), non-liquid (nl), liquid (l)
	z_6 – LV "Level of intellectual capital"	$U(z_6)$ = [1…3] (points)	low (l), medium (m), high (h)
	z_7 – LV "Level of innovation activity"	$U(z_7)$ = [1…3] (points)	low (l), medium (m), high (h)

Each factor is presented in the form of a linguistic variable, a universal set of factor variations and linguistic terms for evaluation are given. Abbreviated names of linguistic terms are used to fill knowledge bases - concentrated expert information – which are then used to teach the mathematical model, its testing and verification. This table also provides universal sets of factor variations, units of measurement, and linguistic terms for expert evaluation.

The block diagram of the fuzzy model is presented in Figure 2.

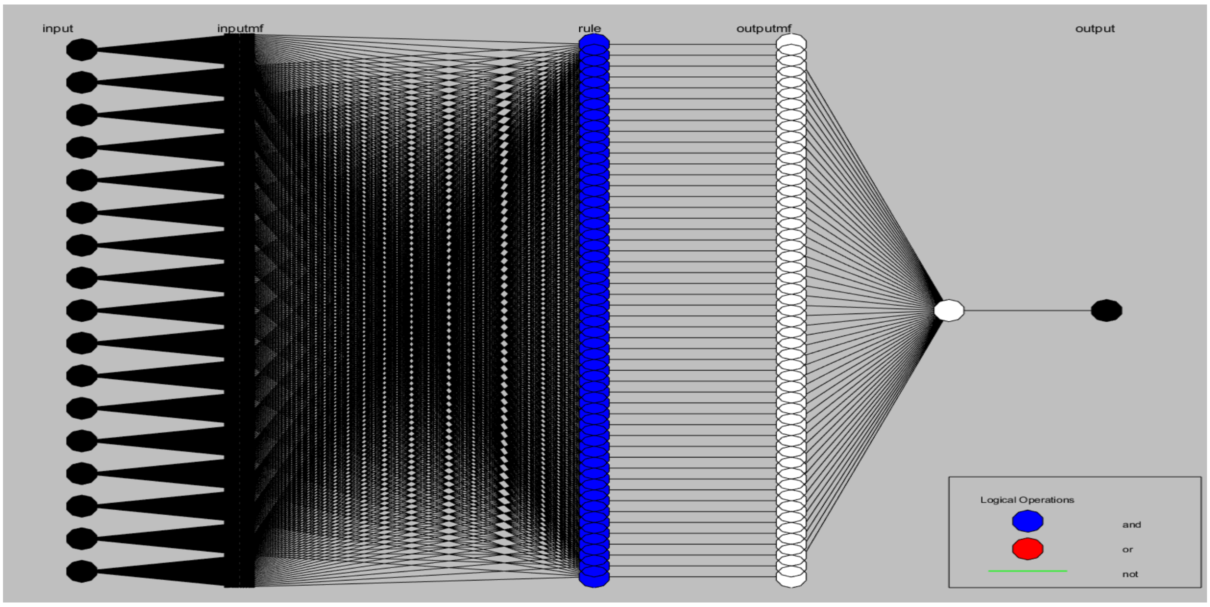

Figure 2. Block diagram of a fuzzy mathematical model

The input layer "input" generates input signals that come from the operator using the model. Input data (signals) are numerical values of linguistic variables.

The second layer "inputmf" of the model defines the parameters of membership functions, the form of which is specified during model development. In our case it is Gaussian. The parameters of the membership function are converted into weight coefficients of neurons of the second layer of the network. These weight coefficients can change during training.

The third layer "rule" of the model corresponds to the structure of the rules, the number of neurons corresponds to the number of logical rules "if-then'. Each of the neurons can perform a multiplicative function or implement a function of "minimum". The "outputmf" and "output" layers implement a defasification procedure, i.e. the conversion of fuzzy information into clear information. Taking onto account the large number of connections that occur between the layers of the fuzzy model, the calculation of its parameters, adjustment and testing of the model must be carried out in specialized mathematical packages.

The input variable, the desired indicator of the effectiveness of financial support for innovation activity, has the following properties, which are summarized in Table 2.

Table 2. Properties of the variable Ff

Parameter	Designation and name of the variable	Universal set	Linguistic terms for evaluation
Initial valuable	*Ff* is LV "indicator of the effectiveness of financial support for innovation activity"	*U*(Ff) = [1…5] (points)	Low (L), below average (bA) average (A) above average (aA) high (H)

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Linguistic terms for estimating the initial indicator acquire values: "low", which on the universal set corresponds to the value 1; "below average", which corresponds to a value of 2; "average" - 3; "above average" - 4; "high" - 5.

The mathematical model of intellectual decision support for finding the indicator of the effectiveness of financial support of innovation activity is presented in the form of a set of fuzzy logical equations, which are formed on the basis of information from knowledge bases.

A fragment of the mathematical model is given below:

$$\mu^{D}(x_1) \wedge \mu^{A}(x_2) \wedge \mu^{A}(x_3) \wedge \mu^{A}(x_4) \wedge \mu^{L}(y_1) \wedge \mu^{L}(y_2) \wedge \mu^{A}(y_3) \wedge \mu^{I}(y_4) \wedge \mu^{N}(y_5) \wedge \mu^{L}(y_6) \wedge \mu^{DV}(z_1) \wedge \mu^{L}(z_2) \wedge \mu^{C}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{B}(z_5) \wedge \mu^{H}(z_6) \wedge \mu^{L}(z_7) \vee$$

$$\mu^{D}(x_1) \wedge \mu^{S}(x_2) \wedge \mu^{D}(x_3) \wedge \mu^{A}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{L}(y_2) \wedge \mu^{A}(y_3) \wedge \mu^{I}(y_4) \wedge \mu^{Y}(y_5) \wedge \mu^{L}(y_6) \wedge \mu^{DV}(z_1) \wedge \mu^{H}(z_2) \wedge \mu^{A}(z_3) \wedge \mu^{M}(z_4) \wedge \mu^{B}(z_5) \wedge \mu^{H}(z_6) \wedge \mu^{H}(z_7) \vee$$

$$\mu^{D}(x_1) \wedge \mu^{A}(x_2) \wedge \mu^{D}(x_3) \wedge \mu^{D}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{L}(y_2) \wedge \mu^{A}(y_3) \wedge \mu^{I}(y_4) \wedge \mu^{Y}(y_5) \wedge \mu^{L}(y_6) \wedge \mu^{DV}(z_1) \wedge \mu^{H}(z_2) \wedge \mu^{A}(z_3) \wedge \mu^{M}(z_4) \wedge \mu^{B}(z_5) \wedge \mu^{M}(z_6) \wedge \mu^{M}(z_7) \vee$$

$$\mu^{D}(x_1) \wedge \mu^{S}(x_2) \wedge \mu^{A}(x_3) \wedge \mu^{D}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{L}(y_2) \wedge \mu^{M}(y_3) \wedge \mu^{F}(y_4) \wedge \mu^{T}(y_5) \wedge \mu^{L}(y_6) \wedge \mu^{I}(z_1) \wedge \mu^{H}(z_2) \wedge \mu^{N}(z_3) \wedge \mu^{M}(z_4) \wedge \mu^{B}(z_5) \wedge \mu^{M}(z_6) \wedge \mu^{L}(z_7) \vee$$

$$\mu^{S}(x_1) \wedge \mu^{A}(x_2) \wedge \mu^{S}(x_3) \wedge \mu^{A}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{M}(y_2) \wedge \mu^{M}(y_3) \wedge \mu^{F}(y_4) \wedge \mu^{O}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{I}(z_1) \wedge \mu^{M}(z_2) \wedge \mu^{N}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{NL}(z_5) \wedge \mu^{M}(z_6) \wedge \mu^{M}(z_7) \vee$$

$$\mu^{S}(x_1) \wedge \mu^{D}(x_2) \wedge \mu^{A}(x_3) \wedge \mu^{S}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{M}(y_2) \wedge \mu^{M}(y_3) \wedge \mu^{F}(y_4) \wedge \mu^{O}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{G}(z_1) \wedge \mu^{M}(z_2) \wedge \mu^{N}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{NL}(z_5) \wedge \mu^{M}(z_6) \wedge \mu^{M}(z_7) \vee$$

$$\mu^{S}(x_1) \wedge \mu^{D}(x_2) \wedge \mu^{D}(x_3) \wedge \mu^{D}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{M}(y_2) \wedge \mu^{M}(y_3) \wedge \mu^{F}(y_4) \wedge \mu^{O}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{C}(z_1) \wedge \mu^{M}(z_2) \wedge \mu^{N}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{NL}(z_5) \wedge \mu^{M}(z_6) \wedge \mu^{M}(z_7) \vee$$

$$\mu^{O}(x_1) \wedge \mu^{A}(x_2) \wedge \mu^{A}(x_3) \wedge \mu^{A}(x_4) \wedge \mu^{L}(y_1) \wedge \mu^{H}(y_2) \wedge \mu^{A}(y_3) \wedge \mu^{A}(y_4) \wedge \mu^{N}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{M}(z_1) \wedge \mu^{L}(z_2) \wedge \mu^{N}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{NL}(z_5) \wedge \mu^{L}(z_6) \wedge \mu^{L}(z_7) \vee$$

$$\mu^{O}(x_1) \wedge \mu^{D}(x_2) \wedge \mu^{D}(x_3) \wedge \mu^{D}(x_4) \wedge \mu^{M}(y_1) \wedge \mu^{H}(y_2) \wedge \mu^{M}(y_3) \wedge \mu^{I}(y_4) \wedge \mu^{O}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{M}(z_1) \wedge \mu^{L}(z_2) \wedge \mu^{PC}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{NL}(z_5) \wedge \mu^{L}(z_6) \wedge \mu^{L}(z_7) \vee$$

$$\mu^{O}(x_1) \wedge \mu^{S}(x_2) \wedge \mu^{D}(x_3) \wedge \mu^{S}(x_4) \wedge \mu^{H}(y_1) \wedge \mu^{H}(y_2) \wedge \mu^{H}(y_3) \wedge \mu^{F}(y_4) \wedge \mu^{Y}(y_5) \wedge \mu^{M}(y_6) \wedge \mu^{DC}(z_1) \wedge \mu^{L}(z_2) \wedge \mu^{C}(z_3) \wedge \mu^{L}(z_4) \wedge \mu^{B}(z_5) \wedge \mu^{L}(z_6) \wedge \mu^{L}(z_7) = \mu^{L}(Ff). \quad (6)$$

The conversion of fuzzy information into clear (defasification) takes place in a special block of the program of the package "Fuzzy logic designer" of the Matlab program, a fragment of the window of which is shown in Fig. 3.

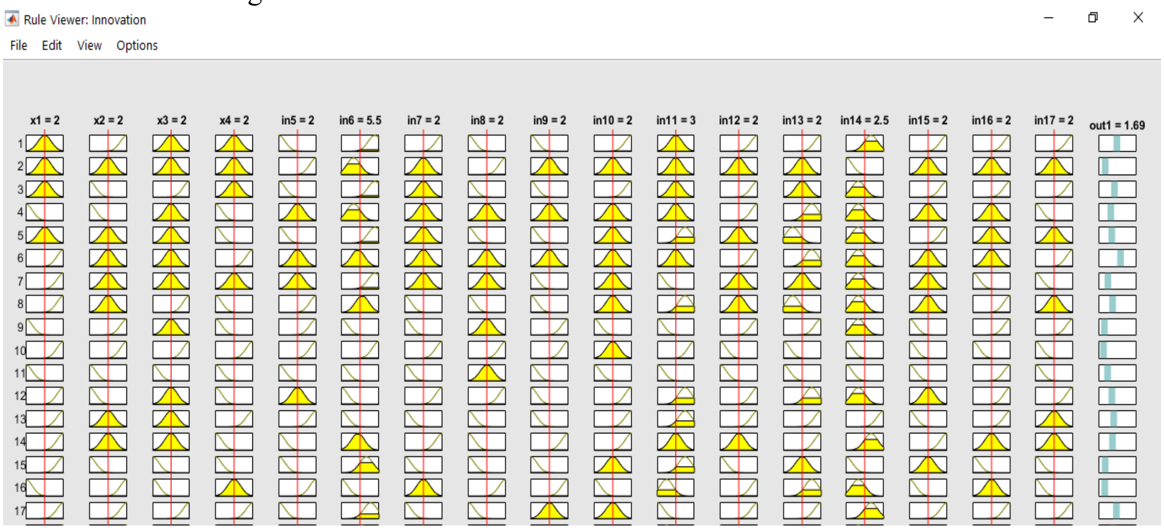

Figure 3. Fragment of the window of the package "Fuzzy logic designer" of the Matlab program

The proposed mathematical model allows us to use the concentrated experience of experts for intellectual support of decision-making on the estimation of efficiency of financial maintenance of innovation activity. Using the Matlab mathematical package turns the process of calculating the required indicator of financial efficiency into a relatively simple set of operations.

According to the results of expert surveys on the values of factors, the software product allows us to determine the value of Ff.

In the presence of a certain set of alternative strategies, it is possible to assess the features of financing each of them from the standpoint of availability or limitation of financial resources, their value to the enterprise, the characteristics of the internal environment of the enterprise. After calculating the values of the indicator of the effectiveness of financial security, it is necessary to rank alternative strategies according to the values of the indicator. The maximum value of which is 5, and the minimum is 1. The strategy with the highest value of the indicator is recommended for implementation at the enterprise.

Assessment of the priority of areas of innovation activity of the enterprise must be carried out taking into account a set of influence factors: external and internal factors, characteristics of funding sources. The developed mathematical model requires training and its use will determine the priority areas of innovation activity of industrial enterprises. The use of the proposed approach allows ranking the priority of innovation strategies that are planned to be implemented in enterprises. Under the terms of the shortage of financial resources, it is necessary to choose only one priority innovation strategy, or several that have the highest values of the efficiency of financial security of innovation activity Ff.

Three machine-building enterprises producing similar products have been selected for the study. The following directions have been chosen as alternative innovative strategic directions: introduction of new equipment for alternative energy supply; implementation of energy saving and resource saving policy; implementation of organizational and managerial decisions aimed at implementing innovation policy; acquisition of new equipment and intangible assets for production; staff training.

The whole range of possible innovation strategies does not end in this set. But such priority areas for the studied enterprises have been identified by the method of selection. Let us consider the proposed strategic innovation solutions in more detail.

Despite the fact that industrial enterprises are usually energy-intensive and production is mainly set up for the use of primary energy sources, a large part of auxilary and technological processes can be transferred to the use of non-traditional energy sources.

For machine-building enterprises, the most important thing is to obtain heat and electricity to meet their own production and sanitary needs. Machine-building enterprises are energy-intensive and the implementation of measures to diversify energy supply is an important area of innovation. The most promising technologies of alternative energy supply of industrial enterprises include those based on the energy used by the Sun, in particular: the use of solar panels for electricity supply; use of solar collectors to obtain hot water. According to [21], the number of renewable energy sources using solar energy is constantly growing and as of 2017 amounted to 149 tons in oil equivalent. The sun is a publicly available resource and the use of its energy in the overall energy balance of the enterprise is relatively simple. Solar energy can be used to produce electricity and heat. Thermal energy is usually used for hot water supply and much less often - for heating.

To do this, it is necessary to use, respectively, solar panels and solar collectors. The amount of solar energy that reaches the earth's surface for the latitudes of Ukraine is quite significant and ranges from 1350 kW × h / m2 to 10000 kW × h / m2 per year. The most common solar collectors by design are vacuum (tubular) and flat. Flat solar collectors are cheaper, but they have greater heat loss in winter, i.e. less efficiency.

Tubular collectors are more efficient to work in the cold season, because they have much less heat loss than flat. But in the warm period of the year they need to maintain a higher pressure of the coolant, because in the mode without heat consumption they can overheat the coolant to 200 ° C, which reduces its service life and the risk of boiling. The service life of flat collectors is 20–25 years, while that of tubular collectors is 15–20 years [21]. The coolant temperature in flat collectors does not exceed 150° C. The choice of a specific type of collector is carried out by technical staff of the enterprise taking into account all the existing disadvantages and advantages. It is necessary to consider that any collector allows carrying out considerable economy of means at water heating.

The efficiency of the solar collector depends on many factors: design, orientation relative to the sides of the world, the angle of inclination to the horizon, location, quality of manufacture and others. The thermal capacity of these devices is also directly dependent on the month of the year, i.e. the amount of daylight and outside temperature. Taking into consideration the significant cost of energy for legal entities, the installation and use of solar devices (panels and collectors) is an effective innovative measure.

Solar panels can be used to produce electricity at the enterprise. By design, they are poly-, single-crystal and thin-film. Polycrystalline panels are the most widespread at present, although they have a lower efficiency (up to 18%) compared to single-crystal (up to 22%), but at a lower cost. The enterprise can use the produced electricity for its own needs or sell it to the state at a "green" tariff.

Significant amounts of hot water are always used in any industrial enterprise: for supplying hot water to showers, for washing dishes, equipment and transport, for cleaning premises, territory and other needs, including technological ones. Energy costs for water heating are very significant and traditionally heating is carried out in the boiler units of the company's own boiler house, heating points for heat supply from an external source, in electric boilers, etc.

Implementation of energy and resource conservation policy will allow the company to get a number of positive effects: in addition to reducing production costs and, consequently, profit growth, the enterprise receives social, environmental, image effects: profit growth allows the enterprise to increase wages, which is positively reflected in the social component of domestic enterprise environment. The use of energy saving measures can reduce environmental pollution, improve the environmental situation in the enterprise and in general in the country, reduce the company's payments for emissions of solid, liquid and gaseous pollutants due to the use of energy saving potential.

The introduction of innovative areas of energy supply, increasing the company's image, contributes to the growth of its marketing attractiveness. In the general case, all energy saving measures can be classified into three categories from the standpoint of financing: cost-effective, low-cost and costly. But, regardless of the size of the initial investment, the economic effect of the implementation of measures should be reflected in the reduction of production costs, reduced emissions, reduction of fuel purchases and environmental tax.

The implementation of organizational and managerial decisions aimed at implementing innovation policy can be carried out through specialized training of employees, the introduction of new departments, or the reorganization of existing ones.

The formation of changes in the enterprise must be carried out in accordance with the organizational and economic mechanism for the implementation of innovation policy. Although organizational and management decisions usually do not require significant investment, they cannot be called cost-effective.

The implementation of management measures requires the modernization of the enterprise management system, the implementation of operations for the initiation, implementation, control and monitoring. The implementation of these components of the enterprise management system requires funds, but even more it requires high motivation and significant intellectual capital of employees. Usually organizational and managerial activities require non-standard approaches and decisions from both performers and management.

Acquisition of new equipment and intangible assets allows the company to improve the technological process, reduce resource consumption, increase the accuracy of manufacturing elements of products, and most importantly - to increase production speed and automate the production process.

Modern metalworking machines with electronic control, as one of the types of innovative equipment allow increasing the processing speed several times, while significantly reducing the number of defective products. Intangible assets, including patents, licenses, permits, know-how can increase the competitiveness of the enterprise through the use of the latest developments in the technological cycle.

Staff training allows increasing the intellectual potential of the enterprise, which allows employees to move to a new level of performance and leads to increased profits. In many cases, it is not possible to use the latest equipment and obtain permits or licenses without training. The increase in intellectual capital directly affects the growth of innovative potential of the enterprise and opportunities for its implementation.

Each alternative strategic direction of innovation activity was evaluated by experts in accordance with the universal set given in Table 1. After simulation for each of the enterprises the value of the indicator of efficiency of financial support of innovation activity Ff was determined. Graphically, the distribution of factors of priority strategic directions of innovation for each enterprise is shown in Figure 4.

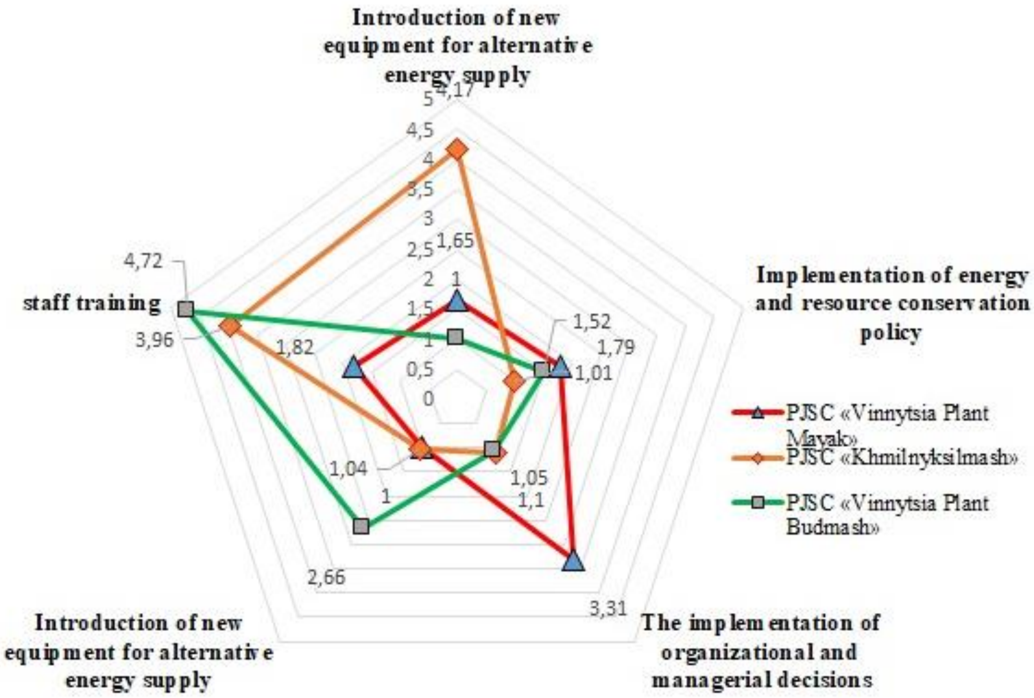

Figure 4. Distribution of factors of priority strategic directions for the researched enterprises

For PJSC “Vinnytsia Plant Mayak” the strategic direction of innovation activity № 1 “introduction of new equipment for alternative energy supply” is the most optimal. The implementation of this strategic direction will allow the company to completely abandon the use of electric boilers for heating hot water and use solar energy for these purposes. The use of electric water heaters is currently an unjustified waste on an industrial scale and, if it is financially possible, enterprises should use an inexhaustible resource of solar energy for their needs. The strategic direction of innovation “introduction of new equipment for alternative energy supply” competed with others and the second priority for this company is the strategic direction of “staff training”. But in the case of this strategic direction, the set of external and internal conditions is not as favorable as for the strategic direction number 1.

For PJSC “Khmilnyksilmash” the strategic direction of innovation activity № 5 “staff training” is the optimal from the standpoint of the internal environment and the characteristics of financing. Staff training is an investment in intellectual capital and will allow the enterprise to obtain the necessary permits for production.

5. Conclusions

According to the simulation results, it is determined that the strategic direction of innovation №3 "implementation of organizational and management decisions aimed at implementing innovation policy" is the priority for PJSC "Vinnytsia Plant Budmash", the strategic direction 1 "Acquisition of new equipment for alternative energy supply" is the priority for PJSC "Vinnytsia Plant Mayak", and it is the strategic direction №5 "staff training" for PJSC "Khmilnyksilmash".

Despite the fact that the researched enterprises are of the same industry and produce a similar range of products, the conditions of internal and external environment for them are still different. First of all, the conditions of the internal environment are different, because they depend on the team structure, enterprise management, traditions and approaches. Therefore, the simulation results were also excellent.

Thus, the assessment of priority strategic directions for machine-building enterprises in terms of efficiency of financial support of innovation activity will determine a hierarchical structured set of innovation strategies for each enterprise, taking into account the available financial support and external and internal environment of the enterprise

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