Applying Fuzzy Logic to Modeling Economic Emergence

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Abstract: - Modeling of financial, socioeconomic and integration indicators of fishing enterprises in conditions of uncertainty and constant transformation requires the development of an economic and mathematical model for studying the emergent state, which would be based on a set of main factors of influence of qualitative and quantitative characteristics of the dynamics of functioning. To create an expert modeling system for multi factorial analysis of the processes of functioning and management decisions of industrial enterprises, a mathematical apparatus based on the theory of fuzzy logic and a linguistic variable was used. This economic and mathematical method is a computer of mathematical algorithms, models and formalized methods and is based on the stagnation of expert linguistic information for predicting indicators of development or decline in order to form the basic mechanism for detecting latent properties of an emergent state. To develop an economic and mathematical model expert assessments and the results of analytical and experimental scientific studies of a qualitative and quantitative nature are used. Fuzzy logic modeling allows you to combine quantitative and qualitative factors and allows you to identify latent signals of emergent properties and determine the level of emergent state of industrial enterprises.

Key-Words: - financial, socioeconomic and integration indicators; mathematical model; fuzzy logic; fuzzy sets; emergent state; modeling; factors; latent signals; industrial enterprises

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1 Introduction

One of the founders of fuzzy logic theory is Professor Zadeh. Such sets are subject to the concepts of inclusion, union, intersection, additions, relations, convexities, etc., and also to the different properties of these concepts in the context of fuzzy sets are established» [1] Increasingly developed theory of fuzzy logic. Fuzzy logic a useful tool for

making decisions in which phenomena are imprecise and vague [2]. Fuzzy logic is a precise logic of imprecision and approximate reasoning. Most practical applications of fuzzy logic are related to logical, theoretically fuzzy sets of sets, epistemic and relational aspects [3].

The application of fuzzy logic is increasing in economic research, in particular for economic modeling prediction of waged-earning employment in Spain, with Jang's algorithm (ANFIS) [4]. To solve modern problems of forecasting economic phenomena, approaches to the implementation of artificial neural networks (ANN) with support for vector machines and fuzzy neural networks type 2 (IT2FNN) have been improved [5]. The application of fuzzy logic is widely implemented in solving various problems in economic research, including theoretical analysis of the development of resource dependence of the economy, the study of innovation processes in the resource-type economy and the construction of various forecasts of economic development [6]. This theory allows combining the quantitative and qualitative properties of the modeling object, as well as obtaining a solution for various related problems based on one knowledge base; on the basis of the information received in the future, teach a fuzzy model, which makes it possible to increase the accuracy and reliability of the results of the mode.

2 Literature Review

Today a new continuation of spherical fuzzy sets with interval value and estimation and accuracy functions, arithmetic and aggregation operations under the conditions of systems operation in an uncertain environment is presented [7]. The integration of loose masses into the modeling of socioeconomic development and financial economies gradually increases its importance, given the achievement of synergistic and emergent effects of economic systems in an uncertain environment [8] identify the peculiarities of financial systems under uncertainty using data analysis and bifurcation analysis based on limited information, namely emergence of new electronic payment instruments. Integration and financial processes in the European area have been linked through microeconomics elements and the causes of the debt crisis [9]. Regression analysis determines the level of interaction between factors of influence and risk, making it possible to form a system of motivators and demotivates determinants of capital structure in the Gulf Cooperation Council (GCC) In addition, to highlight the specification and uniqueness of the institutional environment in developing countries, the authors in the paper proved the identity of the factors influencing the management decisions on capital structure in different countries. A mathematical model has been developed to support intellectual decision-making on the optimal balance of financial security for the innovative activities of industrial enterprises in the face of a shortage of financial resources, is presented as a set of fuzzy logic or judgments of decision makers / experts with a more detailed description [10-11]. In order to identify latent manifestations of the emergent characteristics of the economic system, a methodology for identifying the level of emancipation has been presented and indicators have been developed to enable the identification of these properties at an early stage in industrial operations [12]. A continuation of research on the emergent effects of economic systems is the application of fuzzy logic theory with the use of indicators of the key directions of industrial development. To develop an economic and mathematical model for evaluating financial, socioeconomic and integration indicators of industrial enterprises and making organizational and technological decisions, expert assessments and the results of analytical and experimental scientific studies of a qualitative and quantitative nature are used.

3. METHODOLOGY

To consider the problem of modeling intellectual support for making decisions on the value of the emergence indicator of economic decisions, we will give some theoretical provisions of the theory of fuzzy logic.

– an odd set $\tilde{A}$ on a universal set U is called a set of pairs $(\mu_{\tilde{A}}(u), u)$, where $\mu_A(u)$ – degree of belonging of the element $u \in U$ to fuzzy set $\tilde{A}$. The element contained in a universal set is evaluated by a number from the range $[0,1]$. The lowest degree of affiliation is 0 and the highest degree of affiliation is 1;

– a function of belonging is a function of a certain kind that allows calculating the degree of belonging of an arbitrary element of a universal set to a fuzzy set;

– a linguistic variable is a variable whose meanings are words. The set of possible values of a linguistic variable is called a term set. The most common pounds of accessories are Gaussian, triangular, trapezoidal, sigmoid.

Pacification of fuzzy estimates of factors of influence is a method of constructing functions for

oneself. The falsification process provides for the selection of fuzzy terms (term estimates) for linguistic assessment of impact factors, which is set on the corresponding universal sets in a certain range. The fuzzy set with which the term is formalized $\tilde{S}$, is the set of pairs (Dzhedzhula et al., 2016, Voynarenko et al., 2020).

$$\tilde{S} = \left\{ \frac{\mu_s(u_1)}{u_1}, \frac{\mu_s(u_2)}{u_2}, ..., \frac{\mu_s(u_n)}{u_n} \right\}, \quad (1)$$

Where $\{u_1, u_2, \ldots, u_n\} = U$ – a universal set on which a fuzzy set is given; $S \in U$; $\mu_s(u_i)$ – degree of belonging of the element $u_i \in U$ to an odd set $\tilde{S}$.

The process of making decisions using the theory of fuzzy logic and a linguistic variable is based on a system of fuzzy logical inference - the approximation of dependence $E = f(x_1, x_2, \ldots, y_1, \ldots, z_n)$ using fuzzy rules based on knowledge bases and fuzzy logical operations of complement, merge, intersection and implication.

The fuzzy knowledge base is formed on the basis of expert, experimental and analytical information, all possible data that can be determined analytically must be determined by additional calculations, quali tative information is recorded on the basis of expert information, usually in point dimension. Defasificati on of fuzzy information is the transformation of a fu zzy set into a clear number. The most common scien tific and methodological approach to defasification: center of weight (centroid), center of maxima, medi an, the largest of maxima, the smallest of maxima. I n our work, we will use the most common method - centroid.

Based on the results of the study of non-adaptive (emergent) properties of economic systems, the characteristics and features of the occurrence of unpredictable strategies are determined. The obtained results are the basis for modeling the forecast of the indicator of the effective emissive state of economic systems, which is tested according to the data of the interval of selected financial and statistical statements of industrial enterprises and property levels are determined according to their linguistic values.

The solution of the problem of formation of the basic mechanism of identification of latent properties of the emergent state of activity of industrial enterprises is based on the formation of the economic and mathematical model of fuzzy logic, the manifestation of the latent properties of the emergent state of economic systems, which makes it possible to form management decisions on vectorization of properties to the positive pole of performance values, which will become the basis

When constructing an economic and mathematical model based on the theory of fuzzy logic, it is necessary to select groups of influences that will affect the duality of the simulation results. When sampling, it is advisable to take into account various factors of influence, classified according to various ozone settings and divided respectively into three large groups: financial, socioeconomic and integration indicators of influence. Typically, indicators are qualitative and quantitative in nature.

The process of making managerial decisions using the theory of fuzzy logic is to determine the indicator of the level of emergence in a certain range. As a result of the simulation, we selected the E indicator - the level of emergence, which will allow evaluating and ranking alternative strategies for the formation of emergence of enterprises.

The linguistic variable (LV) corresponding to the emergence indicator of the operation of the industrial enterprise Ff can be represented in the form of a ratio:

$$Ff = f(X, Y, Z), \quad (2)$$

where Ff – indicator of the level of emergent activity of an industrial enterprise; X – linguistic variable describing the impact of the funding source; Y – linguistic variable that is aware of the influence of socioeconomic factors affecting resource formation; Z – linguis is a variable describing the influence of integration factors that affect resource formation.

A linguistic variable describing the impact of financial sources of operation can be deployed as a dependency:

$$X = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7), \quad (3)$$

where x_1 – LV «Increase in profitability»;

x2 - LV "Increase in Value of the Enterprise";

x3 - LV "Gain of pure financial result (profit/loss)";

x4 - LV "Gain of Economic Added Value, EVA";

x5 - LV "Gain of Ebitda";

x6 - LV "Dynamics of Receivables";

x7 - LV "Increase in financial stability."

A linguistic variable indicating the direction of the vector of development of emergent characteristics relative to the socioeconomic direction can be represented as follows:

$$Y = f(y_1, y_2, y_3, y_4, y_5), \quad (4)$$

where y1 - LL "Competitiveness Growth";

y2 - LV "Development of corporate social responsibility";

y3 – LV "Implementation of the circular production model";

y4 - LV "Market Share Growth";

y5 - LV "Reproduction of social capital." A linguistic variable describing the impact of the integration effects of exposure can be presented as follows:

$$Z=f\ (z_1, z_2, z_3, z_4, z_5), \qquad (5)$$

where z1 - LV "Business Process Development";

z2 - LV "Development of the system of adaptation to changes";

z3 - LV "Efficiency of innovative activity";

z4 - LV "Strengthening tax and payment discipline";

z5 - LV "Improvement of control quality system."

The emergence level indicator *Ff* characterizes a set of linguistic variables describing the dynamic processes of the industrial enterprise.

Hierarchical relationships and a set of factors influencing the level of the emergence indicator of the operation of an industrial enterprise are developed and depicted in the form of a logical conclusion tree reflecting the logical relationships of basic events, where the root corresponds to the emergence level indicator, and its hanging vertices are factors of influence on the level of emergence (Fig.1)

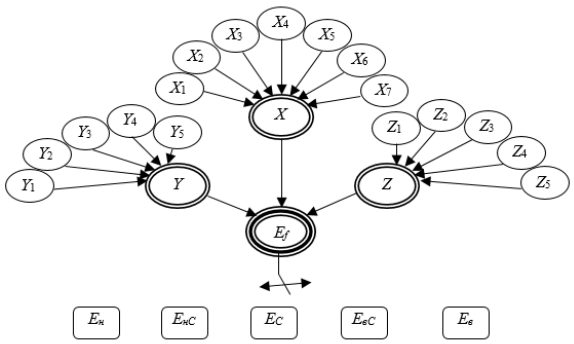

Figure 1: Logical output tree of hierarchical relationships of factors, what affect the emergence level indicator operation of an industrial enterprise/

The proposed economic and mathematical model allows to use the concentrated experience of experts to identify the emergent properties of the activities of industrial enterprises. Mathematical model of evaluation of processes of activation of emergent properties of enterprise is presented in the form of set of fuzzy logical equations, which are formed on the basis of information knowledge base.

4. Empirical results and discussion

A piece of a mathematical model is represented by a fuzzy equation (6):

$$\mu^{НЗК}(x_1) \wedge \mu^{Д}(x_2) \wedge \mu^{НЗ}(x_3) \wedge \mu^{НЕІ}(x_4) \wedge \mu^{НБ}(x_5) \wedge \mu^{ПОБ}(x_6) \wedge \mu^{ДФХ}(x_7) \wedge \wedge \mu^{НЕЗ}(y_1) \wedge \mu^{СУТ}(y_2) \wedge \mu^{ІД}(y_3) \wedge \mu^{ВП}(y_4) \wedge \mu^{Ь}(y_5) \wedge \mu^{НБП}(z_1) \wedge \mu^{Р}(z_2) \wedge \wedge \mu^{Ш}(z_3) \wedge \mu^{НИЗ}(z_4) \wedge \mu^{ДС}(z_5) \vee \ldots \mu^{СОК}(x_1) \wedge \mu^{ОК}(x_2) \wedge \mu^{ВИ}(x_3) \wedge \mu^{ЕІ}(x_4) \wedge \wedge \mu^{ПБ}(x_5) \wedge \mu^{СТЬ}(x_6) \wedge \mu^{ФР}(x_7) \wedge \mu^{ВИС}(y_1) \wedge \mu^{ЗК}(y_2) \wedge \mu^{СМЗ}(y_3) \wedge \mu^{М}(y_4) \wedge \wedge \mu^{И}(y_5) \wedge \mu^{ІБП}(z_1) \wedge {}^{ТР}(z_2) \wedge \mu^{В}(z_3) \wedge \mu^{ОКИ}(z_4) \wedge \mu^{КЗ}(z_5) = \mu^{В}(E). \qquad (6)$$

Given the universal set of variation of linguistic variables and using linguistic terms to evaluate them, it is further necessary to solve the problem of constructing the functions of belonging to fuzzy sets. The functions of belonging are built by mathematical processing of expert information given in questionnaires of experts. The implementation of economic and mathematical modeling is solved in specialized mathematical support. MatLab Such software is modern, convenient and expanded. To build membership functions and form a mathematical model of intelligent support for decision-making to determine the level of emergence of the enterprise, it is necessary to use knowledge bases as a concentrated set of expert knowledge. The fuzzy knowledge base is formed in the form of a table, where each row of the matrix will tell the rule "If - Then." The connection between linguistic variables within one rule is carried out using the operation "AND," the connection between the rules within one eye linguistic term of the original indicator is carried out using the operation "OR" After learning the model for rules, values of significance weights are determined, in the first approximation, the weights of all rules are taken equal to one.

Examples of constructed belonging functions (for the linguistic variable x_1 and the individual variable E) are given in Fig. 2.

The range of variation (region of definition) is equal to the universal set, and the number of curves corresponds to the number of linguistic terms for assessing the influence factor. The degree of belonging for any factor takes meaning from the range [0... 1]. The distribution of influence factors on the process of evaluating the level of emergence of functioning is given in Table 1.

Each factor is presented in the form of a linguistic variable, for each of them a universal set of variations and linguistic terms for evaluation are given. Abbreviated names of linguistic terms are used to fill knowledge bases, which are later used to

teach the mathematical model of its testing and verification.

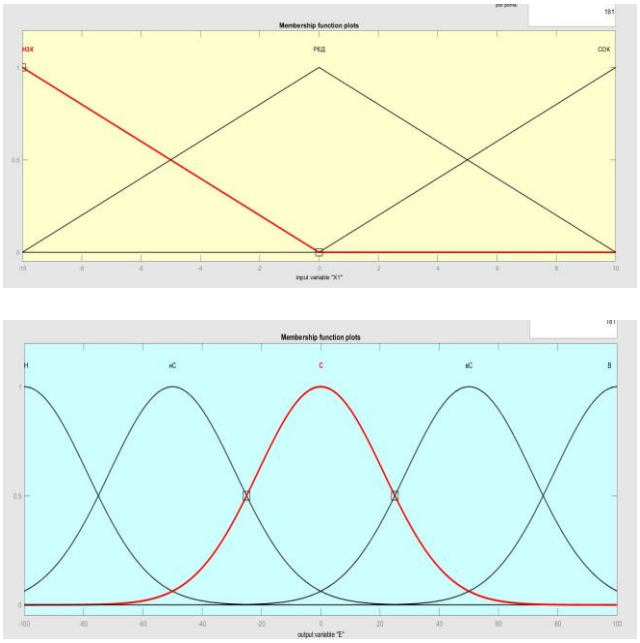

Figure 2: Membership functions of linguistic variables x_1 and E

In Table 1 you can see the universal sets of variations in factor values, units of measurement, and linguistic terms for evaluation by experts. As can be seen from Figure 1, the function of belonging to the variable x1 LV " Increase in profitability " of the "нзк" level has a triangular shape and acquires the maximum value at x = -10 and drops to x = 0. The affiliation function "Medium" acquires the maximum affiliation at x = 0 and falls evenly in both directions to the boundaries of the universal set. Accordingly, the function of belonging "Hight" acquires a maximum at x = 10 and drops to x = 0.

A similar situation with the belonging functions of variable E. The number of belonging functions for this variable corresponds to the number of linguistic terms – 5; function definition range [–100…100]. Other accessory functions are built in the same way using built-in packages «Neuro fuzzy designer» i «Fuzzy logic designer». The parameters of each belonging function are calculated in the software package based on the results of processing expert information. Based on the calculation of the level of stable dynamic functioning of industrial products, the arithmetic average value for negative indicators - 6.15367 was chosen as a standard, and for positive indicators 3,81765 respectively for the increase/decline in profitability of enterprises, on the example of Ukrainian engineering enterprises for 2010-2018.

The scale of estimating the emergence level of engineering enterprises is presented in Table 2.

Linguistic terms for estimating the initial indicator acquire values: "low", which corresponds to the value of 1 for the universal set; "Below average", which corresponds to a value of 2; "Average" - 3; "Above average" - 4; and "high" - 5. The mathematical model of identifying non-adaptive properties of an emergent state is represented in the form of a set of fuzzy logical equations, which are formed on the basis of information from knowledge bases.

Based on the results of expert surveys on the values of factors, the software product allows you to determine the value of indicator E.

The proposed economic and mathematical model allows us to use the concentrated experience of experts to identify the emergent properties of the activities of industrial applications.

The use of a mathematical package MatLab converts the process of calculating noise into a relatively simple set of operations. The conversion of fuzzy information into clear (defasification) takes place in the special application block of the "Fuzzy logic designer" package MatLab, a fragment of the window of which is pointed to Figure 3, and the vector display of the recall surface is shown in Figure 4.

In the presence of a certain set of alternative strategies (a set of values of input factors), we can assess the features of each of them and the need for finance to prevent costly measures to implement the strategy, determine the level of emergence of the enterprise prevention function.

After calculating the values of the emergence indicator, it is necessary to rank alternative strategies according to the values of this indicator, the maximum value of which is 100 and the minimum -100.

Table 1. Influencers as linguistic variables

Designation and name of the variable	**Versatile variation Set (points)**	**Linguistic terms to assess factor**
Financial factors affecting the activation of emergent properties (X)		
x_1 – LV «Increase in profitability»	$U(x_1) = \{-10+10\}$	Low (нзк), Medium (ред), Hight (сок)
x_2 – LV «Increase in enterprise value»	$U(x_2) = \{-10+10\}$	Decapitalization (д), no capitalization (вк), effective capitalization (ек), optimal capitalization (ок)
x_3 – LV «Increase in net financial result (profit/loss)»	$U(x_3) = \{-10+10\}$	Low (нз), pre intermediate (нс), intermidiate (с), upper intermidiate (все), advanced (ви)
x_4 – LV «Increase in economic value added *EVA*»	$U(x_4) = \{-10+10\}$	Inefficient investment (неі), efficiency of investment equates to investments in bank deposits (бд), effective investment (еі)
x_5 – LV «Increase E_{bitda}»	$U(x_5) = \{-10+10\}$	Non-profitable business (нб), static position of fishery/non-profitability, profitable business (пб)
x_6 – LV «Evolution of receivables»	$U(x_6) = \{+10-10\}$	Potential bankrupt (поб), decrease in liquidity of current assets (зла), structuring of debt (сз), absent (сть)
x_7 – LV «Financial sustainability gains»	$U(x_7) = \{-10+10\}$	Dynamic financial chaos (дфх), financial instability (фн), financial equilibrium (фр)
Socioeconomic factors of influence on activation of emergent properties (*Y*)		
y_1 – LV «Competitiveness gains»	$U(y_1) = \{-10+10\}$	Unsatisfactory (нез), low (нзь), satisfactory (за), sufficient (до), high (вис)
y_2 – LV «Development of corporate social responsibility»	$U(y_2) = \{-10+10\}$	Missing (сут), low (ка), medium (ня), high (ок), exemplary (зк)
y_3 – LV «Reinforcement of the circular production model»	$U(y_3) = \{-10+10\}$	Missing (ід), costly (вит), supporting (під), profitable (прб), self-supporting (смз)
y_4 – LV «Market Share Growth»	$U(y_4) = \{-10+10\}$	Loss of positions (вп), competition (к), market expansion (рз), oligopoly (ол), monopoly (м)
y_5 – LV «Reproduction of social capital»	$U(y_5) = \{-10+10\}$	Low (ь), medium (е), above average (ве), high (и)
Integration factors of influence on activation of emergent properties (*Z*)		
z_1 – LV «Business Process Development»	$U(z_1) = \{-10+10\}$	Low (нбн), medium (сбп), above average (всб), high (вбп), innovative (ібп)
z_2 – LV «Development of the system of adaptation to change»	$U(z_2) = \{-10+10\}$	Destruction (р), change of vector (зв), accessory (пр), integration (ін), transformation (тр)
z_3 – LV «Results of innovation performance»	$U(z_3) = \{-10+10\}$	Pest (ш), low (н), medium (с), above average (вс), high (в)
z_4 – LV «Strengthening tax and payment discipline»	$U(z_4) = \{-10+10\}$	Low (нез), medium (сер), high (оки), exemplary (зр)
z_5 – LV «mproving Management Quality System»	$U(z_5) = \{-10+10\}$	Missing (від), low (ька), medium (дня), high (й), exemplary (кз)

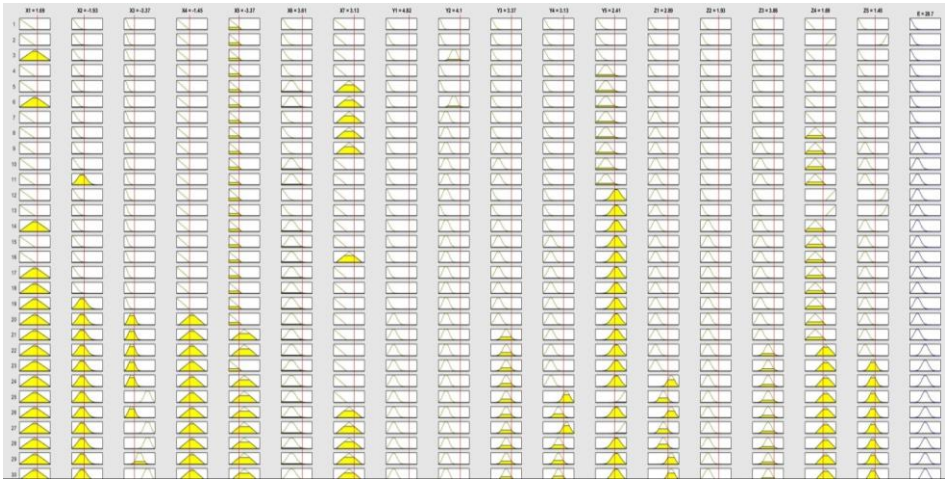

Figure 3: Working window MatLab at defasification of odd information

Table 2. Stages of evaluation of characteristics and simulation of emergence level of engineering enterprises

Linguistic terms of ambient levels	Characteristics of the dual nature of emergence	Emergence		
		Scoring levels	Properties in the economic system by structure characteristic	Level
Positively high	Positive	10	Structural revolution	[75…100]
		9	Restructuring	
		8	Update Structure	
Above average	Above average	7	Reproduction, Restructuring	[50…74,99]
		6		
Positively average	Average incremental	5	Structural stability	[30…49,99]
		4		
Accruing	Accruing	3	Weak deterministic structuring, positive structural shifts	[3,81…29,99]
		2		
		1		
Missing (sustainable development)	Laminarity (sustainable development)	0	Bifurcation	[–6,15…3,81]
Moderately low	Moderately low	–1	Weak "deterministic chaos, negative structural shifts	[–6,15…–29,99]
		–2		
		–3		
Negative average	Medium Low	–4	Strong or hyper-dynamic chaos	[–30…–49,99]
		–5		
Below average	Below average	–6		[–50…–74,99]
		–7		
Negative low	Negative	–8	Super chaos, dynamic chaos, system collapse	[–75…–100]
		–9		
		–10		

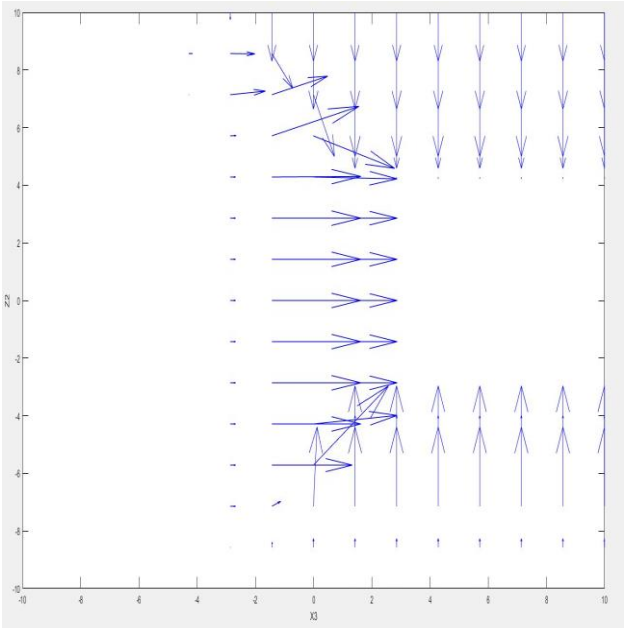

Figure 4: Vector display of the recall surface for incoming factors x_3, z_3

The strategy with the highest measure value is recommended for implementation on the rise. Results of simulation of performance indicators of machine building enterprises are presented in Table 3.

The results of the expert survey on the questionnaire survey became the information base for modeling indicators of the functioning dynamics of engineering enterprises. The proposed concept of modeling emergent properties of economic systems, which makes it possible to form a basic mechanism for detecting latent properties of emergent state of industrial enterprises.

Based on the results of modeling the fuzzy logic of indicators of the dynamics of the functioning of mechanical engineering sub-facilities, it is determined that in accordance with the set of incoming factors, the level of emergence is determined according to the additional fuzzy logic, if the value of such significant factors is determined during activity. Enterprises with the highest levels of emergence will have the best emergent potential, aimed at business structuring and revolutionary changes in the system. Based on the results of modeling fuzzy logic, it was determined that the PJSC "Factory "Nizhinselmash" will become the most productive and has the largest emergent potential among the studied engineering enterprises, the level of emergence has been reached in the amount of 44.4 Em. In second place is PJSC "Eurocar" with a display of 41.9 Em, that is, these enterprises have positive emergent characteristics

and differ from others in stability and adaptability to structural changes.

The most chaotic structure among the studied engineering enterprises stands out PJSC "Kiev Utility Engineering Factory "Commash" with an emergence level indicator of -7.77, the emergence indicator gravitates to a negative field, so such changes in the structure will have negative consequences. Step-by-step modeling of correlation relationships allows you to determine the amplitude or strength of the structure of indicators, and modeling of fuzzy logic allows you to determine the level of emergence for further qualitative strategy and conceptualization of the mechanisms of development of machine-building enterprises. In order to identify impact factors and activate drivers of machine building production, we see it advisable to use economic and mathematical modeling of fuzzy logic to analyze the results of activities and certain levels of emergence of industrial enterprises.

5. Conclusion

The simulation of positive emergence properties by fuzzy logic, taking into account changes in financial, socio-economic and integration indicators, made it possible to present an economic and mathematical model of measurement of the level of emergent state of industrial enterprises. The knowledge base of fuzzy logic makes it possible to identify latent signals of emergent properties and to determine the level of emergent state of an industrial enterprise in the context of dualistic character. solutions and results of analytical and experimental research.

Table 3. Results of simulation of performance indicators of engineering enterprises

LV	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y_1	y_2	y_3	y_4	y_5	z_1	z_2	z_3	z_4	z_5	Emergence level
PJSC "Eurocar"																		
Marks	–3	–5	7	–8	6	5	1	6	3	3	1	4	1	4	1	–1	4	**41,9**
A/m**	–3,4	–19,44	101	–286,47	34,09	11,81	0,07	42,69	4,49	3,6	0,24	6,05	0,19	6,89	0,18	–0,23	5,22	
PJSC "JC "Bogdan Motors"																		
Marks	9	–4	–5	–8	–4	–5	3	9	2	3	–1	4	1	4	2	2	4	**23,2**
A/m	341,36	–9,15	–27,54	–193,78	–8,65	–20,45	2,11	329,27	1,17	4,08	–0,27	5,02	0,42	6,95	1,3	1,1	7,08	
PJSC "Ukrainian Automobile Corporation"																		
Marks	4	–4	8	–5	–3	6	–1	3	2	3	–2	2	1	1	7	–1	4	**35,2**
A/m	–3,6	–8,68	224,95	–27,2	–3,98	49,27	–0,2	2	1,77	2,13	–0,54	1,58	0,01	0,26	101,69	-0,23	5,22	
PJSC "Zaporizhzhya Automobile Building factory"																		
Marks	4	–3	8	5	–5	–6	–1	3	3	3	–2	3	1	3	1	4	3	**30,6**
A/m	5,02	–3,83	157,97	13,93	–24,17	–40,88	–0,09	3,8	4,36	2,01	–0,81	2,5	0,44	4,75	0,42	4,25	2,64	
PJSC "AvtoKrAZ"																		
Marks	–4	–5	–8	–8	–4	–4	–1	–2	4	3	–1	1	–1	3	2	3	1	**-3,26**
A/m	–7,39	–13,08	–150,7	–179,49	–5,85	–6,43	–0,19	–1,93	5,36	2,98	–0,23	1,88	–0,23	3,45	0,91	2,5	0,24	
PJSC "Kalinovsky Machine-Building factory"																		
Marks	–1	–7	6	–8	6	6	–2	4	3	2	1	3	–1	2	3	3	3	**36,2**
A/m	–0,11	–97,42	75,59	–265,82	60,87	54,69	–0,77	8,57	3,4	1,27	0,03	2,5	–0,22	1,73	4,28	3,43	2,6	
PJSC "Mogilev-Podolsky Machine-Building factory"																		
Marks	2	–4	8	8	5	6	–1	7	3	2	1	3	–1	4	2	–2	3	**37,4**
A/m	1,43	–9,12	219,96	167,22	26,69	44,51	–0,78	72,83	2,76	1,33	0,01	3,28	–0,01	4,75	1,29	–1,47	2	
PJSC "Kiev factory of Municipal Engineering "Kommash"																		
Marks	8	–6	–8	–5	5	7	–4	–4	3	3	0	4	–3	3	0	3	3	**–7,77**
A/m	157,13	–42,74	–259,94	–26,02	27,28	67,06	–7,63	–9,94	3,74	2,68	0	5,23	–4,65	2,25	0	2,18	2,75	
PJSC "Zolotonoshsky Machine-Building factory named I.I. Lepse"																		
Marks	3	–7	8	–6	6	9	–1	8	3	4	0	3	–1	4	0	2	2	**32,7**
A/m	2,42	–76,53	272,13	–35,47	45,55	413,42	–0,12	118,97	2,93	6,03	0	2,97	–0,29	4,25	0	1	0,5	
PJSC "Factory "Nezhinselmash"																		
Marks	4	1	6	–6	6	7	1	4	2	4	1	3	1	3	6	–3	3	**44,4**
A/m	6,32	0,24	34,9	–55,27	34,88	78,84	0,36	5,65	1,82	5,35	0,01	2,67	0,15	3,93	39,8	–2	0,92	
PJSC "Novokramatorsky Machine-Building Factory"																		
Marks	2	–5	6	7	5	6	–1	4	3	3	1	4	0	3	1	4	3	**38,5**
A/m	0,88	–12,75	41,08	104,67	23,3	44,5	–0,03	7,91	2,25	3,5	0,21	6,03	0	3,76	0,04	6,23	2,97	

Source: Authors' results*

**A/m – arithmetic mean value of indicators dynamics.

Proposed scientific and methodological approach for estimating emergent properties, based on the modeling of processes according to the theory of fuzzy logic, where the information base became the dynamic changes in the functioning of mechanical engineering enterprises, the system of organizational and organizational acceptance technological.

In our next work, we will study Neural Networks to Model Financial and Economic Emergence and Genetic Algorithms (and other bio-inspired methods for optimization) to Model Financial and Economic Emergence.

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Contribution of individual authors to the creation of a scientific article (ghostwriting policy)

Mykhaylo Voynarenko was formed of research ideas, made general guidance.

Viacheslav Dzhedzhula has implemented model design, model visualization, data analysis, implementation of modeling in MatLab.

Viktoriya Hurochkina has organized data collection for modeling, fuzzy database formation, systematization of influencing factors, description of results, translation.

Iryna Yepifanova has constructed of a tree of logical conclusion of hierarchical connections of factors, selected of quality of the standard for comparison, development of stages of an estimation of characteristics of emergence

Olena Menchynska was responsible for Literature review and Statistics.

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