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Impact of Carbon Emissions Factors on Economic Agents Based on Decisions Modeling in Complex Systems

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Abstract: The article presents a methodology for modeling the impact of factors of both on-farm activity and environmental factors on the resulting indicators of an international company. The dataset includes the company's profit, revenue, valuation, share price, and market share from 2012 through 2022. This empirical period is optimal for such a type of modeling. Modeling the impact of carbon emissions factors on the resulting indicators is considered based on complex systems theory. Endogenous model variables include indicators of the development of the international company. Predefined model variables reflect the influence of both the external environment and internal factors on the development indicators of an international company. An approach of picture fuzzy rough sets based on time series of endogenous and exogenous variables can provide an opportunity to analyze and consider the consequences of feedback changes in the systems of which they are a part. Based on the results of the analysis of the model construction, it is concluded that picture fuzzy rough sets can be an excellent way to model interdependent social processes.

Keywords: impact; on-farm; environment; innovative economy; picture fuzzy rough sets

1. Introduction

This article uses the approaches of Complex systems theory [1]. The authors use these ideas and detection algorithms based on the rules of interacting with participants and identifying them using fuzzy methods [2]. International companies exist in many environments in modern conditions: economic, social, technological, and environmental [3]. Global markets, with their supply and demand, changing technologies, a growing global population with increasing demands, and economic crises and inflation consequences. The environment influences an international company and forms the conditions for its development [4]. Factors of economic, social, technological, and environmental environments affect all indicators of an international company and all processes that occur within the company or any other organization [5]. It is necessary to remember the mutual influence of the resulting indicators of an international company. The net profit of a company depends on the company's total revenue and total assets. The total revenue of the company and its total assets affect its share capital, which depends on its earnings per share. Management is analyzing the company's activities. It should consider the influence of the external environment and the interdependence of the company's performance indicators. Picture fuzzy rough sets are an effective tool for analyzing the company's activities. Picture fuzzy rough sets of the relationship between an international company and the external environment are a significant and exciting topic for research today. The development of a company is the result of many factors, both within the on-farm activities of an international company and the impact of economic, social, technological, and environmental factors on an international company [6].

Based on the above, the study aims to develop picture fuzzy rough sets that reflect the impact of economic, social, technological, and environmental environments on the resulting performance indicators of a company that depends on each other [7,8]. To achieve the research goal, it is necessary to consider the following tasks: choose the form of picture fuzzy rough sets; determine the factors of economic, social, technological, and environmental environments that affect the performance of an international company; select indicators that evaluate the company's performance; build a picture fuzzy rough set that reflects the impact of environments on the company's performance indicators that depend on each other; develop a methodology for determining the parameters of the constructed picture fuzzy rough sets and collect the initial information; analyze the results of determining the parameters of the constructed picture fuzzy rough sets based on Complex systems theory [9].

When developing a methodology for determining the parameters of the constructed picture fuzzy rough sets, and then when defining the parameters of the constructed picture fuzzy rough sets, a critical stage is the analysis of information that characterizes the external environment and the analysis of data that represents the indicators of an international company [10,11].

Indicators of both the external environment and an international company's indicators remain unchanged. They are constantly changing [12]. Some of them change slowly, but some change dramatically and unpredictably. In this direction, it is interesting to study the opinion of the authors who analyzed both the influence of the external environment and evaluated the indicators of an international company. Companies had more time to develop new products and technologies, did not seek to reduce the duration of the product life cycle stages, did not seek to outsource innovative and technological work, mass production was dominant, and warehouses contained large stocks of raw materials and finished products. The situation changed in the late 1970s and early 1980s. Scientific and technological progress has changed the activities and external environment of corporations. At the same time, the fact remains unchanged that the corporation's activities should be evaluated from the point of view of maximizing its consumer value and minimizing the consumption of resources for its activities [13]. In this sense, the ideology of reengineering business processes and related indicators for evaluating the external and internal environment includes removing those processes in the company that do not add any value to customers. With the development of information technologies and computerized data management tools, IT solutions have become a means of implementing new organizational forms and picture fuzzy rough sets for cooperation within and between companies [14].

The laminar nature of environmental indicators and indicators of international companies has changed to turbulent. Ever-changing customer behavior, demands for diversity and customization, and cost-effectiveness are forcing companies to change their corporate strategies. Technologies such as the Internet of Things (IoT), Big Data (BD), Artificial Intelligence (AI), and Blockchains (BC) have become possible solutions that allow you to collect instrumental data and share information in real time and globally. Under these conditions, new management models are emerging to maintain competitiveness [15]. The collective term "Industry 4.0", which combines these rapid changes in the industrial landscape caused by technology, has become an essential criterion for evaluating the performance of international companies. The fast pace of transformation obliges companies to innovate in their production and business processes to take advantage of new business opportunities

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and increase competitiveness. There is a link between production strategy, benchmarking, performance measurement, and business process reengineering. The results confirm the need for a strategic approach to determining estimated performance indicators, taking into account customer orientation [16].

In today's world, it is essential to apply the concepts of Lean, Agile, Resilient, and Green, collectively known as LARG Manufacturing, to achieve business excellence. CLARG's abandonment practices can be combined with various aspects of Industry 4.0 to deliver operational, economic, and environmental benefits. Enhanced process transparency, high level of failure response, and clean production are the main features of the LARG Manufacturing & Industry — 4.0 synergy fueled by automation and big data. A comprehensive, technologically integrated implementation framework may be developed involving LARG participants with Industry 4.0 or artificial intelligence to achieve sustainability [17]. Although sustainability is a significant challenge for most international companies, tangible progress in this area is still not noticeable, mainly due to the lack of reliable methodological foundations and reliable empirical data [18]. Higher sustained organizational effectiveness (SOP) means that the company has a sustained competitive advantage over its competitors and a higher level of customer satisfaction [19].

The external environment is characterized by increased instability, unpredictability, and changes in the behavior of companies in their activities aimed at changing the indicators of economic processes [20]. Companies strive to shorten product life cycle stages, reduce product development duration, reduce inventory to almost zero, and assign expert knowledge-intensive work to external performers. The change in the customer-manufacturer relationship has led to more complex products, which has changed the technical subsystem of the production organization and created parallel execution. Instead of developing as a whole, companies divide the product into separate parts, formulate requirements for the operation of each part, and assign thoughtful design to firms with competencies in the blockchain field [21]. Tough competition has shown that prices in such conditions are not essential to cooperation. A turbulent environment imposes requirements that companies in this environment must comply with. Environmental conditions, such as the division of the product into separate parts, prices, and others related to the turbulence of ecological indicators and indicators of international companies, have become requirements [22].

2. Literature Review

In the scientific literature, much attention is paid to the problems of constructing mathematical picture fuzzy rough sets and expanding the scope of their practical application [23,24]. Procedures for forming a system of mathematical and statistical models for enterprises' production processes are proposed. An essential part of the research is the development of methods for determining model parameters and software tools. A literature review was conducted to research the problems of constructing mathematical picture fuzzy rough sets for modeling the activities of various corporate structures [25].

The research is devoted to forming picture fuzzy rough sets (econometric methods of enterprise management; scenario directions of development) and developing strategies for determining model parameters and software tools based on complex systems theory [1,26].

Table 1 shows that picture fuzzy rough sets can be used for the research problem.

Table 1. Categories of methods and the company's performance indicators.

Methods	Determining the parameters of modeling the impact on the company's performance indicators
Picture fuzzy rough sets	Axiomatics of building an econometric model
Modeling the impact of the external environment on the company's performance indicators that depend on each other	Normalization of values of exogenous and endogenous variables
System-related ones equations	Checking time series of variables for stationarity

ADL-model	Identifiability of a system of equations
ADL model System	Axiomatics of building an econometric model
Using the ADL model system for forecasting	Normalization of values of exogenous and endogenous variables

In addition, it can be noted that of all the articles included in the final review, some concerned specific models, while others covered modeling concepts [27,28].

In the second stage, the methodology for determining picture fuzzy rough sets and software tools for determining model parameters were analyzed [29]. An essential part of the study is to determine the inclusion and exclusion criteria. The primary attention in this section of the study was paid to the stages of the methodology for determining the model parameters [30]. In addition, it can be noted that of all the articles included in the final review, some were thematic and concerned with specific models, while others covered concepts.

3. Materials and Methods

This paper uses picture fuzzy rough sets, as in very cited research based on complex systems theory [19,20].

Within the methodology framework for modeling the influence of factors of both on-farm activity and environmental factors on the resulting interdependent indicators of the company's activity, a model of picture fuzzy rough sets was chosen. The task is to build a model that allows for the prediction of estimates of the values of interdependent dependent variables based on the values of independent indicators, which are time series. Time series analysis is performed on data sets in which the dependent variables have some degree of relationship. Such data sets are pretty standard in all areas of science [31,32]. The basis of the model is an equation in which the values of the dependent variable x are combined with the values of both their variables of past periods, independent indicators (factors), and dependent variables:

$$A = \{\langle x, \mu_A(x)\rangle | x \in X\} \ (1)$$

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle | x \in X\} \ (2)$$

$$A = \{\langle x, \mu_A(x), n_A(x), \nu_A(x), \pi_A(x)\rangle | x \in X\} \ (3)$$

$$A \subseteq B \text{ if } \mu_A(x) \le \mu_B(x) \text{ and } n_A(x) \le n_B(x) \text{ and } \nu_A(x) \ge \nu_B(x), \ \forall x \in X \ (4)$$

$$A = B \text{ if } A \subseteq B \text{ and } B \subseteq A \ (5)$$

$$A \cup B = \left\{\left(x, max(\mu_A(x), \mu_B(x)), min(n_A(x), n_B(x)), min(\nu_A(x), \nu_B(x))\right) | x \in X\right\} \ (6)$$

$$A \cap B = \left\{\left(x, min(\mu_A(x), \mu_B(x)), min(n_A(x), n_B(x)), max(\nu_A(x), \nu_B(x))\right) | x \in X\right\}$$

(7)

$$coA = \bar{A} = \left\{\left(x, \nu_A(x), n_A(x), \mu_A(x)\right) | x \in X\right\} \ (8)$$

$$\underline{Apr}(C_i) = \cup \{Y \in X/R(Y) \le C_i\} \ (9)$$

$$\overline{Apr}(C_i) = \cup \{Y \in X/R(Y) \ge C_i\} \ (10)$$

$$Bnd(C_i) = \cup \{Y \in X/R(Y) \ne C_i\} \ (11)$$

$$\underline{Lim}(C_i) = \sqrt[N_L]{\prod_{i=1}^{N_L} Y \in \underline{Apr}(C_i)} \ (12)$$

$$\overline{Lim}(C_i) = \sqrt[N_U]{\prod_{i=1}^{N_U} Y \in \overline{Apr}(C_i)} \ (13)$$

$$RN(C_i) = \left[\underline{Lim}(C_i), \overline{Lim}(C_i)\right] \ (14)$$

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$$\underline{Apr}\left(C_{i\mu_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{i\mu_A}\right\} \ (15)$$

$$\underline{Apr}\left(C_{in_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{in_A}\right\} \ (16)$$

$$\underline{Apr}\left(C_{iv_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{iv_A}\right\} \ (17)$$

$$\underline{Apr}\left(C_{i\pi_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{i\pi_A}\right\} \ (18)$$

$$\overline{Apr}\left(C_{i\mu_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{i\mu_A}\right\} \ (19)$$

$$\overline{Apr}\left(C_{in_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{in_A}\right\} \ (20)$$

$$\overline{Apr}\left(C_{iv_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{iv_A}\right\} \ (21)$$

$$\overline{Apr}\left(C_{i\pi_A}\right) = \cup \left\{Y \in X/\tilde{R}(Y) \leq C_{i\pi_A}\right\} \ (22)$$

$$\underline{Lim}\left(C_{i\mu_A}\right) = \frac{1}{N_{L\mu_A}} \sum_{i=1}^{N_{L\mu_A}} Y \in \underline{Apr}\left(C_{i\mu_A}\right) \ (23)$$

$$\underline{Lim}\left(C_{in_A}\right) = \frac{1}{N_{Ln_A}} \sum_{i=1}^{N_{Ln_A}} Y \in \underline{Apr}\left(C_{in_A}\right) \ (24)$$

$$\underline{Lim}\left(C_{iv_A}\right) = \frac{1}{N_{Lv_A}} \sum_{i=1}^{N_{Lv_A}} Y \in \underline{Apr}\left(C_{iv_A}\right) \ (25)$$

$$\underline{Lim}\left(C_{i\pi_A}\right) = \frac{1}{N_{L\pi_A}} \sum_{i=1}^{N_{L\pi_A}} Y \in \underline{Apr}\left(C_{i\pi_A}\right) \ (26)$$

$$\overline{Lim}\left(C_{i\mu_A}\right) = \frac{1}{N_{U\mu_A}} \sum_{i=1}^{N_{U\mu_A}} Y \in \overline{Apr}\left(C_{i\mu_A}\right) \ (27)$$

$$\overline{Lim}\left(C_{in_A}\right) = \frac{1}{N_{Un_A}} \sum_{i=1}^{N_{Un_A}} Y \in \overline{Apr}\left(C_{in_A}\right) \ (28)$$

$$\overline{Lim}\left(C_{iv_A}\right) = \frac{1}{N_{Uv_A}} \sum_{i=1}^{N_{Uv_A}} Y \in \overline{Apr}\left(C_{iv_A}\right) \ (29)$$

$$\overline{Lim}\left(C_{i\pi_A}\right) = \frac{1}{N_{U\pi_A}} \sum_{i=1}^{N_{U\pi_A}} Y \in \overline{Apr}\left(C_{i\pi_A}\right) \ (30)$$

$$PFRN(\tilde{C}_\iota) = \left(\left[\underline{Lim}(C_{i\mu_A}), \overline{Lim}(C_{i\mu_A})\right], \left[\underline{Lim}(C_{in_A}), \overline{Lim}(C_{in_A})\right], \left[\underline{Lim}(C_{iv_A}), \overline{Lim}(C_{iv_A})\right], \left[\underline{Lim}(C_{i\pi_A}), \overline{Lim}(C_{i\pi_A})\right]\right) \ (31)$$

Normalization of data is a necessary initial stage of data transformation since variables are measured on scales that differ significantly in values [33]. In the study, the critical value of the pair correlation coefficient for exclusion from further analysis of the variable or leaving the variable in the analysis was assumed to be the value of the pair correlation coefficient equal to |0.7|. The analysis excludes agents of the right-hand side of the equation whose correlation coefficient with the endogenous variable is lower than |0.7| and agents of the right-hand side that have a close relationship with each other above |0.7|.

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$$\tilde{Z}_k = \begin{bmatrix} 0 & \tilde{z}_{12} & \cdots & \cdots & \tilde{z}_{1n} \\ \tilde{z}_{21} & 0 & \cdots & \cdots & \tilde{z}_{2n} \\ \vdots & \vdots & \ddots & \cdots & \cdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{z}_{n1} & \tilde{z}_{n2} & \cdots & \cdots & 0 \end{bmatrix} \quad (32)$$

$$\mathrm{PFRN}(\widetilde{C_{ij}}) = \left(\begin{matrix} \left[\underline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right), \overline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right)\right], \left[\underline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right), \overline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)\right], \\ \left[\underline{\mathrm{Lim}}\left(C_{ijv_{\tilde{z}_{ij}}}\right), \overline{\mathrm{Lim}}\left(C_{ijv_{\tilde{z}_{ij}}}\right)\right], \left[\underline{\mathrm{Lim}}\left(C_{ij\pi_{\tilde{z}_{ij}}}\right), \overline{\mathrm{Lim}}\left(C_{ij\pi_{\tilde{z}_{ij}}}\right)\right] \end{matrix} \right) \quad (33)$$

$$\tilde{k}_j = \begin{cases} 1 & j = 1 \\ \tilde{s}_j + 1 & j > 1 \end{cases} \quad (34)$$

$$\tilde{q}_j = \begin{cases} 1 & j = 1 \\ \frac{\tilde{k}_{j-1}}{\tilde{k}_j} & j > 1 \end{cases} \quad (35)$$

$$\tilde{w}_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (36)$$

$$w_{j\,min} = \underline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right) + \frac{\underline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2} + \frac{\left(1 + \underline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right) + \frac{\underline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2} - \underline{\mathrm{Lim}}\left(C_{ijv_{\tilde{z}_{ij}}}\right) + \frac{\underline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2}\right)}{2} \times \underline{\mathrm{Lim}}\left(C_{ij\pi_{\tilde{z}_{ij}}}\right) \quad (37)$$

$$w_{j\,max} = \overline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right) + \frac{\overline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2} + \frac{\left(1 + \overline{\mathrm{Lim}}\left(C_{ij\mu_{\tilde{z}_{ij}}}\right) + \frac{\overline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2} - \overline{\mathrm{Lim}}\left(C_{ijv_{\tilde{z}_{ij}}}\right) + \frac{\overline{\mathrm{Lim}}\left(C_{ijn_{\tilde{z}_{ij}}}\right)}{2}\right)}{2} \times \overline{\mathrm{Lim}}\left(C_{ij\pi_{\tilde{z}_{ij}}}\right) \quad (38)$$

$$w_j = \frac{(w_{j\,min} + w_{j\,max})}{2} \quad (39)$$

$$\tilde{X}_{ij} = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \ddots & \cdots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} (40)$$

$$\mathrm{PFRN}(\tilde{X}_{ij}) = \left(\begin{matrix} \left[\underline{\mathrm{Lim}}\left(\tilde{X}_{ij\mu_{\tilde{x}_{ij}}}\right), \overline{\mathrm{Lim}}\left(\tilde{X}_{ij\mu_{\tilde{x}_{ij}}}\right)\right], \left[\underline{\mathrm{Lim}}\left(\tilde{X}_{ijn_{\tilde{x}_{ij}}}\right), \overline{\mathrm{Lim}}\left(\tilde{X}_{ijn_{\tilde{x}_{ij}}}\right)\right], \\ \left[\underline{\mathrm{Lim}}\left(\tilde{X}_{ijv_{\tilde{x}_{ij}}}\right), \overline{\mathrm{Lim}}\left(\tilde{X}_{ijv_{\tilde{x}_{ij}}}\right)\right], \left[\underline{\mathrm{Lim}}\left(\tilde{X}_{ij\pi_{\tilde{x}_{ij}}}\right), \overline{\mathrm{Lim}}\left(\tilde{X}_{ij\pi_{\tilde{x}_{ij}}}\right)\right] \end{matrix} \right) \quad (41)$$

Reducing the structural form of picture fuzzy rough sets of the model consists of obtaining equations in which the endogenous variables on the left side of the equations are expressed in terms of all exogenous variables and lagged endogenous variables; i.e., the transition from the structural form of the model to the reduced form consists of transforming such that no endogenous variables remain on the right side [34].

Given the completed procedure when normalizing the values of exogenous and endogenous variables, it is necessary to return from the coefficients of each model equation calculated on the normalized data array to the coefficients corresponding to the actual data [35,36].

$$\tilde{r}_{ij} = \frac{\underline{\mathrm{Lim}}\left(\tilde{X}_{ij\mu_{\tilde{x}_{ij}}}\right)}{\max\tilde{X}_i}, \dots, \frac{\overline{\mathrm{Lim}}\left(\tilde{X}_{ij\pi_{\tilde{x}_{ij}}}\right)}{\max\tilde{X}_i} \quad (42)$$

$$\tilde{v}_{ij} = w_j \times \underline{\mathrm{Lim}}\left(\tilde{r}_{ij\mu_{\tilde{x}_{ij}}}\right), \dots, w_j \times \overline{\mathrm{Lim}}\left(\tilde{r}_{ij\pi_{\tilde{x}_{ij}}}\right) \quad (43)$$

$$Q_i = \sum_{j=1}^{t} v_{ijbenefit} + \frac{R_{min}\sum_{i=1}^{m}\sum_{j=t+1}^{n} v_{ijnon-benefit}}{\sum_{j=t+1}^{n} v_{ijnon-benefit}\sum_{i=1}^{m}\frac{R_{min}}{\sum_{j=t+1}^{n} v_{ijnon-benefit}}} \quad (44)$$

$$U_i = \frac{Q_i}{Q_{max}} \times 100\% \quad (45)$$

3. Results

The analysis of the tightness of the relationship of endogenous variables with each other, the analysis of the tightness of the relationship of endogenous and exogenous variables with each other, and exogenous variables with each other at a critical level of tightness of the relationship of more than |0.7| revealed the variables of the right-hand sides of the equations (Table 2).

Table 2. Criterias table.

Endogenous variables	Exogenous variables
The company's profit in the *t* year (money that remains in the company at the end of the reporting period after all expenses and taxes are paid and can be distributed among shareholders in the form of dividends) is billion rubles.;	Number of integration solutions of the company in the *t* year (the number of integrations of the company with other services/platforms made in a year, including those where the company developed the product or implemented its existing product), pcs.;
The company's revenue in *t* year (the total amount of funds received from the sale of all or part of the products, services, and works produced for the year) is billion rubles. rub.;	Central Bank of Russia interest Rate in the *t* year (the market value of shares directly depends on the interest rate of the Central Bank of Russia, since the lower the rate, the higher the growth of consumption and investment, and vice versa), % per annum;
Company's estimated value in *t* year, is billion rubles. RUB (valuation of the company's value, taking into account all sources of its financing: debt obligations, preferred shares, ordinary shares);	Company expenses in the *t* year (the company's day-to-day costs for doing business, producing products and services) are billion rubles. rub.;
Price of the company's shares in the *t* year, RUB/unit (price per share from the number of sold shares of the company);	Inflation in the *t* year (percentage of inflation in Russia for the year), % per year;

Search Engine market share in *t* year, owned by the company, % .	The main part of investment project costs in the t year (capital expenditures intended for investing in companies, such as the cost of purchasing fixed assets, for example, buildings, equipment, technologies, and other costs) is billion rubles.;
	Number of competitors in the *t* year (other TNCs and major competitors of the company), units;
	Number of employees of the company in the *t* year , human;
	Value of the company's assets in the *t* year (value of the company's property and cash, including property and other rights that have a monetary value), billion rubles.

The pairwise correlation coefficients of endogenous and exogenous variables are presented in Table 3 and include the following: the search engine market share owned by the company in the *t* year depends on the company's profits in the t year (y_t^1), in the company's pods in the *t* year (y_t^2), and on the prices of the company's value in the *t* year (y_t^3).

Table 3. Picture fuzzy numbers.

Scales for criteria	Picture fuzzy numbers		
	(y_t^1)	(y_t^2)	(y_t^3)
Very low (VL)	0,1	0,1	0,5
Low (L)	0,2	0,2	0,4
Middle (M)	0,3	0,3	0,3
High (H)	0,6	0,2	0,2
Very High (VH)	0,8	0,1	0,1

In general, based on the results of the constructed model, it can be concluded that the described modeling approach can assess the impact of factors of both on-farm activity and environmental factors on the resulting indicators of an international company. Practical aspects of the company's activities are pretty consistent with the need to assess the impact of economic, social, technological, and environmental factors on the company's business goals. Within the framework of the model, it is quite possible to assess the impact of such factors on the company's target indicators, both in aggregate and for each group of indicators (Tables 4 and 5).

Table 4. Linguistic evaluations.

	C1			C2			C3			C4			C5		
	DS 1	DS 2	DS 3	DS 1	DS 2	DS 3	DS 1	DS 2	DS 3	DS 1	DS 2	DS 3	DS 1	DS 2	DS 3
Research and Development (criterion 1)	-	-	-	H	H	M	M	L	L	VH	H	M	H	L	M

Commercialization (criterion 2)	M	M	VH	-	-	-	L	L	H	H	VL	VL	VL	L	L
Cost (criterion 3)	H	H	M	H	VH	H	-	-	-	M	VL	VL	L	M	M
Operational issues (criterion 4)	M	L	M	H	H	VH	VH	VH	H	-	-	-	VH	H	M
Functionality (criterion 5)	H	H	L	H	VH	M	H	H	VH	L	VL	M	-	-	-

Table 5. Decisions matrix.

Decision Maker 1																				
	D1				**D2**				**D3**				**D4**				**D5**			
	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π	μ	η	ν	Π	μ	η	ν	π
C1	0	0	0	0	0,3	0,3	0,3	0	0,3	0,3	0,3	0,1	0,8	0,3	0,3	0,3	0,6	0,2	0,2	0
C2	0,3	0,3	0,3	0,1	0,6	0,2	0,2	0	0,2	0,3	0,3	0,3	0,6	0,6	0,2	0,2	0,1	0,3	0,3	0,3
C3	0,6	0,2	0,2	0	0,3	0,3	0,3	0	0	0,6	0,2	0,2	0,3	0,3	0,3	0,3	0,2	0,6	0,2	0,2
C4	0,3	0,3	0,3	0,1	0,6	0,2	0,2	0	0,8	0,3	0,3	0,3	0	0,6	0,2	0,2	0,8	0,3	0,3	0,3
C5	0,6	0,2	0,2	0	0,6	0,2	0,2	0	0,6	0,6	0,2	0,2	0,2	0,2	0,4	0,2	0	0,6	0,2	0,2
Decision Maker 2																				
	D1				**D2**				**D3**				**D4**				**D5**			
	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π
C1	0	0	0	0	0,6	0,3	0,3	0,3	0,2	0,3	0,3	0,3	0,6	0,2	0,2	0	0,2		0,6	0,2
C2	0,3	0,3	0,3	0,3	0	0,6	0,2	0,2		0,6	0,2	0,2	0,1	0,1	0,5	0,3	0,2	0	0,3	0,3
C3	0,6	0,6	0,2	0,2	0,8	0,3	0,3	0,3	0	0,3	0,3	0,3		0,6	0,2	0,3	0,3	0,8	0,2	0,2
C4	0,2	0,3	0,3	0,3	0,6	0,6	0,2	0,2	0,8	0,2	0,2	0,2	0	0,3	0,3	0	0,6	0,2	0,2	0
C5	0,6	0,6	0,2	0,2	0,8	0,1	0,1	0	0,6	0,2	0,2	0	0,8	0,2	0,2	0,3	0	0	0	0
Decision Maker 3																				
	D1				**D2**				**D3**				**D4**				**D5**			
	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π	μ	η	ν	π

C1	0	0	0	0	0,3	0,3	0,3	0,1		0,6	0,2	0,2	0,3	0,3	0,3	0,1	0,3	0,3	0,3	0,1
C2	0,8	0,1	0,1	0	0	0	0	0	0	0,3	0,3	0	0,1	0,1	0,5	0,3	0,2		0,6	0,2
C3	0,6	0,2	0,3		0,6	0,2	0,2	0	0,8	0,2	0,2	0		0,6	0,2	0,3	0,3	0	0,3	0,3
C4	0,3	0,3	0,3	0	0,3	0,3	0,1	0	0,6	0,2	0,2	0	0	0,3	0,3	0	0,3	0,8	0,2	0,2
C5	0,2	0,2	0,4	0,8	0,2	0,2	0,3	0,1	0,8	0,1	0,1	0	0,8	0,2	0,2	0,1	0	0	0	0

The model also allows you to evaluate the mutual influence of target indicators. The range of use of picture fuzzy rough sets is extensive. The article used modeling to analyze the impact of factors of on-farm activity and environmental factors on the resulting indicators. Defuzzified and Stable data is in Tables 6 and 7.

Table 6. Defuzzified matrix.

	D1	D2	D3	D4	D5
D1	0,00	0,34	0,00	0,18	0,22
D2	0,34	0,37	0,26	0,00	0,20
D3	0,34	0,00	0,18	0,22	0,00
D4	0,37	0,26	0,00	0,20	0,20
D5	0,21	0,26	0,35	0,18	0,00

Table 7. Stable matrix.

	D1	D2	D3	D4	D5
D1	0,20	0,34	0,00	0,18	0,22
D2	0,24	0,37	0,26	0,00	0,20
D3	0,34	0,00	0,18	0,18	0,00
D4	0,37	0,26	0,00	0,19	0,19
D5	0,26	0,35	0,18	0,17	0,17

A set of indicators for assessing the state of socio-economic and ecological systems in the Arctic and regular assessments that track progress towards sustainable development of the Arctic territory can be used within the framework of the considered picture fuzzy rough sets. The environmental sphere can be assessed using the indicator emissions of pollutants into the atmospheric air from stationary and mobile (automobile transport) sources. The economic sphere can be estimated using the following indicators: gross regional product, volume of cargo transportation by road, rail, and air transport, and volume of interport cargo transportation by sea (cargo sent and arrived). An indicator for assessing the social sphere is the average monthly monetary income of the population in the Arctic zone (Table 8).

Table 8. Weighted decision matrix.

	BS	DC	FACTS	DLR	PMUs

C1	([0,07;0,15];[0,05;0,07]; [0,05;0,07];[0;0,01])	([0,05;0,07];[0;0,05]; [0,07;0,15];[0,01;0,07])	([0,10;0,10];[0,05;0,15]; [0,01;0,05];[0;0])	([0,05;0,15];[0,05;0,07]; [0,05;0,10];[0;0,05])	([0,05;0,07];[0,05;0,07]; [0,07;0,10];[0,01;0,05])
C2	([0,17;0,13];[0,01;0,05]; [0,01;0,05];[0;0])	([0,17;0,13];[0,01;0,05]; [0,01;0,05];[0;0])	([0,17;0,13];[0,01;0,05]; [0,01;0,05];[0;0])	([0,05;0,08];[0,05;0,08]; [0,08;0,11];[0,01;0,05])	([0,01;0,17];[0,01;0,08]; [0,05;0,14];[0;0,08])
C3	([0,07;0,15];[0,05;0,07]; [0,05;0,07];[0;0,01])	([0,15;0,10];[0,01;0,05]; [0,01;0,05];[0;0])	([0,15;0,10];[0,01;0,05]; [0,01;0,05];[0;0])	([0,05;0,15];[0,05;0,07]; [0,05;0,10];[0;0,05])	([0,01;0,05];[0,01;0,05]; [0,10;0,11];[0,05;0,07])
C4	([0,04;0,14];[0,04;0,07]; [0,04;0,09];[0;0,04])	([0,07;0,18];[0,01;0,07]; [0,01;0,07];[0;0,01])	([0,14;0,18];[0,01;0,04]; [0,01;0,04];[0;0])	([0,04;0,07];[0,04;0,07]; [0,07;0,09];[0,01;0,04])	([0,04;0,14];[0,04;0,07]; [0,04;0,09];[0;0,04])
C5	([0,06;0,11];[0,04;0,06]; [0,04;0,06];[0;0,01])	([0,06;0,11];[0,04;0,06]; [0,04;0,06];[0;0,01])	([0,11;0,16];[0,01;0,04]; [0,01;0,04];[0;0])	([0,04;0,11];[0,04;0,06]; [0,04;0,08];[0;0,04])	([0,04;0,06];[0,04;0,06]; [0,06;0,08];[0,01;0,04])

Table 9 demonstrates that rapid environmental and social changes in the Arctic increase the need for understanding and systematic discussion of various potential futures. For such purposes, the analyzed model may well be suitable. A fundamental problem in the Arctic is the complex dynamics of multiple drivers of change with feedback loops that can accelerate the pace of changes in a set of indicators for assessing the state of socio-economic and ecological systems in the Arctic. An approach to model development based on the use of endogenous and exogenous variables can provide an opportunity to analyze and consider the consequences of changes in feedback in the systems of which they are a part: bulk storage (B), dynamic line (DL), phasor measurement unit (P) and flexible energy (F).

Table 9. Defuzzified decision matrix.

	B	DC	F	DL	P
D1	0,15	0,16	0,18	0,11	0,14
D2	0,23	0,13	0,16	0,12	0,09
D3	0,16	0,18	0,11	0,14	0,09
D4	0,16	0,18	0,11	0,14	0,14
D5	0,13	0,16	0,12	0,09	0,09

The processes of modeling the company's internal and external environment factors are usually considered from the point of view of constructing nonlinear adaptive models with an assessment of risks and consequences of decisions made. Modern agent-based models take into account, first of all, innovative research models and strategies. Emerging technological innovations often lead to a realignment of the agent-based models of established companies, requiring them to incorporate new external knowledge into their internal activities. Established agent-based models are changing in response to the emergence of Industry 4.0.

Information system analysts widely use business process models in companies to represent complex business requirements and environmental constraints. This understanding is extracted from graphical processes models, as well as from production and business rules. A representative integrated modeling method allows you to improve the representation of such models, focusing primarily on the performance factor of the modeled system itself. Linking rules is superior to separate modeling in terms of understanding efficiency, productivity, perceived mental effort, and visual attention.

One of the most important problems faced by the company's modeling practices is that the simulated systems are presented more from the technical side and do not have a social orientation. The company's architecture frameworks are of interest from the point of view of social aspects — these are soft aspects of the organization that lead to organic development of the company.

5. Conclusions

The paper widens the knowledge base on the problem of modeling the impact of factors of both on-farm activity and environmental factors on the resulting indicators of the company as a whole. It can highlight the fact that there is an urgent need to develop modeling approaches. The development of a full-fledged methodology for picturing fuzzy rough sets of the impact of factors on target indicators of a production or territorial system will allow us to assess and overcome barriers that exist in real life and will serve as a factor for the sustainable development of the analyzed system based on Complex systems theory.

From the above, we can outline the direction of further development of the picture fuzzy rough sets. Following the idea of picture fuzzy rough sets, absolute similarity is impossible for most systems, and the primary goal of picture fuzzy rough sets is that it reflect the functioning of the modeled system well enough it is necessary to increase the size of the model consistently. In other words, it increases the number of endogenous and exogenous variables at each subsequent stage. The number of endogenous and exogenous variables can be increased at the expense of variables with high and low communication tightness. An approach to model development based on the use of endogenous and exogenous variables can provide an opportunity to analyze and consider the consequences of changes in feedback in the systems: bulk storage (B), dynamic line (DL), phasor measurement unit (P) and flexible energy (F).

The results of this paper have policy implications: government regulators and businesses can use soft aspects of Complex systems theory in the organization that leads to the organic development of the company (communication, collaboration, culture, skills, and personal goals).

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