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Economic Security Management for Sustainable Planning

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ABSTRACT

Sustainable development is one of the most important challenges facing mankind today. The essence of sustainable development is to maximize economic and social benefits while protecting the environment and ensuring the long-term sustainable use of natural resources. In economic terms, sustainable development means not only the growth of the national economy and per capita income, but also improvements in all aspects of social security. The main purpose of this study is to model the assessment of the negative impact of threats on the information space of sustainable development planning within the context of managing economic security in a given socio-economic system. The research methodology involves the use of modern econometric methods based on fuzzy relations theory. This methodology fully contributed to achieving the set goals and resulted in justifying the application of weighted measures for each class of security threats in the information support system for sustainable development planning. Additionally, it was shown to be expedient to develop a clear plan for organizing information space protection while ensuring a balance between the level of information risk and the acceptable costs of ensuring economic security during planning for sustainable development in a given socio-economic system. This study has limitations, and they are related to the narrowness of identified threats and the choice of only one specific socio-economic system as an example. These aspects should be broadened in future research.

1. INTRODUCTION

Informatization plays a pivotal role in enhancing the quality of life in contemporary society. The level and quality of services, culture, education, and work organization increasingly hinge on the sophistication and quality of information and communication technologies. The process and essence of informatization are epitomized by the proliferation of these technologies, which in turn, integrate society.

Informatization permeates all aspects of human life: it fosters labor productivity growth, enhances economic management, bolsters the development of knowledge-intensive industries and high technologies, enriches spiritual life, and catalyzes further societal democratization. Information technologies herald a new chapter in the evolution of science and society as a whole. In the political sphere, society's transition to the information stage of development allows for leveraging democratic institutions as instrumental tools. In the economic sphere, informatization triggers the emergence of new industries and transforms the economic paradigm, increasingly integrating real and virtual sectors. The possibilities and scale of capital flows are burgeoning, with financial transactions executed at unprecedented speeds.

The active informatization of modern society and the surge in confidential information flows have necessitated the assurance of economic security across various public activity domains. All processes in the financial, industrial, political, or social sectors are directly linked to information resources and the application of information technology. Simultaneously, the escalating complexity of the information space and technologies is augmenting the number of potential threats to these systems in the context of sustainable development planning. Hence, assessing the security level of information protection systems circulating in the socio-economic system is integral to ensuring economic security and forecasting sustainable development.

The challenge of ensuring high-quality functioning of information space systems is becoming increasingly urgent due to the emergence of new threats and the amplification of existing ones. One practical challenge lies in establishing an optimal balance between ensuring the security of the information space system and the costs for its maintenance, in addition to efficiently allocating resources for individual protection areas. At the initial stages of creating an effective protection system for sustainable development planning objects, it is imperative to determine the quantitative significance of potential threats. The execution of these threats can disrupt the functioning of the studied objects, instigating social, political, environmental, and economic instability. The primary sources of threats could include a high level of depreciation and accident rate of fixed assets, the impacts of hazardous natural phenomena, and a tense military-political and economic situation in the country. Most of these issues can be tackled using statistical analysis methods, necessitating substantial information volumes, complex calculations, and time-consuming analysis. One solution is threat ranking, which enables the determination of the permissible intensity of downgrading the systems under study and establishing a proportional ratio of the permissible costs to ensure their security.

To fulfill the set goals, this article employs specific terminology related to econometric methods using the theory of fuzzy relations. These technical terms are used to construct specific models that facilitate the achievement of the research objectives.

The primary objective of this study is to model the assessment of the negative impact of threats on the information space of sustainable development planning within a single socio-economic system context. The innovation of this article lies in the fact that, through the methods and the established model for assessing the negative impact of threats, we not only enumerate these threats but also quantify their impact degree.

2. LITERATURE REVIEW

Leading scientists have noted that the question of balanced development among countries is becoming increasingly critical at the start of the third millennium [1, 2]. A novel direction in the socio-economic development of states is the integration of economic and environmental needs of the population with social necessities. A systematic approach combined with modern information technologies enables the modeling of various options for countries' economic development directions, predicting their outcomes with high precision, and choosing the most optimal ones.

The study of the driving forces and factors influencing the development of the world economy has been the subject of research by economists for centuries [3, 4]. However, the various approaches to defining the concept of development in the general economic systemic concepts of building the world economy necessitate the grouping and generalization of existing interpretations.

According to Kondur and Fuchynska [5], the concept of informatization aims to optimize the ideology of the information society and ensure its sustainable development by forming a techno-humanitarian and noospheric balance in modern society. This balance is a conceptual model that delineates the mechanism for exacerbating and overcoming anthropogenic and cultural crises in the context of globalization, as determined by economic crises. The formation of the concept of the ideology of the information society plays a compensatory role, acting as a determining factor in times of crisis and contributing to the restoration of the disrupted balance between instrumental (technogenic) and humanitarian nature.

Scientists acknowledge that achieving sustainable development, which encompasses the well-being of present and future generations, is a profoundly complex task that requires time to solve. Sustainable development serves as a strategy for regional and national development. Considering the three main types of relations in the regional system—ecological-economic, socio-economic, and environmental-social—there is a possibility of simultaneously achieving three important optimums within this system: the ecological-economic optimum, socio-economic optimum, and ecological and social optimum. This state of equilibrium allows the regional system to develop uniformly in all directions. Therefore, the balance from the perspective of sustainable development of the regional socio-ecological and economic system will provide for the continual attainment of such a state in which the optimal ratio of one subsystem of sustainable development does not result in a qualitative and quantitative deterioration of the other but is aimed at developing the entire system [6, 7].

Several scientists note [8-11] that planning for sustainable development aims to achieve harmony between people, societies, and nature, resolving currently existing contradictions, such as those between nature and society, ecology and economy, developed and developing countries, the rich and the poor, established needs and reasonable needs, and present and future generations.

The world economy is going through a strenuous recovery phase where the creation of new mechanisms for a modernized economy should occur against the backdrop of economic development stabilization of the entire socio-economic structure of the regions. The problem of sustainable development is exacerbated by the emergence of numerous destabilizing factors. Instability has become a characteristic feature of the functioning of economic systems at all levels, and the disintegration and polarization of regions in terms of socio-economic development are intensifying [12-14].

Despite the robust scientific base in the field of countering the diverse negative impact of threats to the socio-economic system and sustainable development planning, the issue of the negative impact of threats on the information space of sustainable development planning in the context of economic security management remains pertinent. Therefore, it is necessary to apply appropriate sets of countermeasures.

3. METHODOLOGY

To achieve the objectives of this article, we will apply the ranking methodology, encompassing various analysis methods. For instance, in our case, these include theories of fuzzy relations and the least influence method.

It is noteworthy that a specific socio-economic system should be chosen as an example for the application of the methodology and its concept of sustainable development planning. A complex socio-economic system, such as the large enterprise "SoftServ"—a leader in the development of robust technical and information software for Eastern European countries—should be selected. This choice is not arbitrary; using the practical selection method, the researchers who work at this enterprise and have a comprehensive understanding of its sustainable development system made this decision.

The threat to the “SoftServ” information space in the sustainable development planning system is a combination of conditions and factors that endanger vital interests.

Let's construct a set of the most significant threats from the perspective of applying the method of analysis and synthesis to studying this problem:

– G_1 – leakage protection by technical channels;

– G_2 – protection of the information transmission channel used by the socio-economic system;

– G_3 – disclosure of information by the personnel of the enterprise;

– G_4 – physical protection of key elements of sustainable development;

– G_5 – unauthorized access to information by an intruder;

– G_6 – organizational support of economic security for sustainable development;

– G_7 – unintentional actions, errors of maintenance personnel;

– G_8 – reliability, fault tolerance of hardware and software;

– G_9 – regulatory support of protection;

– G_{10} – natural and man-made phenomena.

These threats to the information space of the "SoftServ" sustainable development planning system in the context of managing its economic security may lead to failure to meet criteria such as:

– T_1 – accessibility - the ability to receive the necessary information service in a reasonable time;

– T_2 – integrity - protection from destruction and unauthorized changes;

– T_3 – confidentiality - the property of information to be inaccessible and closed to an unauthorized user, logical object or process;

– T_4 – reliability - protection against falsification, forgery and fraud.

Next, we will rank the threats to the information space of planning the sustainable development of our socio-economic system according to the essence of the ranking method. The impact of the threat G_i, which leads to the non-fulfillment of the criterion T_j, we define the fuzzy set as O (μ_{im}/T_m).

Using the method of least influence, we determine the number μ_{ij}, which is assigned to each pair of elements (G_i, T_j). To form the initial data for the least impact method, the method of expert analysis should be used. In the group of experts, we included the employees of "SoftServ" involved in planning its sustainable development and ensuring economic security. The expert analysis was carried out exclusively subjectively and did not provide for the most professional assessment, only to demonstrate the effectiveness of the proposed methods of the selected research problem.

Despite the broad scope of the article, which covers many elements, the proposed modeling method does not allow for more than 10 positions. Furthermore, even though a specific enterprise was chosen, most of the identified threats are also common in other enterprises. Our aim is to demonstrate how to implement the appropriate countermeasures for these threats.

4. RESULTS OF RESEARCH

Fuzzy relationships are of fundamental importance in the analysis of fuzzy systems. Methods of fuzzy relations are widely used in the theory of fuzzy automata, in modeling complex systems in the development of automated decision-making systems.

Thus, applying the above and described methods, we present our results of the study. An expert comparison of the impact forces F_{ij} with the lowest impact forces F_{il} is presented in Table 1.

Table 1. Matrix analysis of the dependence of threats to demographic security and sustainable development of the region

T	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
T_1	1	1	1	9	1	1	7	9	1	9
T_2	7	7	6	4	7	6	5	5	5	3
T_3	9	5	9	1	9	7	3	6	6	1
T_4	5	5	7	5	7	6	1	1	5	1

Note that T_l contains all the criteria that G_i threats have the least impact on, and F_{ij}/F_{il} are expert comparisons of the forces of influence F_{ij} with the least forces of influence F_{il}.

Let us calculate the least degree of influence of the G_i threat in the sustainable development planning system using formula (1):

$$\mu_{il}=(F_{im}/F_{il})^{-1} \tag{1}$$

Based on this value, we can calculate the degree of impact corresponding to each pair (G_i, T_j) (2):

$$\mu_{il}=\mu_{im}F_{im}/F_{il}, \tag{2}$$

Using the data in Table 1, we determine the degree of influence μ_{ij}, which form a fuzzy relation (Table 2).

To normalize the ratio (Table 2), we divide the elements of each row by the maximum value available in the corresponding row, and we get the result presented in Table 2.

Let us form a fuzzy similarity relation consisting of a set of values of similarity measures ($D_{ij}/(G_i,G_j)$).

d_{ij} ($1/n\sum[\mu_{ik}-\mu_{jk}]$) – is the distance between the fuzzy sets of the influence of threats G_i and G_j (μ_{im}/G_m).

Thus, having carried out all the above calculations, we obtain a fuzzy similarity relation for the subject area under study (Table 3).

Let us grant the original similarity relation R the property of transitivity by defining the composition of relations as the maximum product of the corresponding matrices. As a result, from Table 3, we will obtain, after appropriate calculations, Table 4.

Table 2. The results of the calculations and normalization

O (Fuzzy Relation)										
T_1	1/22	1/18	1/23	9/19	1/24	1/20	7/16	9/21	1/17	9/14
T_2	7/22	7/18	6/23	4/19	7/24	6/20	5/16	5/21	5/17	3/14
T_3	9/22	5/18	9/23	1/19	9/24	7/20	3/16	6/21	6/17	1/14
T_4	5/22	5/18	7/23	5/19	7/24	6/20	1/16	1/21	5/17	1/14
T_1 (Normalization)	0.1	0.1	0.1	1	0.1	0.1	1	1	0.2	1
T_2 (Normalization)	0.8	1	0.7	0.4	0.8	0.9	0.7	0.5	0.8	0.3
T_3 (Normalization)	1	0.7	1	0.1	1	1	0.4	0.7	1	0.1
T_4 (Normalization)	0.6	0.7	0.8	0.5	0.8	0.9	0.1	0.1	0.8	0.1

Table 3. Matrix of calculation based on our research

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
	1	0.83	0.92	0.47	0.94	0.9	0.51	0.53	0.9	0.33
	0.83	1	0.8	0.46	0.39	0.86	0.5	0.5	0.86	0.32
	0.92	0.8	1	0.44	0.96	0.92	0.46	0.5	0.93	0.3
	0.47	0.46	0.44	1	0.41	0.38	0.75	0.72	0.4	0.86
D	0.94	0.39	0.96	0.41	1	0.95	0.46	0.47	0.96	0.28
	0.9	0.86	0.92	0.38	0.95	1	0.42	0.44	0.98	0.24
	0.51	0.5	0.46	0.75	0.46	0.42	1	0.89	0.45	0.8
	0.53	0.5	0.5	0.72	0.47	0.44	0.89	1	0.46	0.8
	0.9	0.86	0.93	0.4	0.96	0.98	0.45	0.46	1	0.26
	0.33	0.32	0.3	0.86	0.28	0.24	0.8	0.8	0.26	1

Table 4. The results of the D^2 and D^3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
	1	0.86	0.94	0.53	0.94	0.94	0.53	0.53	0.94	0.53
	0.86	1	0.86	0.5	0.86	0.86	0.51	0.53	0.86	0.5
	0.94	0.86	1	0.5	0.96	0.95	0.51	0.53	0.94	0.5
	0.53	0.5	0.5	1	0.47	0.47	0.8	0.8	0.53	0.86
D*D	0.94	0.86	0.96	0.47	1	0.96	0.51	0.53	0.94	0.47
	0.94	0.86	0.95	0.47	0.96	1	0.51	0.53	0.94	0.44
	0.53	0.51	0.51	0.8	0.51	0.51	1	0.89	0.53	0.8
	0.53	0.53	0.53	0.8	0.53	0.53	0.89	1	0.53	0.8
	0.94	0.86	0.96	0.47	0.96	0.98	0.51	0.53	1	0.46
	0.53	0.5	0.5	0.86	0.47	0.44	0.8	0.8	0.46	1

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
	1	0.86	0.94	0.53	0.94	0.94	0.53	0.53	0.94	0.53
	0.86	1	0.86	0.53	0.86	0.86	0.53	0.53	0.86	0.53
	0.94	0.86	1	0.53	0.96	0.96	0.53	0.53	0.96	0.53
	0.53	0.53	0.5	1	0.53	0.53	0.8	0.8	0.53	0.86
D^2*D	0.94	0.86	0.53	0.53	1	0.96	0.53	0.53	0.96	0.53
	0.94	0.86	0.96	0.53	0.96	1	0.53	0.53	0.98	0.53
	0.53	0.53	0.53	0.8	0.53	0.53	1	0.89	0.53	0.8
	0.53	0.53	0.53	0.8	0.53	0.53	0.89	1	0.53	0.8
	0.94	0.86	0.96	0.53	0.96	0.98	0.53	0.53	1	0.53
	0.53	0.53	0.53	0.86	0.53	0.53	0.8	0.8	0.53	1

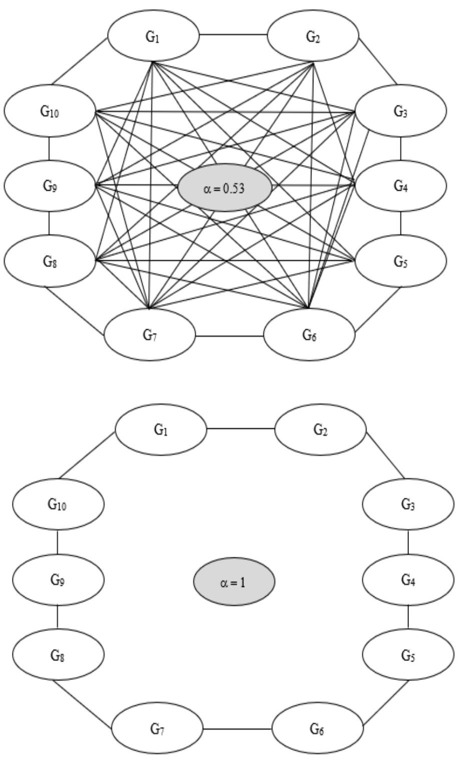

Figure 1. Relationship α levels

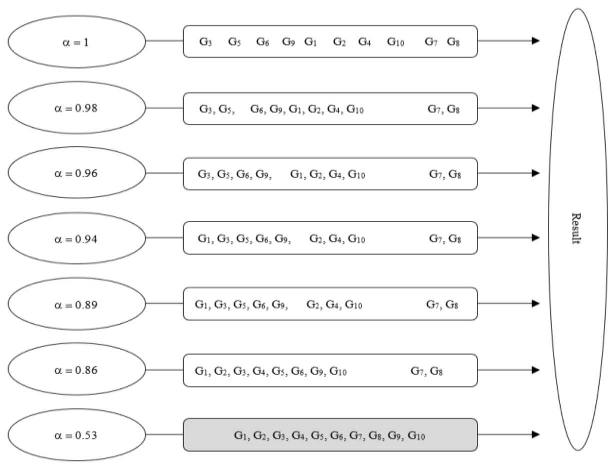

Figure 2. Decomposition into equivalence classes

Subsequent calculations show that $D^3=D^4$, so the transitive closure will look like (3):

$$\underline{D}=D\cup D^2 \dots\cup D^K=D^3 \quad (3)$$

These ranks correspond to the overall impact of i - this threat on the fulfillment of all criteria by the sustainable development planning system. Let us expand the fuzzy relation (3) into α – levels (4):

$$\underline{D}=\cup\alpha D_\alpha=0.53D_{0.53}\cup 0.86D_{0.86}\ 0.89D_{0.89}\cup 0.94D_{0.94}\ 0.96D_{0.96}\cup 0.98D_{0.98}\ D_1 \quad (4)$$

where, D_α – are clear ratios of α –level. Moreover, the numbe α – is the level of certainty of knowledge about the system. The above relations and their graphs are presented in Figure 1. However, in order to reduce the volume of presented calculations, we have shown in Figure 1 only α=0.53 deserves attention and demonstration in the article.

The considered clear relations of the α –level form classes of threats to the information space of planning the sustainable development of our enterprise, which are equivalent in importance. That is, threats of the same class are almost the same in terms of importance and comparative dynamics of their growth. Thus, we have the following elements: class 1 - α=0.53; class 2 - α=0.86; class 5 - α=0.89; class 6 - α=0.94; class 7 - α=0.96; class 9 - α=0.98; class 10 - α=1.

The tree of threats to the information space of sustainable development planning of our enterprise for equivalence classes is shown in Figure 2. From Figure 2 it can be seen that with the maximum certainty (α=1) each threat to the sustainable development planning system is a universal weight class. However, if we consider the level α=0.53, then all threats to the information space of sustainable development planning for our enterprise do not differ in ranks.

Summing up the values of the rows of the matrix (Table 2), we obtain the quantitative values of the ranks of threats: ρ_1=2.45; ρ_2=2.56; ρ_3=2.55; ρ_4=2.11; ρ_5=2.67; ρ_6=2.86; ρ_7=2.28; ρ_8=2.34; ρ_9=2.83; ρ_{10}=1.55.

Given these values, we choose the level of certainty α=0.98, at which: $\rho_6=\rho_9$=1/2(2.86+2.83)=2.85; ρ_1=2.45; ρ_2=2.56; ρ_3=2.55; ρ_4=2.11; ρ_5=2.67; ρ_7=2.28; ρ_8=2.34; ρ_9=2.83; ρ_1=1.55.

If H_0 is the allowable costs for ensuring the security of the “SoftServ” sustainable development planning system, then these costs should be distributed in accordance with the place and level of influence of information threats (H):

$$\sum H_i=H_0,\ H_6=H_9=0.118H_0,\ H_1=0.101H_0,\ H_2=0.106H_0,\ H_3=0.105H_0,\ H_4=0.087H_0,\ H_5=0.110H_0,\ H_7=0.094H_0,\ H_8=0.097H_0\ H_{10}=0.064H_0 \quad (5)$$

Similarly, if L_0 – is the maximum level and dynamics of the decrease in the level of security of sustainable development "SoftServ" sustainable development planning system, then we will obtain the necessary L -characteristics of threats (6):

$$\sum L_i=L_0,\ L_6=L_9=0.118L_0,\ L_1=0.101L_0,\ L_2=0.106L_0,\ L_3=0.105L_0,\ L_4=0.087L_0,\ L_5=0.110L_0,\ L_7=0.094L_0,\ L_8=0.097L_0\ L_{10}=0.064L_0 \quad (6)$$

The use of one specific example was not for the purpose of presenting the latest requirements and innovativeness of the proposed model, but for the purpose of what the methodology requires. It is impossible to model such a process as sustainable development planning within the framework of economic security management. The research content of the article is revealed by the proposed methodological approach and its detailed analysis and use.

5. DISCUSSIONS

Various scientists and practitioners have devoted significant attention to this issue in their works. In particular, the studies [15, 16] suggest a non-strict ranking method, where the expert ranks all the criteria in descending order based on the acceptability of the negative consequences associated with each safety criterion. The criteria are then sequentially numbered, with the rank of a criterion determined by its number. Some researchers [17] have applied fuzzy logic to rank information risks, using the Mamdani algorithm, one of the first used in fuzzy inference systems.

Moreover, there are numerous studies concerning ranking in other fields. A method of ranking factors affecting system reliability has been introduced that relies on formalizing cause-and-effect relationships. This is represented by a directed graph, where vertices correspond to system reliability and influencing factors, and the weighted arcs reflect the impacts of these factors on each other and on system reliability. This method uses the Birnbaum element importance index as an analog for factor ranking.

The problem is further simplified to automatic classification using the transitive closure of a fuzzy similarity relation. Initial system information is represented as a fuzzy ratio of the impact of element failures on function performance. Steps of element influence on system functions are calculated by comparing the least influence on the Saaty scale [18-21].

Cioacă et al. [22] also employed a modeling method to study the state of economic security management systems in sustainable development contexts. However, their model only describes the internal ranking of hypotheses, whereas our model can assess the influence level of all elements involved.

Unlike other studies, our research allows for the application of comprehensive measures to each threat class to the information support system for sustainable development planning. These measures don't vary in weight, and it is advisable to develop a clear protection plan, considering the influence degree of each threat class for balancing risk level and acceptable security measure costs. This is particularly relevant for a specific system under the concept of sustainable development planning.

6. CONCLUSIONS

In modern society, intensive access to information or knowledge shapes learning patterns, cultural expressions, and social participation, offering opportunities for sustainable development, rapid poverty alleviation, and peace preservation. Knowledge has become a primary force for social transformation. Profound societal structure changes have occurred. The post-industrial economy, as an innovation and information production sphere, has laid the technological groundwork for global integration. Enhanced communication network technologies have integrated the latest information developments into the daily lives of millions, driving significant changes in various societal spheres.

To achieve this goal, numerous threats and corresponding violation criteria are established. The influence degree of these threats on certain criteria is determined by expert means. The input information is formalized as an influence fuzzy relation, which evolves into a similarity fuzzy relation and its transitive closure. For each threat set, a decomposition tree into equivalence classes is displayed.

The study has limitations, namely the narrow scope of identified threats and the selection of a single specific socio-economic system as an example. These aspects should be addressed in future research.

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