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Development of a methodology for reducing uncertainty in conditions when making management decisions

Rylova, N.*, Miakota, Ye.

Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchuk, Ukraine

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Abstract. The article is dedicated to the development of a methodology for reducing uncertainty when approving the management decisions under unexpected situations and risks. The importance of improving the management decision-making process for modern organizations and systems is emphasized. Various types of uncertainties, such as quantitative, informational, cost-related, professional, and others, are identified, highlighting the need for diverse methods to identify and reduce them. Cases of incomplete situational clarity requiring the development of effective solutions are discussed. Probabilistic assessments are introduced to reduce uncertainty, especially in risky conditions. Defining conditions of uncertainty allows for increased operational efficiency and reduced costs in choosing target checks. Despite the available risk analysis information, the article points out that many decisions are still made intuitively. The main focus is on a developed methodology that utilizes information technology to assess the level of uncertainty in different situations. This methodology contributes to enhancing the efficiency of the management decision-making through mathematical models and uncertainty reduction methods. Additionally, it organizes and systematizes the student learning process. To reduce uncertainty, it is proposed to select distribution laws of external environment states that best match the sample data and to calculate necessary probabilities, for which students are encouraged to use the STATISTICA software package (TIBCO Statistica™ Evaluation trial version). After determining the probabilities of external environment states, solving the problem under uncertainty conditions becomes a problem under risk conditions, for which the decision acceptance criteria can be applied. The article concludes with a description of the developed methodology for teaching computer science student's management decision-making under uncertainty. The methodology utilizes information technology to assess the level of uncertainty and teaches learners to reduce the uncertainty of the external environment conditions for effective management decision-making. As a result of using this methodology, learners will acquire the ability to apply fundamental principles of management decision-making, in particular, reducing uncertainty in the external environment conditions.
Key words: training, methods, STATISTICA, decision-making.

Розробка методики щодо зменшення невизначеності умов при ухваленні управлінських рішень

Рилова Н. В., М'якота Є. О.

Кременчуцький національний університет імені Михайла Остроградського, Кременчук, Україна

Анотація. Стаття присвячена розробці методики зменшення невизначеності умов при ухваленні управлінських рішень в умовах несподіваних ситуацій та ризиків. Визначена важливість удосконалення процесу управлінського прийняття рішень для сучасних організацій та систем. Виділяються різні типи невизначеностей, такі як кількісна, інформаційна, вартісна, професійна та інші, і вказується на необхідність застосування різноманітних методів для їх визначення та зменшення. Розглядаються випадки відсутності повної визначеності ситуацій, які вимагають розробки ефективних рішень. Вводяться імовірнісні оцінки для зменшення невизначеності умов, особливо в умовах ризику. Визначення умов невизначеності дозволяє збільшити оперативність та зменшити витрати на вибір цільових перевірок. Незважаючи на доступну інформацію про аналіз ризиків, стаття вказує на те, що багато рішень все ще приймаються інтуїтивно. Основний акцент робиться на створеній методиці, яка використовує інформаційну технологію для оцінювання рівня невизначеності в різних

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Corresponding Author: Rylova Nataliy Viktorivna. E-mail: rylovanataly422@gmail.com
Kremenchuk Mykhailo Ostrohradskyi National University,
vul. Universytetska, 20, Kremenchuk, Poltava Region, Ukraine, 39600.
Відповідальний автор: Рилова Наталя Вікторівна. E-mail: rylovanataly422@gmail.com
Кременчуцький національний університет імені Михайла Остроградського,
вул. Першотравнева, 20, м. Кременчук Полтавської обл., Україна, 39600.

ситуаціях. Ця методика сприяє підвищенню ефективності прийняття управлінських рішень за допомогою математичних моделей та методу зменшення ступеня невизначеності. Крім того, вона організовує та систематизує процес навчання студентів. Для зменшення невизначеності пропонується підбирати закони розподілу станів зовнішнього середовища, що найбільш добре узгоджується з вибірковими даними, та обчислювати необхідні ймовірності, для чого студентам пропонується застосовувати програмний комплекс STATISTICA (тріальна версія TIBCO Statistica™ Evaluation). Таким чином, після визначення ймовірностей станів зовнішнього середовища розв'язання задачі в умовах невизначеності зводиться до задачі в умовах ризику, до якої можна застосовувати критерії прийняття рішень. Стаття завершується описом розробленої методики навчання студентів комп'ютерних наук щодо прийняття управлінських рішень в умовах невизначеності. Методика використовує інформаційну технологію для оцінювання рівня невизначеності та навчає здобувачів зменшувати невизначеність умов зовнішнього середовища для ефективного прийняття управлінських рішень. У результаті використання даної методики здобувачі навчяться застосовувати основні принципи прийняття управлінських рішень, зокрема, зменшення невизначеності умов зовнішнього середовища..
Ключові слова: навчання, методика, STATISTICA, прийняття рішень.

I Introduction

Emerging unexpected situations in managerial activities often require urgent and unconventional actions associated with risk. The issues that arise and the risk associated with their resolution can have both explicit and implicit characteristics, depending on the incoming information. In the first case, it is more defined, while in the second, it weakly signals the impending danger. It is crucial not to ignore the signals but to intensify monitoring of the unfolding events.

Improving the process of management decision-making is a crucial component in the operation of modern organizations and systems. Finding quality decisions is essential to balance conflicting values, criteria, and goals.

In practical work, cases of the complete situational clarity absence are not uncommon. In such instances, the elements of the situation are identified and ranked by the degree of their determinacy. If decisions are made under conditions of risk (measurable uncertainty), the introduction of probabilistic assessments significantly reduces uncertainty [1].

The work [2] explores multi-criteria decision-making problems under uncertainty conditions. Specifically, it discusses criteria for selecting the classical approach to handling informational uncertainty in single-criteria decision-making as target functions within multi-objective models. A general scheme of multi-criteria decision-making under uncertainty is described, aimed at generating multi-criteria decisions by constructing representative combinations of initial data, natural states, and scenarios, with direct use of qualitative information (with the possibility of applying experts' various preference formats), presented together with quantitative information, implementing the process of merging information within multi-objective models.

Based on the criterion of information determinacy, decisions are distinguished under conditions of:

a) determinacy;

b) probabilistic determinacy (risk);

c) uncertainty conditions (unreliability).

If decisions are made under conditions of determinacy (reliability), the speed of development increases, and costs for choosing the target checks of the optimal variant decrease. The advantage of such a situation: all variables for calculations are entered by the management subject at the same state of objective conditions (object) [3].

In spite of all the information obtained through the risk analysis science, many judgments and decisions are still made intuitively rather than analytically. The work [4] describes four decision-making strategies based on the complexity of the decision-making task and the decision context. The central role of evidence in decision-making regarding risk management is reviewed. This leads to a crucial strategic question: how much evidence is enough? In this context, the best time to make a decision is considered. Several classifications of uncertainty are examined, and decision-making strategies under conditions of deep uncertainty are discussed, including robustness, adaptive and static resilience, the precautionary principle, and others. Risk managers need a practical approach for decision-making under uncertainty, and a four-stage approach is proposed.

Games against nature are games against a player whose wins in the game are unknown, and there is a complete ignorance about the probabilities with which they will choose their strategies. An example of such a game is discussed in the work [5]. It is a game against a fruit machine, where a person, playing against such a machine, has two strategies: to play or not to play. Rewards for various fruit combinations are known. For some combinations, the player has positive gains, while for others, they have negative payouts (losing the fee for the game). If they do not play, their reward is zero. The probability of a combination appearing in the window is unpredictable for a person who is not an expert. Therefore, for them, it is a game against nature. In the section of the work [5], some decision-making rules proposed by various authors are provided. Regardless of whether games are played with knowledge or without any knowledge of the probabilities with which the opponent will use their strategies, the player is likely to seek more information about the natural state that will likely prevail.

In the work [6], an introduction to decision-making under uncertainty is considered from a computational perspective, encompassing both theory and applications, ranging from speech recognition to air collision avoidance.

Many important problems include decision-making under uncertainty, i.e., choosing actions based on often imperfect observations with unknown outcomes. Developers of decision support systems must consider various sources of uncertainty, balancing the numerous goals of the system. The book [6] contains an introduction to decision-making under uncertainty from a computational perspective. It presents the theory underlying decision-making models and algorithms, along with a set of program examples ranging from speech recognition to aircraft collision avoidance.

This work is dedicated to developing a methodology for teaching students majoring in Computer Science (specialty 122) to make management decisions under uncertainty, which is characteristic of modern organizations. The theme of reducing uncertainty in decision-making is one of the topics of laboratory work when studying the academic discipline "Decision Theory."

The goal of the work is to enhance the effectiveness of student learning by acquiring skills in making management decisions by reducing uncertainty in the external environment conditions.

II Material and methods of research

The essence of uncertainty manifests itself in the presence of an unlimited number of states of objective conditions where assessing the probability of each of these states occurring is impossible due to a lack of assessment methods. The decision-making criterion in these circumstances is determined by the inclinations and subjective evaluations of the decision-maker. The task boils down to reducing uncertainty by converting it into risk conditions.

The decisive word remains with the manager, although discussion of issues with colleagues, experts, and representatives of public authorities is not excluded. In this case, the heuristic abilities of the decision-maker play an important role. Often, such decisions have to be made in rapidly changing (extreme) situations, and they are most characteristic of socio-economic systems, political, and knowledge-intensive environments [7].

Various types of uncertainty arise during the decision-making process, depending on the causes of its occurrence. In particular, uncertainty is identified as:

- Quantitative, caused by a significant number of objects or elements in a situation.
- Informational, caused by a lack of information or its inaccuracy for technical, social, and other reasons.
- Cost-related, due to excessively expensive or unavailable payment for determinacy.
- Professional, resulting from insufficient professionalism of the decision-maker.
- Restrictive, caused by constraints in decision-making situations, such as time constraints, and others.
- Environmental, related to its behavior or the competitor's reaction to the decision-making process.

Therefore, conditions of uncertainty in decision-making are characterized by the absence of a sufficient amount of information for the rational organization of actions. The quality of the decision-making process depends on the completeness of considering all factors influencing the consequences of decisions made. Uncertainty can be eliminated either completely or partially by two means: in-depth study of available information or acquisition of missing information [8].

The complexity of management tasks continues to grow, creating a demand for continuous improvement of methodological principles, methods, and guidelines. The quality of scientifically substantiated decisions and their optimality correlate with the degree of perfection of the methods used during the formulation and implementation of decisions, as well as the level of competence of personnel in managing various methods. The choice and study of specific management decisions related to financial risks are based on the principles and methodology of decision theory. This theory emphasizes that in decisions related to risks, there are always elements of uncertainty in the behavior of primary parameters, complicating the clear definition of expected results. Depending on how unpredictable the behavior of initial parameters is, decision-making conditions can be divided into risk situations (when it is possible to determine the probability of certain events affecting the outcome with known accuracy) and uncertainty situations (when it is impossible to determine such probability due to a lack of information) [1].

As material-financial resources are limited, it is important to correctly identify priorities in the activities of enterprises. Thus, budgeting is aimed at ensuring competitiveness, provided optimal use of all resources, and at maintaining the stability and development of enterprises, considering changes in external conditions. The development of a program to achieve the desired state of the enterprise includes the process of forming a development strategy, which consists of several interconnected stages [2].

The methodology of decision-making under risk and uncertainty suggests using several methods that help researchers and practitioners analyze risks and choose optimal strategies.

Scenario Analysis. This is an informal method of analyzing isolated project risks, involving the evaluation of potential interactions between various factors [1].

Monte Carlo Method - it is a numerical method for assessing probabilities that allows modeling various decision scenarios based on random samples.

Risk Analysis. This method involves identifying potential threats, assessing their probability, and evaluating possible consequences.

Sensitive Risk Analysis allows exploring the sensitivity to risk by studying unreliable input variables and their probable distributions, stochastic dependencies between unreliable input variables, and the reliability of input variables.

The «Decision Tree» Method. Decision trees help visualize possible event developments and their consequences. Each path on the tree represents a specific decision and its potential outcomes. This method is used to determine the best decision, considering potential states of the external environment and their probabilities.

When using the proposed group of methods to account for uncertainty and risk, one needs to have a certain level of mathematical preparation and the ability to perform calculations. Additionally, they require significant time investments, which can be a hindrance for direct use by decision-makers [3].

Decision-Making in Risk and Uncertainty is a key aspect of managerial activity. This process requires consideration of many factors and the involvement of specific tools.

The methodology of expert assessments is also useful in uncertainty. Experts from various fields can provide their opinions on potential decisions, their advantages, and disadvantages.

Moreover, the methodology of multiple criteria is crucial. It allows evaluating various aspects of the decision, including its economic, social, and environmental consequences [9].

Game theory focuses on the interaction of different participants in the decision-making process. It enables the analysis of participants' strategies and predicts their reactions to different actions [10].

The sensitivity analysis method helps determine how changes in individual parameters can affect the final result. This is useful when there is uncertainty about input data.

Group decision-making approaches, such as brainstorming or the Delphi method, aim to involve opinions from different individuals. This can improve decision quality and reduce uncertainty.

The concept of a «risk map» is used to visualize various risks and their potential impact on the organization. This helps managers prioritize risks and develop strategies for their management [11].

Decision-making criteria, such as maximin, maximax, or Laplace, indicate strategies that consider varying degrees of optimism or pessimism regarding uncertainty.

Threshold theory helps determine the point at which collecting additional information becomes disadvantageous compared to making decisions based on available information [12].

One of the key concepts in decision-making under risk is utility maximization. Utility helps determine the most desirable decision considering potential consequences.

Management decision is considered stable and effective if, in all situations considered, the interests of participants are adhered to, and possible adverse consequences are eliminated through created reserves or compensated by insurance payments [13].

Therefore, management decision-making under uncertainty is the result of analysis, forecasting, optimization, economic justification, and the selection of alternatives in conditions of insufficient information, either partially or completely lacking information.

Thus, the existence of risk is directly related to uncertainty. Uncertainty implies the presence of factors where the results of actions are deterministic, and the degree of possible impact of these factors on outcomes is unknown; it is the incompleteness or inaccuracy of information about project implementation conditions [14].

The task faced by the Decision-Making Person (DMP) involves determining the possibility of composing quantitative and qualitative, objective and subjective factors and developing an appropriate method for evaluating such a composition. In the development of this task, it is necessary to rely on the determination of a measure, as the measure is an essential unity of quantitative and qualitative, and each object and process has its own measure, i.e., qualitative-quantitative determinacy [15-16].

The development of an enterprise management system includes necessary steps, such as identifying the object of management, establishing basic parameters describing the current state, evaluating these parameters, and creating mechanisms for formulating a strategy and implementing development programs. The following characteristics will shape the management process:

$$U =< Q,\ X,\ X',\ O_j(X'),\ P(O_j|x_i),\ P(O_j|x_i, s_k), S(Q),\ R,\ F(x) >, \quad (1)$$

where $Q = (q_1, \dots, q_j, \dots, q_n)$ – set of goals; X – set of states of the managed object; X' – set of directions of activity of the managed object according to the chosen goals; $O_j(X')$ – assessments of directions of activity (results); $P(O_j|x_i)$ – probabilities of results; $x = (x_1, x_2, \dots, x_n)$ – set of strategies used for making management decisions; $u(x_i, O_j)$ – utility of result when using strategy; x_i; $s_1, s_2, \cdots s_k$ – environmental state; $P(O_j|x_i, s_k)$ – probability of result O_j depending on the environmental state; *S(Q)* – set of alternative development strategies; *R* – resource provision and constraints; $F(x_j) \to y_j$ – function of forming assessments of directions of activity.

The decision-making task in conditions of risk arises when each adopted strategy x_i is associated with a whole set of different results O_j with known probabilities $P(O_j|x_i)$. Adopted strategies x_i can represent decisions, for example, regarding possible investments of financial or material resources into respective productions.

It is considered that the result O_j is achieved if a certain quantity Z falls within the interval of values $[Z_{j-1}, Z_j]$. The distribution of the random variable Z depends on the adopted strategy x_i.

Conditional densities $f(z|x_i)$ are unknown. However, during the observation process, corresponding statistical data are accumulated, presented in the form of samples for each of the possible strategies. Thus, based on these samples, it is possible to fit theoretical distribution laws that are closest to empirical data. Knowing the distribution laws, it is then possible to calculate the probabilities of Z falling into the corresponding intervals and, thus, the conditional probabilities of results depending on the adopted strategy. To choose the distribution law that best fits the sample data and subsequently calculate the required probabilities, students are encouraged to use the STATISTICA software package (TIBCO Statistica™ Evaluation trial version).

The distribution laws of possible outcomes for different strategies can be of various types. Naturally, in each case, the theoretical distribution law should be selected for which checking the agreement with sample data using all statistical criteria will yield the best results.

The use of the STATISTICA package to select the distribution law of environmental states that best fits the sample data and then calculate the necessary probabilities of environmental states.

For distribution analysis using the STATISTICA tool, histograms, Q-Q graphs, and other methods can be used to assess the distribution. To choose the theoretical distribution law based on the sample distribution analysis, it is necessary to select the theoretical distribution law that best fits the sample data. STATISTICA helps in selecting the distribution law.

In the parameter selection stage of distribution in STATISTICA, for the chosen theoretical distribution law, parameters that best fit the investigated data must be determined. STATISTICA can assist in this process either automatically or through maximum likelihood methods.

After selecting the theoretical distribution law and parameters, this data can be used to calculate the probabilities of results according to the adopted strategy.

After calculating the probabilities of results, it is necessary to conduct an analysis and evaluation of the obtained results in the context of the study.

Choosing the theoretical distribution law and selecting parameters can be a challenging task and may require experience in data analysis. It is also essential to adhere to scientific standards and methods when using these results in research.

To choose the distribution law that best fits the sample data using STATISTICA, the procedure for fitting the distribution based on the least squares fitting method or the maximum likelihood estimation method can be employed.

As a result of using the STATISTICA package, calculated probability values of states are obtained. Next, it is necessary to determine whether the computed values fall within the boundaries $[Z_{j-1}, Z_j]$.

Typically, the process of updating the core assets of the enterprise usually takes a considerable amount of time and requires significant capital investment from management. Therefore, during the execution of projects of this type, responsible individuals must make decisions based on mathematical models and tools, rather than solely relying on their own experience, knowledge, and intuition.

The criteria used in making economic decisions can be utilized to effectively support the optimal functioning of the enterprise, especially in minimizing potential risks when choosing the best alternative from the available options. In a general context, this can be described as follows [17–19], where:

A_i – alternative of i-th decision (i = n);

S_j – possible j-state of the surrounding environment (j = 1, m);

a_{ij} – assessment of the effectiveness of the i-th alternative in the event of the j-th state of the external environment.

Table 1. Criteria and Alternatives

	Q_1	…	Q_m
A_1	a_{11}	…	a_{1m}
…	…	…	…
A_n	a_{n1}	…	a_{nm}

The main recommendations for using criteria for economic decision-making in the most common situations for an enterprise are provided in Table 2. Depending on the chosen variant of the laboratory work, students select the necessary decision-making criteria.

Letter grades correspond to the following values:

A – «most advisable»;

B – «recommended»;

C – «acceptable»;

D – «not advisable».

Therefore, in the context of choosing optimal decisions during the update of the company's core assets, the most reasonable option is to use the Hurwicz criterion, as this task can be related to the acquisition of new equipment. The application of this criterion will allow for a comprehensive analysis of the situation and, as a result, reduce the risk of making suboptimal business decisions.

Thus, the developed learning methodology is based on the use of a combined method to reduce uncertainty in management decision-making, consisting of the following stages:

1. Load numerical values into the STATISTICA software.

2. Based on the entered samples, select theoretical distribution laws that best match the empirical data. Choose distribution laws that are most consistent with the sample data and calculate the necessary probabilities of environmental states. Examples of distribution laws include normal, Fisher, and Student distributions, exponential, etc.

3. Using the found distribution laws for sample values, find the probabilities of Z falling into the corresponding intervals and conditional probabilities of results depending on the adopted strategy $P(O_j|x_i, s_k)$, whose values are further used in decision-making criteria.

4. Search for the best alternatives among the possible ones using decision-making criteria: Wald, Savage, Hurwicz, Hodges-Lehmann.

Table 2. Appropriateness of using decision-making criteria in standard situations

	Wald Criterion	Savage Criterion	Hurwicz Criterion	Hodges-Lehmann Criterion
Strategic decisions of the company (entering new markets, reorientation to produce an entirely new product, forming a strategic alliance, changing marketing policies, etc.)	A	D	C	B
Issues related to the preservation of life and health of individuals (both within and beyond the company)	A	D	D	C
Investment of available funds	C	A	B	B
Diversification of production	D	C	B	A
Changes in organizational structure	C	B	C	B
Acquisition of new production equipment or software	C	C	A	B
Personnel decisions	D	B	A	B

To justify the effectiveness of the developed mathematical support in practice, a forecast was made for a certain period, and the obtained values were compared with those that were actually observed.

The use of decision-making criteria such as Wald, Savage, Hurwicz, and Hodges-Lehmann, supported by mathematical tools, will allow managing risks in the process of making business decisions, especially those related to capital investments in the company's fixed assets. This aspect of management significantly requires mathematical support since investing in fixed assets usually involves substantial financial expenditures for the company and, consequently, a high level of responsibility for the manager.

III Results

For the laboratory work on the discipline "Decision Theory" by students majoring in Computer Science (specialty 122), a mathematical model for reducing uncertainty in decision-making has been developed. The formal model is presented in the form of a matrix, and the further use of the STATISTICA package is justified.

The developed risk management method in decision-making is described, and its stages are outlined. The feasibility of applying decision-making criteria for solving applied problems according to students' individual variants.

The proposed information technology for reducing uncertainty in decision-making is illustrated in Figure 1.

The main processes of the information technology include data collection and processing, data analysis, modeling, and simulation. The mechanisms for all three business processes are a decision-maker and a personal computer.

The normative, instrumental, and procedural research base influences the first business process. Based on this base, information is collected for further processing and the formation of conditional probabilities of results obtained based on the processing of input samples using the tools of the STATISTICA software package.

The input information for the "Data Collection and Processing" and "Data Analysis" processes includes information about the states of the external environment and expert assessments of alternatives. For example, states of the external environment encompass various risk groups, including currency (the possibility of a sharp drop in the exchange rate of the national currency against foreign currencies), credit (an increase in the cost of using credit funds), financial, and investment risks (the risk of non-return of invested funds). Accordingly, in the event of a worsening economic situation, the likelihood of the occurrence of these risks will be extremely high, in an unchanged economic situation – average, and in the case of an improved economic situation in the country, the chance of these risks occurring will be minimal.

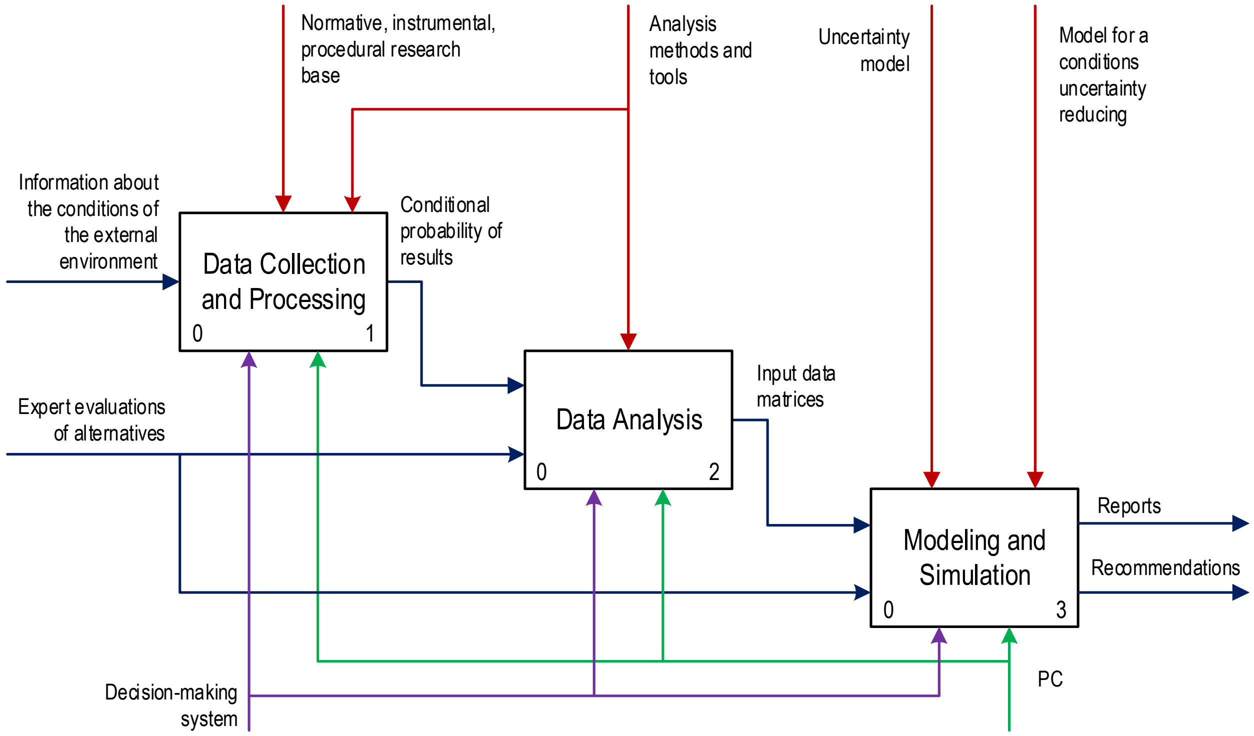


Fig. 1. Information Technology for reducing the uncertainty of conditions in management decision-making

The obtained conditional probabilities of results and expert assessments of alternatives are input flows for the "Data Analysis" process. Regarding expert assessment of alternatives: in case of the need to invest in the modernization of certain enterprise's fixed assets, including its tangible assets, the decision-maker seeks to maximize future benefits from capital investments. The values of the cells formed at the intersection of alternative A_n and possible external environmental state Q_n, are determined by expert assessments of the attractiveness of these combinations.

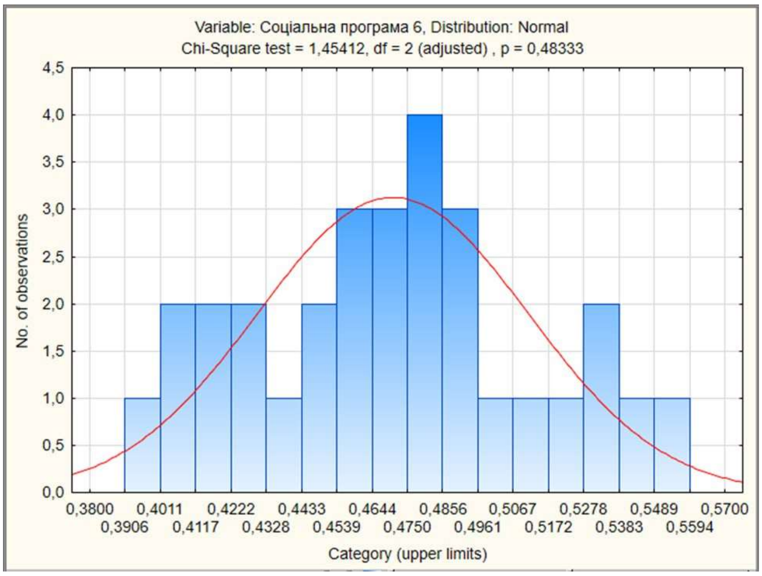
There are peculiarities in the process of selecting qualified experts and their number to obtain consistent assessments of matrix values.

The input data matrices and expert assessments of alternatives are input flows for the next process, "Modeling and Simulation." The control flows for it are the model and method of uncertainty reduction in decision-making conditions. The output of the process includes reports and recommendations for decision-makers in the form of statistical decisions that involve the selection of optimal strategies (decisions) that would provide the maximum possible positive effect.

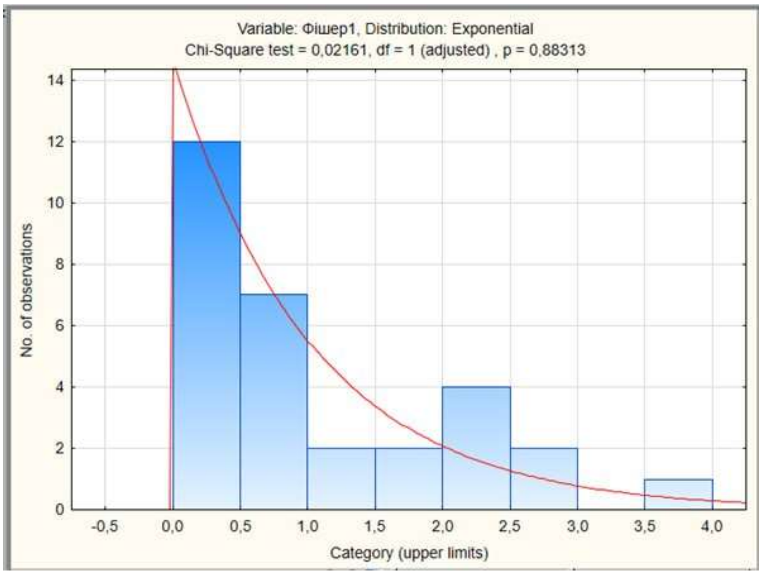
During the laboratory work, in the stage of obtaining distribution laws in the STATISTICA program, students obtain diagrams similar to those depicted in Figure 2.

In Figure 3, the results of determining the probabilities of distribution laws in the SATISTICA program are displayed.

Normal distribution (social program 6)



Exponential distribution (social program 7)



Rectangular distribution (social program 10)

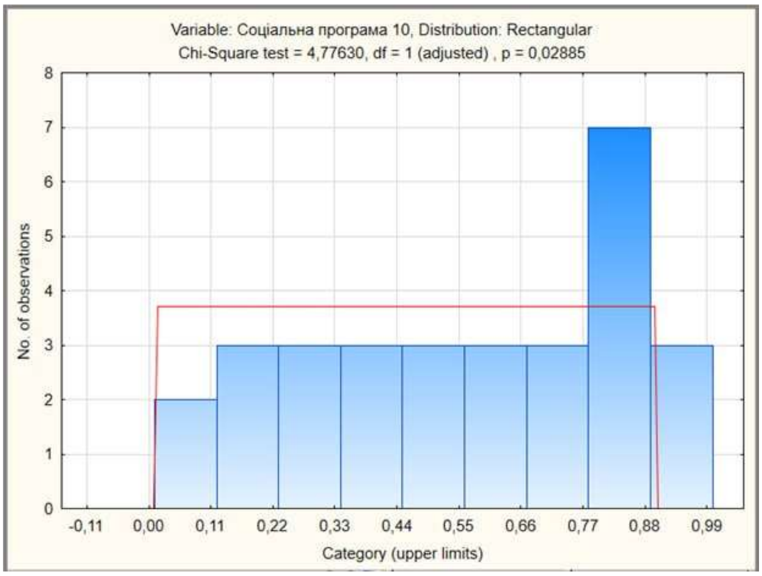
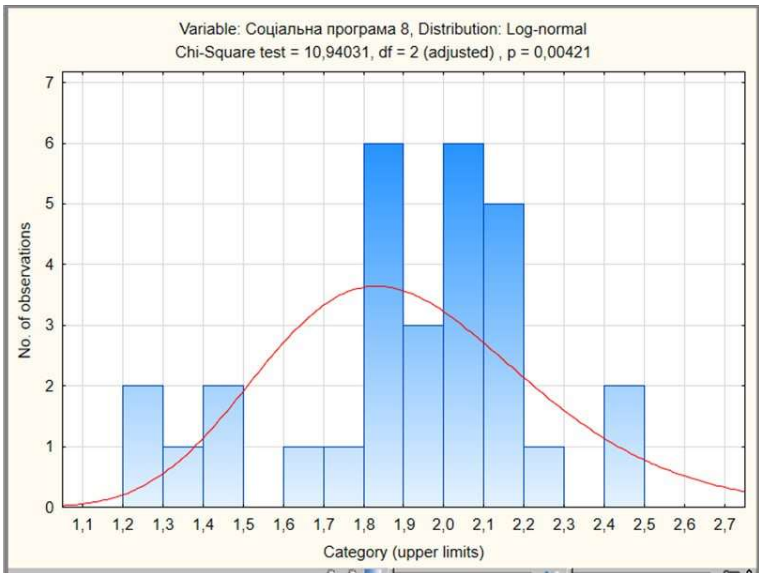
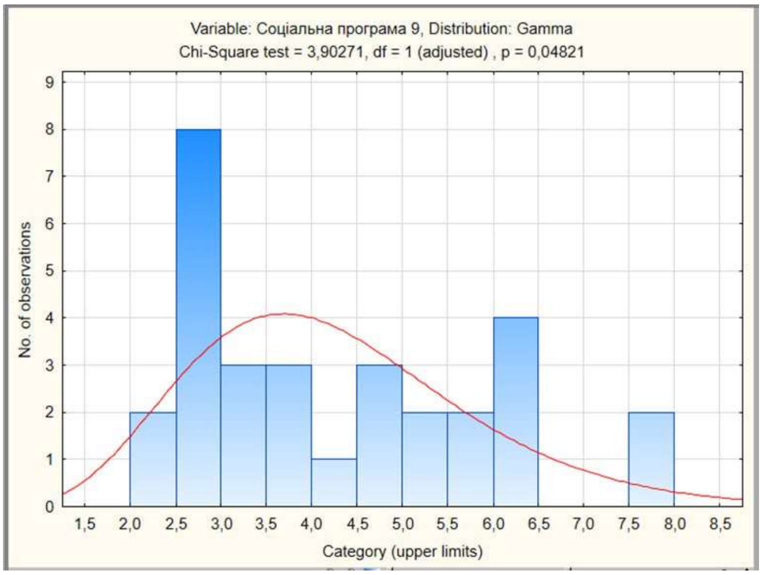


Fig. 2. Distribution Laws of Sample Data

Lognormal distribution with parameters:
$\mu = 0,\ \sigma = 1$
(social program 8)



Gamma distribution with parameters:
$k = 2,\ \theta = 3$
(social program 9)



Shi-square distribution with 5 degrees of freedom:
$df = 5$
(social program 2)

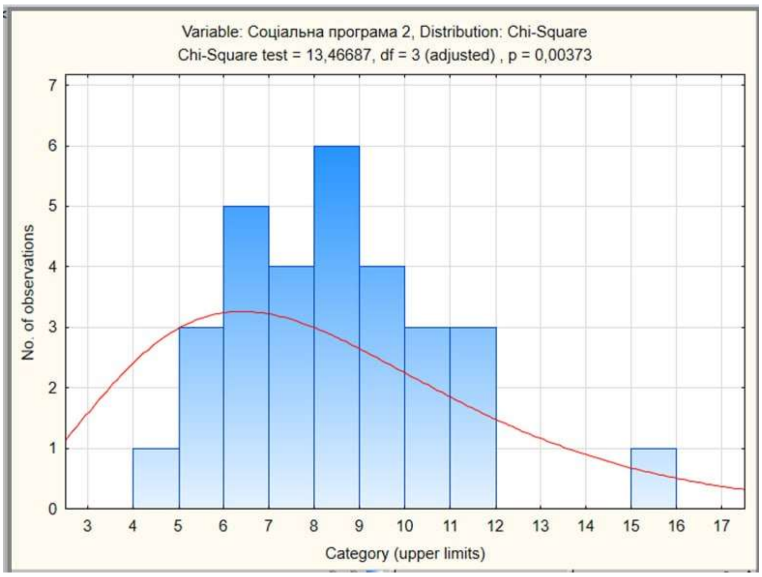
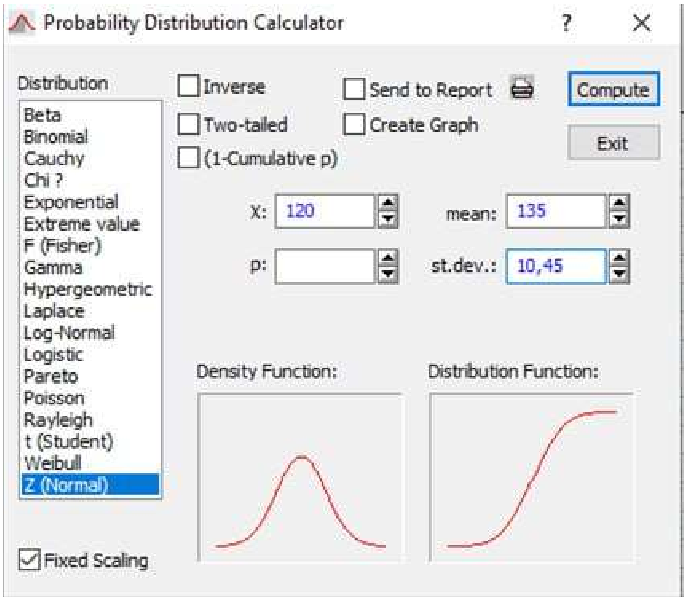
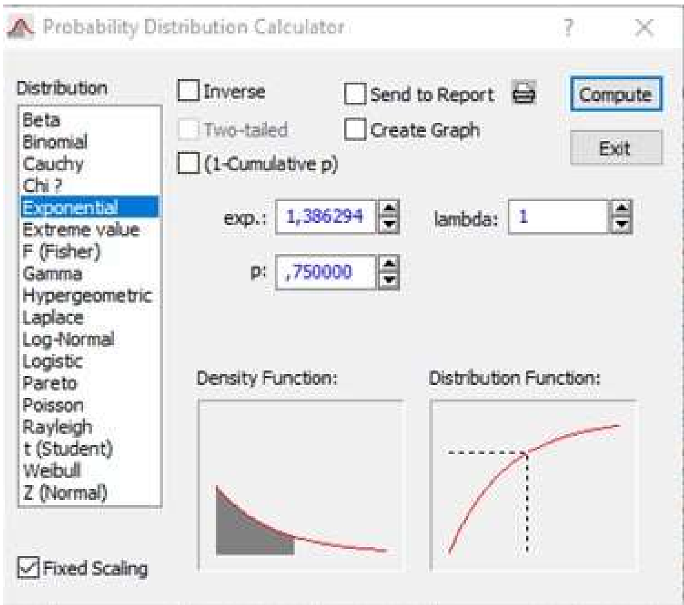


Fig. 2. Distribution Laws of Sample Data (Continuation)

Normal distribution (social program 6)



Exponential distribution (social program 7)



Lognormal distribution with parameters: $\mu = 0,\ \sigma = 1$ *(social program 8)*

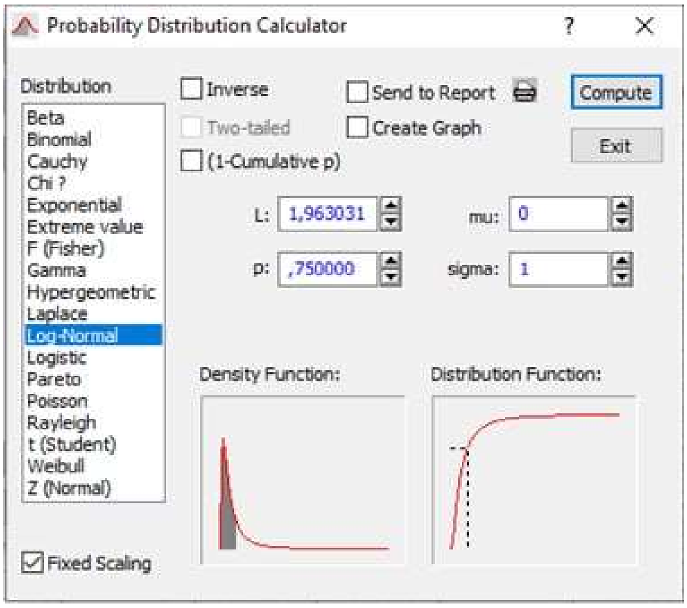
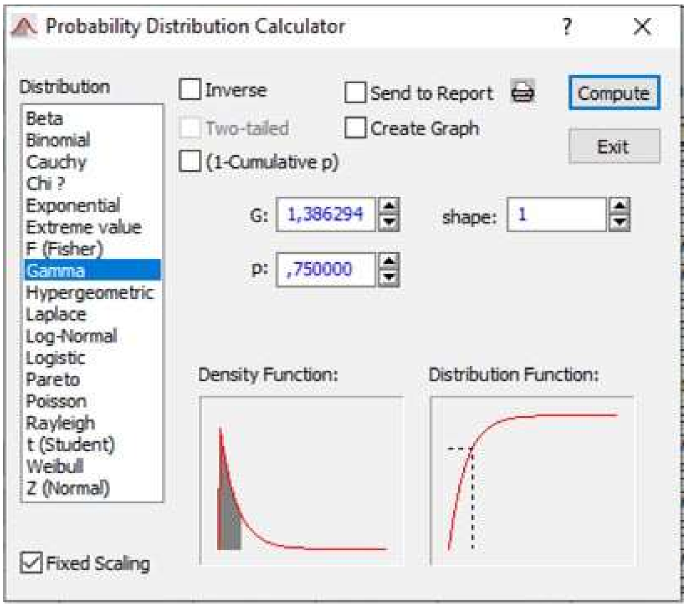


Fig. 3. Results of Determining Probabilities of Distribution Laws in the SATISTICA Program

Gamma distribution with parameters:
$k = 2,\ \theta = 3$
(social program 9)



Shi-square distribution with 5 degrees of freedom:
$df = 5$
(social program 2)

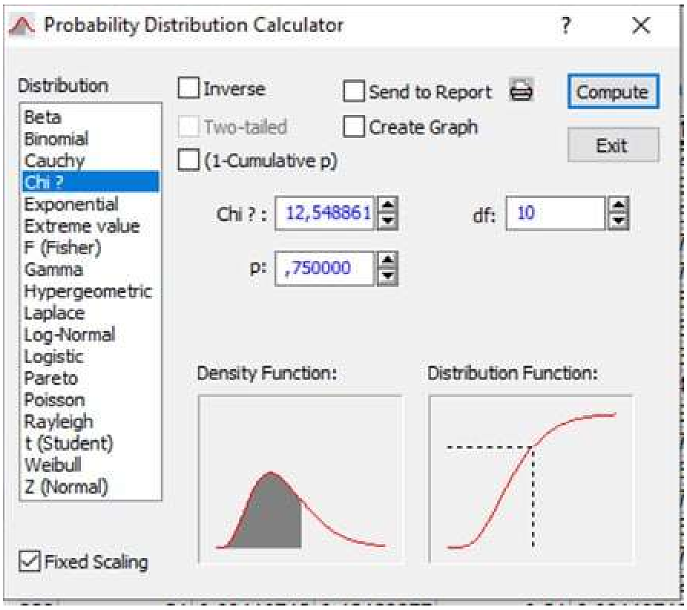


Fig. 3. Results of Determining Probabilities of Distribution Laws in the SATISTICA Program (Continuation)

After identifying the distribution laws for the input data, for which probabilities of the magnitude falling within a specified range have been found, students need to normalize the values and apply decision-making criteria: Wald's criterion, Savage's criterion, Hurwicz's criterion, and Hodges-Lehmann criterion. Afterward, the best alternative or several such alternatives are determined. The laboratory work provides recommendations in case ambiguous research results are obtained.

IV Discussion

In the work [4], practical tools for implementing a four-stage approach are presented, including changing meetings for decision-making, halting decision-making, and socializing errors for effective risk management. The need for new risk indicators is discussed, along with some traditional decision analysis methods, including the value of information strategies.

In the work [5], focusing on two methods of designing decision-making agents, planning, and reinforcement learning, probabilistic models are covered, presenting Bayesian networks as a graphical model that captures probabilistic relationships between variables; utility theory as the basis for understanding optimal decision-making under uncertainty; Markov decision processes as a method for modeling sequential problems; uncertainty models; a state of uncertainty; and joint decision-making involving multiple interacting agents. Several applied programs demonstrate how theoretical concepts can be applied to face recognition systems, language programs, collision prevention, and continuous monitoring of unmanned aerial vehicles.

The discussed approach allows for the application of a combined approach in conducting laboratory work based on the developed information technology for reducing uncertainty in decision-making. The sequence of steps is as follows:

Step 1: Apply the method to determine the distribution law of numerical values depending on the adopted strategies x_i by using the STATISTICA package.

Step 2: Check and analyze the data obtained in Step 1: check the parameters of the probabilities of states for the occurrence of calculated values Z in the corresponding intervals $[Z_{j-1}, Z_j]$. In case the value does not fall within the interval, return to Step 1. Otherwise, enter the calculated parameters into the matrix of initial calculations.

Step 3: Enter the profit parameters matrix E=(eij), i ∈ L, j ∈ {1, 2, …}, whose values are obtained from experts. In the case of different units of measure uncertainties, normalize them (determine the maximum value in each row and divide all values of the corresponding row by it).

Step 4: Apply criteria to the rows of the matrix E=(eij), i ∈ L, j ∈ {1, 2, …}.

Step 5: Calculate the values of the elements of the new matrix in the next iteration of the procedure, assigning these values to the elements of the next column of the matrix E=(eij), i ∈ L, j ∈ {1}.

Step 6: Compare the results of the best alternatives obtained using different criteria. If the results match, output the best alternative. If not, output recommendations for applying additional criteria.

V Conclusions

Analyzing existing approaches to reducing uncertainties, it becomes evident that it is a complex and multifaceted issue requiring deep understanding and an individualized approach. Different types of uncertainties, such as quantitative, informational, cost-related, professional, limiting, and environmental, demand various methods for their identification and reduction [20].

The developed methodology relies on the use of information technology to assess the level of uncertainty in different situations. This approach enhances the efficiency of management decision-making by applying the developed mathematical model and method for reducing the degree of uncertainty. Additionally, it allows for the organization and systematization of student learning. As a result, students acquire fundamental principles of decision-making with prior uncertainty reduction in external environmental conditions.

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Рилова Наталя Вікторівна.
Старший викладач кафедри автоматизації та інформаційних систем,
Кременчуцький національний університет імені Михайла Остроградського,
вул. Першотравнева, 20, м. Кременчук Полтавської обл., Україна, 39600.
E-mail: rylovanataly422@gmail.com

Rylova Natalia Viktorivna.
Senior Lecturer of the Automation and Information Systems Department,
Kremenchuk Mykhailo Ostrohradskyi National University,
vul. Universytetska, 20, Kremenchuk, Poltava Region, Ukraine, 39600.
E-mail: rylovanataly422@gmail.com

ORCID: 0000-0002-1136-653X
Researcher ID: https://publons.com/researcher/4697983/nataly-rylova/
Scopus ID: 57210561011

М'якота Євгеній Олександрович.
Магістрант кафедри автоматизації та інформаційних систем,
Кременчуцький національний університет імені Михайла Остроградського,
вул. Першотравнева, 20, м. Кременчук Полтавської обл., Україна, 39600.
E-mail: benyapikaso@gmail.com

Miakota Yevhenii Oleksandrovych.
Master's student of the Automation and Information Systems Department,
Kremenchuk Mykhailo Ostrohradskyi National University,
vul. Universytetska, 20, Kremenchuk, Poltava Region, Ukraine, 39600.
E-mail: benyapikaso@gmail.com

ORCID: 0009-0009-8478-2540

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