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SIMULATION OF THE PROCUREMENT PROCESS WITH RISK CONSIDERATION USING DECISION TREES

МОДЕЛЮВАННЯ ПРОЦЕСУ ЗАКУПІВЕЛЬ З УРАХУВАННЯМ РИЗИКІВ ЗА ДОПОМОГОЮ ДЕРЕВ РІШЕНЬ

The article proposes an approach to modeling the procurement process under risk using the decision tree method. A universal multi-criteria model has been developed, enabling the analysis of supply alternatives considering key economic indicators and risk factors. The system of criteria includes purchase cost, delivery expenses, potential supply delays, payment delays, and the risk of receiving defective products. For each of these criteria, probabilistic scenarios of corresponding events have been defined, and expected costs have been calculated. The decision tree method is applied to visualize the decision-making process and to implement folding and pruning procedures. A multi-criteria comparison of alternatives is carried out using classical optimization methods. The model can be used as a tool to support managerial decision-making in procurement logistics.

Keywords: *multi-criteria optimization, procurement risks, decision trees, logistics costs, supply, decision making, rollover and blocking procedures.*

У статті досліджується задача оптимізації процесу закупівель з урахуванням ризиків, що притаманні сучасному ринковому середовищу. Запропоновано підхід до прийняття рішень, заснований на використанні методу дерев рішень як інструменту аналізу альтернатив із урахуванням багатьох критеріїв та ймовірнісних сценаріїв. Актуальність дослідження обумовлена потребою підприємств мінімізувати ризики, пов'язані з порушеннями логістичних ланцюгів, затримками постачання, простроченнями платежів і надходженням неякісної продукції. У межах запропонованої моделі розглядаються п'ять основних приватних критеріїв: вартість закупівлі, витрати на доставку, втрати внаслідок затримки постачання, витрати через прострочення платежу та втрати, пов'язані з постачанням бракованої продукції. Для кожного критерію формалізовано ймовірнісні сценарії реалізації ризиків, що дозволяє оцінити очікувані витрати та порівняти можливі варіанти закупівлі. Аналіз проводиться для чотирьох альтернативних варіантів постачання з різним поєднанням типу постачальника (виробник або посередник) та способу доставки (самовивіз або транспорт постачальника). Застосування методу дерева рішень дозволяє детально змоделювати логіку розвитку подій у разі реалізації різних ризиків і послідовно виконати процедури згортки та блокування для вибору найкращого рішення. Проведено порівняльний аналіз альтернатив на основі кількох класичних методів багатокритеріальної оптимізації, таких як мінімаксний критерій, метод середньозважених оцінок, узагальнений скалярний критерій, метод ідеальної точки та критерій добутків. Результати свідчать, що вибір оптимального рішення залежить від пріоритетів суб'єкта прийняття рішень та обраної моделі оцінювання. Розроблений підхід може бути адаптований до практичних умов функціонування підприємств різних галузей. Модель дозволяє формалізувати процес прийняття рішень, враховувати ризики та критерії одночасно, що сприяє *підвищенню ефективності закупівельної діяльності та зниженню витрат у логістичних процесах. Представлений інструментарій може бути основою для побудови інформаційно-аналітичних систем підтримки рішень у сфері постачання.*

Ключові слова: *багатокритеріальна оптимізація, ризики закупівель, дерева рішень, логістичні витрати, постачання, прийняття рішень, процедури згортки і блокування.*

Formulation of the problem. In today's conditions of globalization, unstable market relations, and growing uncertainty, the problem of increasing the efficiency of procurement management becomes particularly relevant. Purchasing activities significantly affect the cost part of a company's budget, and an unsuccessful choice of supplier or logistics strategy can lead to delays in delivery, disruption of production plans, increased indirect costs, and loss of competitive advantages. The decision-maker in the subject sector must evaluate not only direct economic indicators, but also potential risks that accompany various choice alternatives.

Analysis of recent research and publications. The issue of formalizing decision-making processes under conditions of risk and uncertainty is the subject of research by many scientists. The textbook by Voloshyn O.F. and Mashchenko S.O. [1] outlines the basics of building decision-making models with an emphasis on mathematical formalization of alternatives and multi-criteria analysis. In turn, Faynzilberg L.S., Zhukovska O.A. and Yakymchuk V.S. [2] consider the application of decision theory methods in the field of information technologies, in particular with the involvement of probabilistic analysis methods, which is relevant for taking into account risks in logistics processes. Classical approaches to decision-making under uncertainty were laid down in the works of Ivanenko V.I. and Diduk M.M. [3], where attention is focused on the importance of assessing the probabilities of event scenarios in the process of choosing alternatives.

Modern approaches focused on processing large data sets and applying intelligent analysis models are considered in [4], which proposes a systematization of methods for detecting patterns in complex information environments. In [5], a study was conducted, where the use of a minimum spanning tree model was proposed to solve an applied data analysis problem, which can be effectively adapted to the tasks of selecting optimal suppliers or logistics routes.

Therefore, despite significant scientific achievements in the field of decision-making, there remains a need to integrate classical and innovative approaches to build adaptive models that simultaneously take into account multiple criteria, risks, and probabilistic scenarios.

Formulation of the purpose of the article. The purpose of the article is to develop a multi-criteria decision-making model for the organization of procurement, taking into account risks, based on the decision tree method, which allows for a formal evaluation of supply alternatives and the selection of the best option according to the given criteria.

Presentation of the main material. As part of the study, we will present a generalized decision-making model for optimizing procurement based on many criteria. The model is not tied to a specific enterprise, which allows it to be adapted to the conditions of different industries. As a decision-making method that takes into account the significance of criteria and probabilities of risk events [2]. The decision-making subject (DMS) in the model is a conditional person or system that evaluates supply alternatives according to given parameters. n the format of such a model, the problem of choosing the best solutions under risk conditions can be represented as a multi-criteria problem with the following private criteria:

– Private criterion **C** – the cost of purchasing goods (the indicator is minimized);
– Private criterion **D** – delivery costs of goods (the indicator is also minimized);
– Private criterion **L** – average expected losses due to delayed delivery of goods (the indicator is minimized). These expected losses, depending on the specifics of the model and

DMS requirements, may include fines for a delay in the start of work due to the non-receipt of the goods necessary for these works; payment for downtime for production workers; payment for daily wages to drivers and costs for paid parking in the event of a delay in the shipment of goods; warehouse costs in the event of refusal to perform work when the goods arrive at the warehouse; administrative costs for resolving a risky situation; costs associated with changing production schedules, etc.

– Private criterion **P** – costs associated with late payment (the indicator is minimized);

– Private criterion **F** – costs associated with the supply of defective or poor-quality goods (the indicator is minimized). These include, for example, costs for finalizing goods; costs associated with returning goods to the supplier in the event of untimely detection of a defect; costs for downtime of the contracting organization due to the lack of materials and the inability to start work on time, etc.

Let us present the attributes of a general optimization model. It considers a situation where a manufacturing enterprise needs to purchase goods or raw materials in a given volume. It can purchase from both an intermediary and a manufacturer. In this case, delivery can be carried out by self-pickup or by the supplier's transport. It is necessary to determine the best solution that optimizes the purchase of goods, which includes the choice of: 1) an intermediary or manufacturer; 2) delivery by self-pickup or using the supplier's transport.

Purchasing from the manufacturer often allows you to minimize the price of the product, but such a decision, as experience and statistics show, will be accompanied by greater defects. Purchasing from an intermediary provides a range of services: from delivery processes to acceptance processes, which allows you to count on fewer defects, but the price of the goods will be higher than the manufacturer's price. Self-pickup of products requires both transport units and a staff of employees who manage the transport. In addition, delivery costs may increase due to a delay in shipment by the supplier, vehicle breakdown, etc. If delivery is carried out by the supplier, the delivery costs remain unchanged. From this we can conclude that the considered private criteria may contradict each other. The following four alternatives are analyzed: **MP** – purchase will be made from the manufacturer using self-delivery; **MS** – purchase will be made from the manufacturer using the supplier's transport; **IP** – purchase will be made from an intermediary using self-delivery; **IS** – purchase will be made from an intermediary using the supplier's transport.

In general, the manager can consider any other available solutions, since the DMS itself has the right to make decisions. Let us assume that the risks taken into account are caused only by the following factors: random delays in deliveries **L**; random late payment **P**; random losses due to defect **F**. Let us clarify the structure of the indicators of the analyzed private criteria.

Let the indicators of private criteria that correlate with the cost of purchasing and delivery costs of goods (criteria **C** and **D**) be as follows:

1) the cost of purchasing from the manufacturer is 500 thousand CU (conventional unit) for the entire batch of goods, and from the intermediary it is 10% more expensive, i.e. 505 thousand CU;

2) the cost of transportation costs is 1,63 thousand CU for self-delivery and 2,51 thousand CU for supplier's transport.

Before specifying the indicators of the private criterion **L**, which is related to the costs due to delivery delays, we note that delays can be critical (**LC**) and non-critical (**LN**). In the event of critical delivery delays, there are costs for downtime of key production employees, their transfer to other work; costs for claims work, including communication and correspondence; disruption of the production schedule; breach of obligations to counterparties. When delivering by self-pickup, additional costs arise for double wages and travel for the driver and forwarder. Here are the relevant statistics on the frequency of the above-mentioned events:

1) With a probability of 0,3 when supplied from the manufacturer and with a probability of 0,45 when supplied from an intermediary, delays will be critical and will lead to losses of 4 thousand CU for the given volume of purchase. At the same time, under self-delivery conditions, the probability of a critical delay is 0,2 when supplied from the manufacturer and 0,35 when supplied from an intermediary, and indirect (variable) costs in the amount of 0,7 thousand CU will be added to the above losses.

2) With a probability of 0,7 when supplied from the manufacturer and with a probability of 0,55 when supplied from an intermediary, delays will be non-critical and will lead to losses of 0,9 thousand CU for the given volume of purchase. At the same time, under self-delivery conditions, the probability of a non-critical delay is 0,8 when supplied from the manufacturer and 0,65 when supplied from an intermediary, and indirect (variable) costs in the amount of 0,3 thousand CU will be added to the above losses.

Let us specify the attributes of the model that relate to the indicators of the private criterion **P**, which is correlated with the costs of late payment. During the fulfillment of contractual terms, the company, for various reasons, is faced with the need to pay for the delivery after the deadline specified in the contract. This creates the risk of paying a penalty for late payment of the delivery. The late payment factor can be critical (**PC**) and non-critical (**PN**). The model assumes that for a critical delay in payment, the amount of losses will be 25 thousand CU, for a non-critical delay – 3,5 thousand CU.

Let us assume the probabilistic characteristics of a random late payment as follows:

– Critical/non-critical payment delay – 0,25/0,75 respectively when delivered from the manufacturer by pickup in case of critical delivery delay;

– Critical/non-critical payment delay – 0,1/0,9 respectively when delivered from the manufacturer by pickup with non-critical delivery delay;

– Critical/non-critical payment delay – 0,3/0,7 respectively when delivered from the manufacturer by the supplier’s transport with a critical delivery delay;

– Critical/non-critical payment delay – 0,15/0,85 respectively when delivered from the manufacturer by the supplier’s transport with a non-critical delivery delay;

– Critical/non-critical payment delay – 0,3/0,7 respectively during delivery from an intermediary by self-pickup with a critical delivery delay;

– Critical/non-critical payment delay – 0,15/0,85 respectively when delivered from an intermediary by self-pickup with non-critical delivery delay;

– Critical/non-critical payment delay – 0,3/0,7 respectively when delivered from an intermediary by the supplier’s transport with a critical delivery delay;

– Critical/non-critical payment delay – 0,15/0,85 respectively during delivery from the intermediary by the supplier’s transport with non-critical delivery delay.

Let us specify the attributes of the model that belong to the indicators of the private criterion **F**, which is related to the costs of supplying defective products. A product shortage can be critical **(FC**) or non-critical (**FN**) for DMS. The amount of costs from the supply of defective products in the format of the analyzed model can be:

1) critical when supplying products by the manufacturer and will amount to 25 thousand CU with a probability of 0,6 when self-delivered and with a probability of 0,65 when transported by the supplier;

2) non-critical during the delivery of products by the manufacturer and will amount to 2,5 thousand CU with a probability of 0,4 when self-delivered and with a probability of 0,35 when transported by the supplier;

3) critical when supplying products through an intermediary and will amount to 3,5 thousand CU in cash with a probability of 0,45 when self-delivered and with a probability of 0,35 by the supplier’s transport;

4) non-critical when supplying products through an intermediary and will amount to 0,5 thousand CU in cash with a probability of 0,55 when self-delivery and with a probability of 0,65 by the supplier’s transport.

We optimize the presented structure of indicators of the considered private criteria using the decision tree method. This method allows finding the best solutions under risk conditions [1–2]. At the same time, its modification will allow implementing procedures for selecting the best solution, taking into account both risk factors and multi-criteria selection. Note that the decision tree method allows DMS to formalize any scenario format for the specified factors. Let's move on to solving the problem when you need to find the best solution, which involves: both choosing a supplier and choosing a method of product delivery, taking into account the specified risk factors and given private criteria, the indicators of which are minimized.

Let us present the procedure for choosing the best solution when purchasing goods or raw materials based on the decision tree method. Fig. 1 demonstrates the procedure for constructing a decision tree for the presented model.

One of the tree fragments will take into account the possibility of organizing the purchase of goods from the manufacturer by self-exporting the goods, which has the designation **MP**. Let’s consider the structure of this branch of the decision tree.

Taking into account the delivery delay factor scenarios, this fragment of the tree is divided into two components that correspond to critical **LC(MP)** and non-critical **LN(MP)** delays in the delivery of the product with probabilities of 0,2 and 0,8, respectively. In turn, these fragments, due to the variability of payment delays, branch into:

1) critical payment delay with critical delivery delay **PC(MPLC)** – probability 0,25;
2) non-critical payment delay with critical delivery delay **PN(MPLC)** – probability 0,75;
3) critical payment delay with non-critical delivery delay **PC(MPLN)** – probability 0,1;
4) non-critical late payment with non-critical delivery delay **PN(MPLN)** – probability 0,9.

Taking into account the defect's factor (critical and non-critical), each of these fragments includes its components according to the analyzed scenarios of possible defect. As a result, we get 8 options for the development of events, each of which will be displayed on a branch of the decision tree and has its own cost values:

– for the purchase of goods (**C**),
– for the delivery of goods (**D**),
– for costs associated with delivery delays (**L**),
– for losses associated with late payment (**P**),
– for losses associated with the supply of defective products (**F**).

All cost values are presented in Fig. 2 by the specified set of indicators of the given private criteria (in the corresponding rectangles assigned to the analyzed vertices of the decision tree).

Convolution procedures within a decision tree are implemented for end vertices of the round type [2–4]. The format of these procedures allows us to replace the given probability distributions of a random final outcome for a round vertex with the corresponding set of parameters necessary for decision-making under risk conditions. With a neutral attitude to risk, the result of the convolution is a single parameter – it is the average expected final results for the corresponding indicators of the private criteria. The corresponding risk theory approach is called EVC (Expected Value Criterion). This is the approach to risk accounting that we will use for the model under consideration. We will perform the convolution procedure for the “defect” vertex, which lies on the **MP-LC(MP)-PC(MPLC)** branch.

Criterion **C**: the cost of purchasing goods from the manufacturer in the case of a critical defect with a probability of 0,6 is 500 thousand CU, in the case of a non-critical defect with a probability of 0,4 – 500 thousand CU. As a result of the folding procedures, we obtain: 500×0,6+500×0,4=500 thousand CU.

Criterion **D**: the cost of transportation costs when delivering from the manufacturer by self-delivery in the case of a critical defect with a probability of 0,6 is 1,63 thousand CU, in

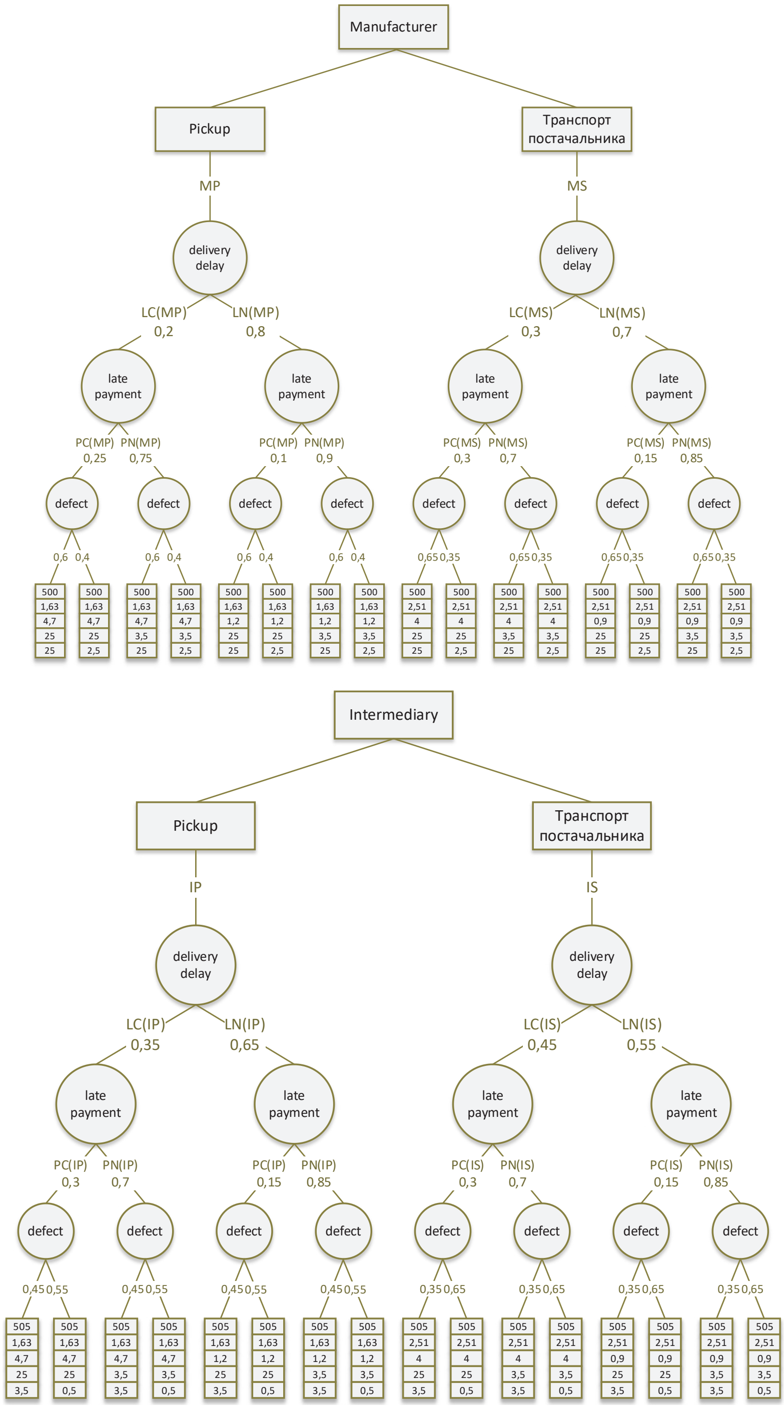

Figure 1. Fragments of the decision tree for choosing the best option for the procurement of goods

Source: author's development

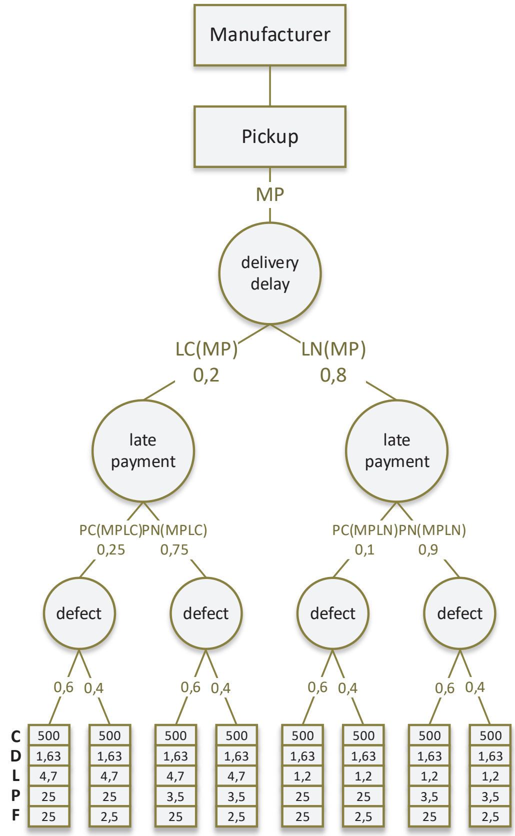

Figure 2. Fragment of a decision tree corresponding to the purchase of goods from a manufacturer by self-delivery

Source: author's development

the case of a non-critical defect with a probability of 0,4 – 1,63 thousand CU. As a result of the calculation, we get: 1,63×0,6+1,63×0,4=1,63 thousand CU.

Criterion **L**: the costs associated with a critical delay in the delivery of goods, with a critical defect with a probability of 0,6, is 4,7 thousand CU, with a non-critical defect with a probability of 0,4 – 4,7 thousand CU. As a result of the convolution, we obtain: 4,7×0,6+4,7×0,4=4,7 thousand CU.

Criterion **P**: costs associated with late payment, with a critical delay in delivery by self-collection in the case of a critical defect with a probability of 0,6 is 25 thousand CU, in the case of a non-critical defect with a probability of 0,4 – 25 thousand CU. As a result of the convolution, we obtain: 25×0,6+25×0,4=25 thousand CU.

Criterion **F**: the costs associated with the supply of poor-quality goods, with a critical defect with a probability of 0,6, is 25 thousand CU, with a non-critical defect with a probability of 0,4 – 2,5 thousand CU. As a result of the convolution, we obtain: 25×0,6+2,5×0,4=16 thousand CU.

The convolution procedures for other round-type vertices are implemented similarly. The results of such procedures are shown in Fig. 3.

Blocking procedures within the decision tree method are implemented for vertices of rectangular type [2, 5]. These vertices take into account alternative choices in the format of

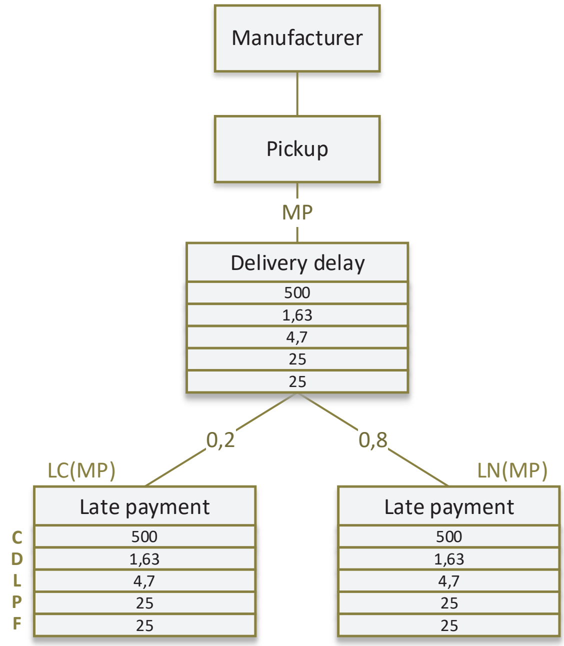

*Figure 3. Fragment of the "**MP**" decision tree after the convolution procedure*

Source: author's development

the corresponding attributes of the analyzed alternatives. Let us imagine a decision tree in the format that requires blocking procedures. To implement these procedures, all the indicators of the private criteria are summarized in Table 1. The essence of the blocking procedure is to leave unblocked only the alternative with the best set of private criteria indicators. In the format of problems of choosing the best solutions under many conditions, there are different ways to determine the best solution when comparing alternatives. To implement the best choice, it is necessary to apply one of the known methods for solving multi-criteria optimization problems in the format of the specified blocking procedure.

Next, we will present the procedures for selecting the best solution based on the selection criteria traditionally used in the optimization of logistics systems [3–5]. The best options for organizing procurement will be found using the minimax criterion method, the weighted evaluation method of private criteria, the generalized scalar criterion method, the ideal point method, and the geometric mean criterion method. The use of a specific selection criterion will be determined by the DMS preference system. The larger the arsenal of such approaches to choosing the best solution a manager has, the better he can adapt the choice to the DMS preference system.

Table 1

Indicators of alternatives according to private criteria

	C	**D**	**L**	**P**	**F**
MP	500	1,63	1,9	6,295	16
MS	500	2,51	1,83	7,6925	17,125
IP	505	1,63	2,425	7,85375	1,85
IS	505	2,51	2,295	8,17625	1,55

Source: author's development

The minimax criterion method consists in comparing the analyzed alternatives of the worst indicators among all private criteria. At the same time, the best one is selected from among these worst indicators. It indicates the optimal solution (Table 2).

The last column shows the worst indicators by rows in Table 2. The lowest indicator is 500. It corresponds to the alternatives **MP** (supply from the manufacturer by self-collection) and **MS** (supply from the manufacturer by supplier's transport). They are the best solutions in the format of the minimax criterion method. The other alternatives (**IP** and **IS**) are blocked, that is, they cannot be chosen as the best according to this selection criterion.

Using the method of weighted evaluations of private criteria, DMS assigns its own weight coefficient (by level of importance) to each private criterion. The best alternative is the one with the lowest weighted average among all private criteria (when all private criteria are minimized). In this model, weight coefficients are given to private criteria: the criterion "cost of goods" is given a coefficient **C** = 0,02; the criterion "delivery costs" – **D** = 0,18; the criterion "delay in delivery" – **L** = 0,3; the criterion "delay in payment" – **P** = 0,1; the criterion "defect" – **F** = 0,4 (last row of Table 3).

The last column "weighted sum" of Table 3 shows the results of the arithmetic average weighted indicator for each row, taking into account the weighting coefficients. The smallest indicator that determines the best solution is selected (indicator 12,6463 for the IP alternative). As a result, using the weighted estimation method, the best solution is to have the goods delivered by the intermediary with self-pickup. Other alternatives are blocked.

For selection using the generalized scalar criterion method, DMS determines weighting factors for the indicators of private criteria using a special formula. The selection function $G(A_k)$ can be defined as follows:

$$G(A_k) = \sum_{i=1}^{n} \frac{g(C_i^{(k)}) - g_{min}(C_i)}{g_{min}(C_i)},$$

where $g(C_i^{(k)})$ is the indicator of the i-th criterion for the k-alternative; $g_{min}(C_i)$ is the indicator of the minimum value of the i-th criterion from all analyzed alternatives.

The alternative with the smallest value of the criterion function G is accepted as the best solution based on this method. A feature of this method, as well as the generalized minimax

Table 2

Choosing the best solution for the minimax criterion

	C	D	L	P	F	Minimax
MP	500	1,63	1,9	6,295	16	**500**
MS	500	2,51	1,83	7,6925	17,125	**500**
IP	505	1,63	2,425	7,85375	1,85	505
IS	505	2,51	2,295	8,17625	1,55	505

Source: author's development

Table 3

Choosing the best solution using the method of weighted evaluations of private criteria

	C	D	L	P	F	Weighted sum
MP	500	1,63	1,9	6,295	16	17,8929
MS	500	2,51	1,83	7,6925	17,125	18,6201
IP	505	1,63	2,425	7,85375	1,85	**12,6463**
IS	505	2,51	2,295	8,17625	1,55	12,6779
Weighting factor	0,02	0,18	0,3	0,1	0,4	

Source: author's development

criterion method, is the orientation of the choice to the utopian point, that is, the orientation of the choice to the best indicators of the private criteria. In the format of the generalized scalar criterion method, the indicators g_{min} (C_i) are first determined for each of the criteria (last row of Table 4). These indicators determine the value of the criterion selection function. For example, for the **MP** alternative, the value of the specified function will be:

$$G(\mathbf{MP}) = \frac{500-500}{500} + \frac{1,63-1,63}{1,63} + \frac{1,9-1,83}{1,83} + \frac{6,295-6,295}{6,295} + \frac{16-1,55}{1,55} = 9,3608.$$

The values of the criterion function of choice for other alternatives are calculated similarly and are indicated in the last column of Table 4. The smallest value of the choice function is 0,7763 and corresponds to the **IP** alternative. Thus, using the generalized scalar criterion method, the optimal solution is the supply of goods from the intermediary by self-collection.

The choice using the geometric mean criterion method is carried out in such a way that for each alternative it is necessary to find the geometric mean value based on the estimates of the private criteria. Among these indicators, the smallest is chosen, indicating the best solution. The choice will not change if, instead of the specified indicator, DMS uses the indicator of the product of all the values of the private criteria for each alternative. Accordingly, this selection criterion is also called the product criterion. The values of the indicators when choosing this method are presented in the last column of Table 5.

The smallest value of the product indicator is 29002,773 and corresponds to the **IP** alternative (supply of goods from an intermediary with self-delivery).

To implement the ideal point method, a "utopian point" of the UP (the point with the best coordinates/indicators of private criteria) is specified. For each alternative, a "distance" to the UP is determined. The best solution corresponds to the shortest distance from the UP. n the format of the model under consideration, the coordinates of the utopian point are the best indicators in the corresponding columns of Table 6 – UP (500; 1,63; 1,83; 6,295; 1,7). The distance from the alternative to the UP is calculated using a linear algebra formula – it is the square root of the sum of the squares of the differences in coordinates for the UP and the analyzed alternative. The calculation results are given in Table 6.

Table 4

Choosing the best solution using the generalized scalar criterion method

	C	**D**	**L**	**P**	**F**	**Value of the selection function**
MP	500	1,63	1,9	6,295	16	9,3608
MS	500	2,51	1,83	7,6925	17,125	10,8103
IP	505	1,63	2,425	7,85375	1,85	**0,7763**
IS	505	2,51	2,295	8,17625	1,55	1,1028
indicators g_{min} (C_i)	500	1,63	1,83	6,295	1,55	

Source: author's development

Table 5

Choosing the best solution using the geometric mean criterion method

	C	**D**	**L**	**P**	**F**	**Product of private criteria scores**
MP	500	1,63	1,9	6,295	16	155964,92
MS	500	2,51	1,83	7,6925	17,125	302547,035
IP	505	1,63	2,425	7,85375	1,85	**29002,773**
IS	505	2,51	2,295	8,17625	1,55	36866,648

Source: author's development

Table 6

Choosing the best solution using the ideal point method

	C	D	L	P	F	Distance to UP
MP	**500**	**1,63**	1,9	**6,295**	16	14,4502
MS	**500**	2,51	**1,83**	7,6925	17,125	15,6623
IP	505	**1,63**	2,425	7,85375	1,85	**5,2796**
IS	505	2,51	2,295	8,17625	**1,55**	9,6354
UP	500	1,63	1,83	6,295	1,55	

Source: author's development

The distance to the UT of other alternatives is calculated similarly. The shortest distance to the UT corresponds to the IP alternative (delivery of goods from the intermediary with self-pickup). Other alternatives are blocked.

Conclusions. As a result of the research, an approach to modeling the procurement process taking into account risks was developed by using a decision tree. The proposed model allows us to take into account a variety of alternative supply options and possible scenarios for their implementation with different levels of probability and costs.

The main results are: formalization of risk factors that influence decision-making in the procurement process; construction of a decision tree as a tool for visualization and analysis of procurement options under conditions of uncertainty; justification of the feasibility of using expected value as a criterion for choosing the optimal solution; demonstration of the practical application of the model using an example.

Using a decision tree allows you to increase the validity of management decisions in the field of procurement logistics, reduce the impact of uncertainty and risks, and optimize costs. Further research may be aimed at automating model building for more complex scenarios and integrating with enterprise information systems.

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