Scheme of Sequential Analysis of Options for Creating an Intelligent System for Analyzing Competitive Proposals for Urban Transformation[1]

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Abstract

This study focuses on the procedural aspects of identifying effective solutions and analyzing scientific works related to the application of decision-making methods in various managerial tasks. It introduces a framework for the comprehensive analysis of options, which serves as an effective tool for narrowing down the initial set of admissible solutions. Additionally, a generalized methodology for project selection on a competitive basis is proposed. The study also emphasizes the formalization of selection procedures, as well as the digitalization and automation of initial data processing during the early stages of research.

Keywords

project competition, digitalization, formalization of the project selection procedure, scheme of sequential analysis of options

1. Introduction

Digitization is one of the defining and enduring trends of the 21st century. The transition to a digital environment and the use of digitized data entail a fundamental systemic transformation across all aspects of organizational systems at various levels. This shift to a new level of management is marked by the formalization of management processes and organizational activities, the development of mathematical models for business processes, the application of various intelligent tools, and the extensive automation of workflows and document management using modern information technologies [1].

Urbanization has emerged as a persistent trend in global development [2, 3]. The "Smart City" concept represents a modern model of urban transformation that leverages digital technologies to address key urban challenges, transform management systems, and foster the development of city residents and their communities. Addressing these challenges and implementing innovative projects require adopting competitive principles for the analysis, evaluation, and selection of effective solutions. This need has driven the integration of competitive procedures into the Smart City framework [4, 5].

The objective of this study is to explore approaches to structuring the problem of supporting the competitive selection of urban transformation projects at all stages of preparation and implementation. To formalize the components of this process, the authors employ mathematical tools from various disciplines, incorporating methods and algorithms from expert evaluation, decision-making theory, and system analysis, alongside other modern tools and technologies [6, 7]. This research develops both theoretical and practical aspects of applying modern digital technologies

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and decision-making methods to automate and enhance the intelligence of competitive project selection procedures.

2. General scheme of competitions

We outline the process of preparing and conducting competitions in the form of several stages, each divided into individual phases that detail various aspects of the competition. It is important to note that any such scheme inherently involves some degree of abstraction and serves as a model of real-world processes. Consequently, when organizing specific competitions across different fields of activity, the stages and phases may be modified, omitted if unnecessary, or supplemented with additional functions or options to suit particular practical requirements. Similarly, the sequence of the described stages and phases may also vary.

Nevertheless, the proposed scheme is comprehensive and provides a holistic view of the range of issues addressed in this work. While not all stages of tenders can be fully formalized, it is often sufficient to define the decision-making structure or process flow for certain stages to enhance clarity and understanding. Below, we list and briefly describe the key functions and sub-stages that are essential for the successful execution of a tender.

I. Preliminary stages

1.1. Formalizing the rules of the competition: approving or updating the already approved Regulations on the competition.

1.2. Create supporting regulatory documents to regulate in detail the procedures for conducting the tender at all stages and ensure its reliable regulatory and legal support.

1.3. Creation and development of a modern innovative ecosystem or system of digital solutions. That is, the creation or activation of a complex of information, organizational, communication, structural and functional institutes that ensure the successful conduct of competitions, in particular, at the level of providing the organization's back office. At the same time, the ecosystem ensures the availability of modern services and tools, the digital transformation of competitions, etc.

1.4. Determine the list of functions to be performed by the organizers, competition commissions, experts and participants in the course of the competition. If necessary, these functions should be schematized, structured or formalized, depending on their nature, the level of the problem and the capabilities of the analysts.

1.5. Formalization and automation of business processes for organizing, conducting, summarizing and publishing tenders, ensuring confidentiality, high level of analytical capabilities, information security, avoidance of corruption, subjectivity, conflict of interest, etc.

II. The instrumental stage

2.1. Archiving of information support and decisions on all stages of the competition and all information about the organization, competition committee, experts, participants, etc.

2.2 Maintain and support the archive of applicants' participation in competitions, their previous victories and awards.

2.3 Archiving the participation of the organization's employees in previous projects - as organizers, members of the competition committee, experts, or participants.

2.4. Establishing and maintaining an employee rating system within the organization, based on criteria such as participation in previous competitions, the effectiveness of their evaluations, and the alignment of their high scores with the outcomes of competition winners.

2.5. Analyse the archive to identify new knowledge and use the experience of holding competitions for their continuous improvement at all stages.

III. Organizational stages

3.1. Determination and appointment of the person responsible for the organization of competitions in each individual organization or at the level of organizational units.

3.2. The decision to hold a competition in the organization and its execution in the form of administrative documents.

3.3. Establishment of an appeal commission.

3.4 Announcement of the start of the competitive selection.

IV. Initial stages

The initial stages of the competition are extremely important, as they ensure confidentiality, equality and fairness of the competition assessments for all participants.

4.1. The formation of an expert group or competition commission is a critical step. Depending on the nature, purpose, and specific features of the competition, the roles and titles of these individuals may vary, such as:

- Experts;
- Reviewers;
- Members of the competition committee;
- Other names.

The process for forming this group may include actions such as obtaining the personal consent of candidates to serve as experts, allowing candidates to express their own interest, and securing approval of the selected experts by the competition organizers. This stage can be implemented using several approaches, which may differ significantly in their methods and procedures:

- ensuring the required number of experts by directive methods, if this process takes place in a hierarchical structure with an appropriate corporate (organizational, internal) culture [8];
- determining the number and list of experts on quotas;
- selection of the most suitable experts among the set of applicants;
- ensuring sufficient material and intangible modification of potential experts;
- increasing the prestige of the expert status and the popularity of this activity in various fields of activity.

4.2. Formation of rules for assessing the competence of experts, their good faith, adequacy of assessment, unreasonable demands or uncritical leniency, etc.

4.3. Formation of rules for the work of the expert group and moderation of its activities.

4.4. Formation of rules for making a collective judgment of the group.

V. The formalization stage

To formally represent a contest as a mathematical object, we assume that each contest can be expressed as a tuple:

$$\langle A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9, A_{10} \rangle$$

Elements of a tuple are follows:

A_1 – Regulations, orders and other regulatory documents governing the tender;

A_2 – Organizer of the competition;

A_3 –The lot of experts;

A_4 –A set of formal characteristics of experts;

A_5 –The plural of contestants;

A_6 –The set of constraints that are taken into account in an expert assessment;

A_7 –The multiple criteria;

A_8 –The system of preferences of the expert group;

A_9 –A convolution of criteria defined for a particular competition to aggregate expert opinions and decision criteria, for example, in the form of an additive linear criterion or using the sum of squares;

A_{10} —A set of goals for the researcher:

$a_{1a} \in A_{10}$ – evaluation of projects submitted to the competition;

$a_{2a} \in A_{10}$ – manipulating the results of the competition, appointing additional reviewers, etc;

$a_{3a} \in A_{10}$ – distribution of limited resources among the best participants of the competition in order to motivate them further;

$a_{4a} \in A_{10}$ – analysis of the experts' competence and the results of their evaluation;

$a_{5a} \in A_{10}$ – distribution of experts into clusters based on the similarity of their characteristics and statistical analysis of their assessments;

$a_{6a} \in A_{10}$ – aggregation of expert ratings into a single, reasonable, consistent indicator.

VI. The main stage

6.1. Ensuring receipt of applications and all necessary documents from the tenderers.

6.2. Admission of projects to the call for proposals, taking into account the criteria and restrictions, in particular:

- those, who did not submit all the documents listed in the announcement;
- those who submitted documents after the deadline for submitting documents;
- those who are not eligible to participate in the competition;

6.3. Encryption of applications, projects or works submitted to the competition.

6.4. Distribution of encrypted applications, projects or works to experts for their expert evaluation.

6.5. Conducting competitive selection and evaluation processes of applications, projects or relevant works in several stages:

- Performance of test tasks on knowledge of the regulatory framework [9].
- Testing of professional competencies by means of a written case study [10].
- Presentation of a promising application, project or work to the competition committee by the author or authors of the application, as well as answering questions from the competition committee members within the scope of the competition test.
- Other restrictions and requirements regarding the features of the competition.

To ensure the reliability of the expert assessment, double or batch "blind" peer review procedures may be applied, experts may be required to assess the confidence in their conclusions, etc.

The tender committee decides to determine the winner of the tender or to recognize the tender as not having taken place. The competition does not take place if:

- no one applied for the competition;
- no one was allowed to participate;
- none of the candidates or projects were recognized as winners.

6.6. Aggregation of individual scores obtained in the course of several rounds of the competition by a team of experts.

6.7. Determination of the winners of the competition based on the results of all scores received in all rounds of the competition.

VII. The final stage

7.1. Analysing the consistency of expert information, “smoothing” the results.

7.2. Decryption of applications, candidates for vacant positions, projects or works that have received encrypted scores at the competition.

7.3. Informing the tender participants and ensuring that they receive feedback.

7.4. Receiving and registering appeals against the evaluation of projects or candidates for positions that seem unfair or unreasonable to the participants of the competition.

7.5. Consideration of appeals by the tender committee, providing responses to applicants and reviewing the results of the tender if necessary.

7.6. Final determination of the winners, taking into account possible changes in the evaluation based on the results of appeals.

7.7. Publication of the final results of the competition.

7.8. Formalization of the winners' status in the form of administrative documents.

3. Sources of intelligence in the creation of computer systems

It is important to note that an intelligent information system is now recognized as a type of automated information system grounded in knowledge. Such a system comprises a set of software and mathematical tools designed to support the activities of decision-makers.

Let us examine the critical issue of incorporating various aspects of intelligence into data processing [11]. According to the authors, multiple areas of intelligence can be utilized in the design, development, implementation, and operation of intelligent systems. Below, we outline these areas of intelligence and their primary purposes.

Designate areas – via d_i, $i = 1,...,k$, designate areas – via a_j, $j = 1,...,m$, individual areas of research – via α_s, $s = 1,...,n$,

where k – number of possible areas of activity that can be sources of intelligence in the creation and operation of intelligent systems;

m – number of indices that identify elements of the set of assignments of directions (sources) of intelligence of automated systems;

n – number of possible indices that identify a set of individual research fields used in the development and improvement of intellectual property sources.

Let us consider in more detail all these components, which the authors of this paper consider to be the main sources of intelligence in the creation and operation of computer systems that contain elements of intelligence or can be considered intelligent in the modern definition of this concept [12].

$d_1 = d_1(a_{11}, a_{12})$ – using the intelligence of analysts and experts [13];

a_{11} – expert knowledge is integrated into the algorithmic support of computer systems through formalization and appropriate processing;

$a_{12} = a_{12}(\alpha_{121}, \alpha_{122}, \alpha_{123})$ – Analysts and experts, as intelligent agents, participate in decision-making situations.

In turn, the characteristic of a_{12} has different manifestations in different situations:

α_{121} – in the process of forming hypotheses;

α_{122} – in ontological engineering;

α_{123} – in evaluating and interpreting the models obtained for the subject area.

$d_2 = d_2(a_2)$ – expert decision-making and data processing technologies [14];

$a_2 = a_2(\alpha_{21}, \alpha_{22}, \alpha_{23})$ – expert evaluation of alternatives;

α_{21} – processing and collapsing partial estimates;

α_{22} – multidimensional scaling of pairwise comparison results;

α_{23} – simulation modeling based on semantic networks;

$d_3 = d_3(a_3)$ – use of artificial intelligence methods [15, 16];

a_3 – modelling the biological basis of human intellectual activity (for example, using artificial neural networks).

$d_4 = d_4(a_4)$ – evolutionary foundations of biological systems [17];

a_4 – use, in particular, in the form of genetic algorithms.

$d_5 = d_5(a_5) -$ the basics of the logic of human thinking [18];

$a_5 -$ modeling using the theory of fuzzy sets and measures, as well as by organizing fuzzy inference systems.

$d_6 = d_6(a_6) -$ research results of knowledge engineers;

$a_6 -$ research results of knowledge engineers.

$d_7 = d_7(a_7) -$ statistical methods of data analysis;

$a_7 = (\alpha_{71}, \alpha_{72}, \alpha_{73}, \alpha_{74}, \alpha_{75}, \alpha_{76}, \alpha_{77}) -$ statistical methods of data analysis;

$\alpha_{71} -$ correlation analysis;

$\alpha_{72} -$ regression analysis;

$\alpha_{73} -$ analysis of variance;

$\alpha_{74} -$ discriminant analysis;

$\alpha_{75} -$ factor analysis;

$\alpha_{76} -$ cluster analysis;

$\alpha_{77} -$ other types of analysis.

$d_8 = d_8(a_8) -$ OLAP, online analytical processing [19, 20];

$a_8 -$ real-time analytical processing – an interactive system that allows you to view various summaries of multidimensional data: results are obtained within seconds, without a long wait for the query result.

$d_9 = d_9(a_9) -$ Data Mining;

$a_9 = a_9(\alpha_{91}, \alpha_{92}) -$ tasks and types of analysis;

$\alpha_{91} = \alpha_{91}(\alpha_{911}, \alpha_{912}, \alpha_{913}) -$ Data Mining tasks;

$\alpha_{911} -$ classification tasks;

$\alpha_{912} -$ modeling tasks;

$\alpha_{913} -$ forecasting tasks;

$\alpha_{92} = (\alpha_{921}, \alpha_{922}, \alpha_{923}) -$ types of analysis;

$\alpha_{921} -$ data mining;

$\alpha_{922} -$ intelligent data analysis;

$\alpha_{923} = \alpha_{923}(\alpha_{9231}, \alpha_{9232}, \alpha_{9233}, \alpha_{9234}) -$ in-depth data analysis;

$\alpha_{9231} -$ in-depth analysis using the methods of mathematical statistics;

$\alpha_{9232} -$ in-depth analysis using artificial neural networks;

$\alpha_{9233} -$ in-depth analysis using the methods of fuzzy set theory;

$\alpha_{9234} -$ in-depth analysis using genetic algorithms.

$d_{10} = d_{10}(a_{10}) -$ Machine Learning [21];

$a_{10} = a_{10}(\alpha_{10a}, \alpha_{10b}, \alpha_{10c}, \alpha_{10d}) -$ machine learning methods;

$\alpha_{10a} -$ algorithms for building databases and rule trees;

$\alpha_{10b} -$ algorithms for building associative rules;

α_{10c} – methods using Bayesian networks;

α_{10d} – other machine learning methods.

Some of the areas of intelligence in the processing of expert information can be successfully applied to the creation of an intelligent system for analyzing urban transformation bids.

4. Expert decision-making technologies

Expert technologies are a common strategy for solving practical decision-making problems in various fields of human activity [22]. Expert knowledge is used in cases where the problem is insufficiently studied, poorly formalized, poorly structured and difficult to model directly. In decision-making situations with high dimensionality and considerable computational complexity, schemes of sequential analysis of options are successfully used [23]. It should be noted that managerial decision-making is a complex and multifaceted task that requires significant time and labor resources. Digitalization greatly facilitates the decision-making process by providing quick access to the necessary information, automating business processes, and supporting collaboration between teams [24]. Digital technologies can improve the accuracy of analysis, reduce decision-making time, and make the process more efficient and transparent, eliminating the subjective factor as much as possible [24, 25]. One of the decision-making tools is competitive selection, which involves the involvement and evaluation of various ideas, proposals, or projects in order to select the best or most appropriate one to solve a particular task or problem.

The study [26] focuses on analyzing publications related to the use of decision-making methods. It examines the application of these methods across various tasks, decision-making levels, and implementation stages. The authors identify four main categories of methods: multi-criteria decision-making methods, mathematical programming methods, artificial intelligence methods, and integrated methods that combine multiple approaches for enhanced effectiveness.

Given the widespread use of competitive selection technologies in managing Smart City projects, the development of tools to address several challenges – such as preventing abuse, improving the quality of management decisions, and ensuring transparent and algorithmically controlled selection procedures – has become a pressing need. In the absence of specialized software, creating information technology solutions for competitive project selection is particularly urgent.

5. Schemes for sequential analysis of options

To address the challenges of selecting competition winners, the authors propose using a sequential analysis of options. Building on the principles of sequential decision theory and dynamic programming, Academician V.S. Mikhalevich developed a general framework for sequential analysis of options [27]. This framework views the decision-making process as a multi-stage structure, akin to the design of a complex experiment. Each stage involves evaluating specific properties of a subset of options, which either directly reduces the initial set of options or sets the stage for such a reduction in future steps.

Today, the elements of sequential option analysis are selectively applied to create rules of interaction in many industries and areas of human activity.

6. Application of mathematical apparatus for solving problems of urban development

Urban development and the associated processes of urbanization are central features of the modern world. Cities concentrate populations and resources, creating additional demands and conditions for implementing fundamental changes in areas such as energy, transportation, water use, land use, housing, consumption, and lifestyles. These changes are necessary to ensure the viability, well-being, and sustainability of urban development.

One key aspect of urban transformation is the integration of innovative technologies in municipal management, exemplified by the “Smart City” concept. The core idea of a “smart city” is to enhance the capabilities of city administrations through strategic management, the adoption of innovative technologies, effective urban resource management solutions, and active citizen engagement in shaping a higher standard of living within the urban environment. An analysis of publications [26, 28] reveals that decision-making tasks—particularly those related to selecting the best options—are central to both the transformation process and the implementation of Smart City technologies. These tasks span a wide range of areas. Based on the reviewed publications, the authors have developed a diagram illustrating the distribution of publications across the main components of Smart City projects (Figure 1).

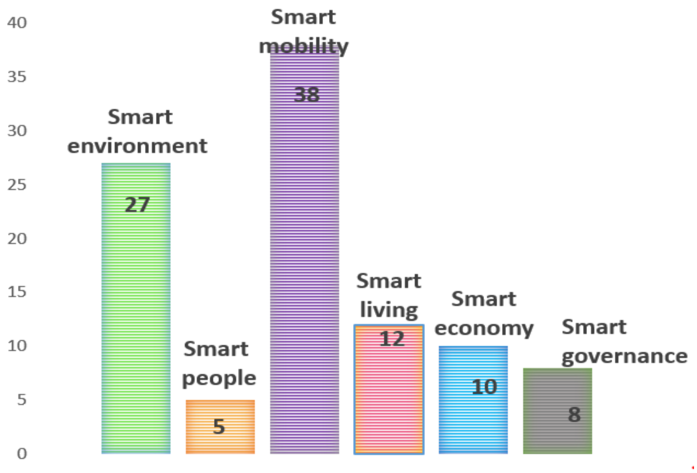

Figure 1: Distribution of publications by the main components of Smart City projects.

The task to be solved in the study is to organize and conduct a tender for the right to perform consulting (advisory, audit, legal, and evaluation) services to identify the best urban transformation projects. The need to create and formalize such a selection procedure arose due to the scale of the problem and the presence of hundreds of potential participants for such a competition. Obviously, the number of people who could provide consulting and legal services was even greater.

Thus, in order to create a system for fair selection of the best candidates from a sufficiently large number of potential participants, it was decided to base the selection on a sequential selection scheme. The purpose of this approach is to narrow down the initial set of participants by excluding unpromising candidates from the tender for the provision of consulting services in the field of state corporate rights management. This approach helps to improve the quality of services and transparency of selection procedures.

Given the participation of hundreds of companies in the urban transformation project competition, it was decided to select the winners in two stages. Expert decision-making technologies were combined with consistent analysis and preliminary elimination of unpromising options. This approach allowed the organizers to establish the necessary conditions for participation in the competition.

At the first stage of this procedure, the organizers of the tender offered participation to those companies that met certain pre-established restrictive requirements. Thus, already at the first stage of the competition, some companies simply decided not to participate, other companies were unable to meet the requirements, and some companies did not comply with bureaucratic procedures, etc.

After the first stage of the tender was completed, the number of potential participants decreased several times compared to the initial number. These companies signed general agreements to continue participating in the tender procedures. This indicates that the scheme of sequential analysis and elimination of unpromising options proved to be effective.

At the second stage of the project competition, sufficient conditions for the participation in the competition of organizations that successfully passed the first stage of the competition have been created. At this stage, the technology of using expert decisions is also logically and reasonably applied, just as it happens in the first stage. If some indicators of the organization's activity cannot be reliably measured, the organizers of the competition traditionally used expert evaluation.

The formal model of structuring the problem of competitive selection looks like this. Let us denote by A^0 the set of all applicants who can potentially provide management services and training for company management, as well as the need for an open and transparent management policy, it is necessary to develop appropriate selection mechanisms from the set of A^0, that would allow for the most efficient use of the best resources in project management.

Suppose that some individuals and legal entities from the set A^0 have expressed a desire to work in the field of consulting on urban transformation projects. The set of such persons is denoted by A^1. It is clear that there is such an investment:

$$A^1 \subset A^0 \tag{1}$$

The task is to determine the suitability of such persons by narrowing down the set. According to the methodology of sequential analysis of options, there are two stages of competitions:

1. Enter into a General Cooperation Agreement for the provision of consulting (advisory, audit, legal and valuation) services.

2. Enter into an agreement for the performance of services.

The winner of the tender will be entitled to provide one or more services for the management of state corporate rights. Moreover, only those participants who have passed the previous stage and have General Cooperation Agreements with the organizer of the tender project will participate in the second stage of the tender.

The criteria for determining the winners for each specific case may be different and are selected from a common set of criteria F :

$$f_i \in F, i \in I \tag{2}$$

where I is the set of indices of the criteria of the set (2).

The main criteria selected by the organizers of the competition from the set (2) to determine the winners of the competitions are:

f_1 – the level of professional qualifications of the participants;

f_2 – Participant's profile;

f_3 – at least two years of work experience in the field;

f_4 – availability of relevant documents that allow specialists to provide services;

f_5 – participants' proposals on the terms of payment for services;

f_6 – additional restriction: the term of the General Agreement is only two years or there are cases of unqualified or poor quality services, violation of the law or obligations under the agreement.

To formalize the procedure for conducting tenders in this area of sequential option analysis and for a specific subject area, we will introduce the following notation:

A^2 – a set of persons with whom the General Agreement has been concluded;

A^3 – a set of persons with whom an agreement has been concluded to perform a current service (by type of activity);

A^4 – a set of persons who have not yet reached the age of two years.

Taking into account the use of formula (1), we naturally obtain a chain of inclusions, which is formed as a result of the correct and justified application of a sequential analysis of options:

$$A^0 \supset A^1 \supset A^2 \supset A^3 \supset A^4. \quad (3)$$

Thus, at each stage, the process narrows the set of applicants according to the above scheme (3).

Figure 2 provides a graphical illustration of a sequential option analysis diagram. The diagram is depicted in the plane of two criteria f_1, f_2. Each point on the diagram corresponds to a separate option (candidate for a deal).

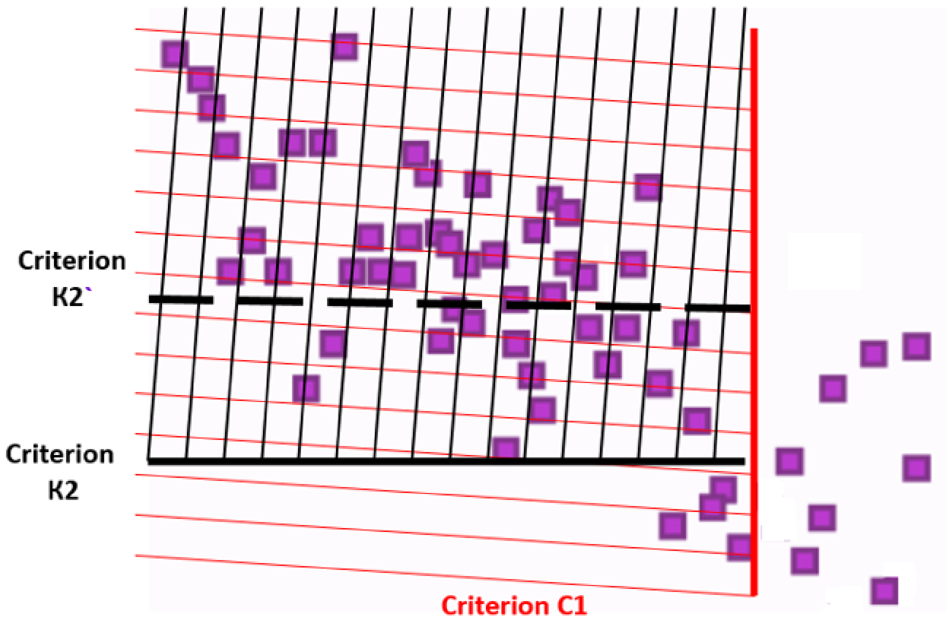

Figure 2: Schematic diagram of the selection of effective options using the sequential option analysis scheme.

At the first stage of the developed competition procedure, a preliminary selection of participants is conducted based on the requirements of criterion f_1. Participants who satisfy this criterion gain the right to conclude a General Cooperation Agreement (criterion f_1). In Figure 2, the red shading represents the set of tenderers who meet the f_1 criterion and are eligible to proceed to the next stage. This stage involves decision-making on the prospects of potential options or the early elimination of unpromising options.

The selection process at the second stage is carried out on a reduced set of options. Furthermore, at each stage of the algorithm, if the number of options to be excluded is zero or small, the selection conditions can be tightened.

The second stage involves selecting participants based on criterion f_2, which grants the chosen participants the right to provide one or more services related to the management of state corporate rights (criterion f_2).

In the diagram, the black shading represents the set of participants who satisfy the f_2 criterion. It is important to note that selection under criterion f_2 applies only to candidates who have already met criterion f_1. Consequently, the black shaded area is a subset of the previously defined red shaded area. Candidates who satisfy both criteria are represented in the double-shaded area.

For the specific competition described in this paper, the selection conditions for the second stage were as follows:

$$f^2 = \{\text{"Persons for whom the } 2 - \text{year limitation period has not yet expired"}\}.$$

Since the number of available slots for providing services related to the management of state corporate rights was smaller than the number of applicants, the selection condition at the second stage was tightened to:

$$f^3 = \{\text{"Persons for whom the 3 − year limitation period has not yet expired"}\}.$$

Another viable approach involves considering bidders' proposals on payment terms and deadlines during the final stage of the selection process. Such methods enable a flexible adjustment of the pool of participants.

In some cases, especially in specific subject areas, sequential option analysis schemes are employed. These schemes consist of multiple stages where unpromising options are gradually eliminated, thereby reducing the initial set of options. Figure 3 illustrates an example of such a scheme.

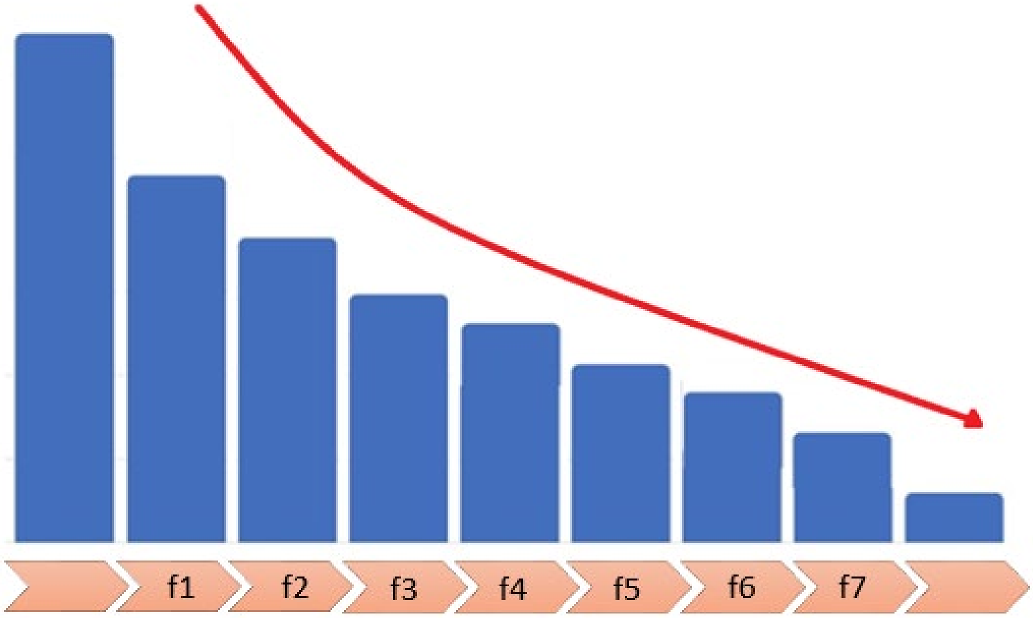

Figure 3: Illustration of the application of sequential option analysis when the seven criteria are applied sequentially.

In this context, let us assume that the main criteria selected by the organizers of the competition from the set (2) to determine the winners are as follows:

f_1 − Acceptance of documents for participation in the competition;

f_2 − Admission to the competition;

f_3 − Testing of conative skills;

f_4 − Solving situational problems;

f_5 − Checking for compliance with the integrity criterion;

f_6 − Interview with candidates.

We introduce notation for the sets that remain after applying each subsequent criterion. These sets form a chain of nested subsets, as described in expression (3), which result from the sequential application of the criteria listed above:

A_0 − is the initial set of applicants who decided to participate in the competition;

A_1 − after accepting the documents for participation in the competition;

A_2 − after being admitted to the competition;

A_3 – after testing the cognitive skills of the selection participant;

A_4 – based on the results of solving specially developed cases or situational tasks;

A_5 – as a result of checking the integrity of the completed task and general training of the candidate;

A_6 – based on the results of face-to-face or remote interviews with candidates;

A_7 – after the stage of preliminary selection, agreement and approval of the lists of winners;

A_8 – publication of the list of winners through mass media or other means after the final decision on the results of the competition.

It is evident that these subsets of the initial set of applicants satisfy a relationship analogous to expression (3):

$$A^0 \supset A^1 \supset A^2 \supset A^3 \supset A^4 \supset A^5 \supset A^6 \supset A^7 \supset A^8. \quad (4)$$

Figure 3 provides a graphical representation of formula (4), as developed by the authors. It should be noted that this example is derived from the official announcement of the results of a competition for vacant civil service positions, published this year in the mass media.

7. Conclusions

This study has demonstrated and illustrated that the development and implementation of expert technologies based on schemes for the sequential analysis of options enable the formalization of key aspects of the decision-making process in organizational system management. Practical experience with the developed toolkit confirms the effectiveness of the proposed approach. Conducting tenders and ensuring their transparency is a complex task that necessitates the development and implementation of effective strategies and solutions to address a wide range of challenges. Notably, the issues associated with competitive selection at all stages of organizational system activity highlight the need for digitization and the adoption of modern decision-making methods and procedures [29, 30]. The authors have demonstrated that the decision-making process, particularly in the context of selecting optimal options, is a critical component of organizational system management technologies, especially during the stages of conducting various competitions [31, 32]. The formalization of a sequential analysis scheme for the competitive selection of projects, as proposed by the authors, minimizes the impact of human factors in decision-making by systematically formalizing different aspects of determining competition winners [33, 34]. This article clearly illustrates the successful formalization and practical application of the sequential analysis scheme as a general methodology for conducting tender procedures [35]. Practical experience with the proposed tools further validates their effectiveness.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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