DEVELOPMENT OF A DECISION SUPPORT SYSTEM IN THE INTERNATIONAL ECONOMY BASED ON ECONOMIC AND MATHEMATICAL MODELS

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Abstract— The authors of the article have developed the following recommendations for the development of decision support system in the international economy on the basis of economic and mathematical models, namely improved a decision-making mechanism that is consistent with generally accepted decision-making principles and is applicable to support decision-making in the international economy; a decision-making process model that describes institutional, motivational and information management, and a management system model with an agent decision-making structure.
Index Terms— Decision-Making Technology, Decision maker, Decision Support System, Economic Model, International Economy, Mathematical Model, Probability.

1 INTRODUCTION

Today, in a complex dynamic environment, characterized by constant uncertainty and volatility of political, economic and social factors, the basis for the successful functioning of business entities is the adoption of adequate management decisions. Modern decision support systems are systems that are as adapted as possible to meet the challenges of day-to-day management and are a tool designed to assist decision-makers. The interest in DSS as a promising direction for the use of computers and as a tool for improving labour efficiency in the field of economic management is continuously increasing. With the help of decision support systems, which concentrate powerful methods of mathematical modelling, management theory, information technology, the choice of solutions of some unstructured and semi-structured problems, including multicriteria ones, can be made [1-3]. This is why decision support systems are usually the result of a multidisciplinary study involving theories of databases, artificial intelligence, interactive computer systems, simulation methods, and more.

2 THEORETICAL BASIS OF DECISION MAKING IN THE SYSTEM IN THE INTERNATIONAL ECONOMY

Decision making is a creative process in the activities of executives. It involves several stages: goal setting; study of the problem; substantiation of performance criteria; analysis of the consequences of the decisions made; final formulation and decision making; bringing the decision to the executors; control over the implementation of the decision [4-5].In the theory of decision-making distinguish the organizational and technological direction of research, in which the subject of research is the methods and technology of preparation and decision-making. Features of organizational and technological decisions are as follows [6-8]:

a) the process of developing and making management decisions is applied by its technology, which is subject to evaluation, planning and development.

b) knowledge of decision-making technology - the essential condition for the functioning of a manager of any level, his sufficient work.

c) scientifically grounded decision-making system - one of the modern models of organizational and technical control systems that combine independently formed mechanical, natural, general control models.

From the information point of view, in the process of making a management decision, there is a reduction of uncertainty about the problem situation and ways of its elimination.

Stages of development and implementation of management decisions.

a) Problem statement. It consists of an analysis of a problem situation, a study of the state of affairs and goals, a preliminary formulation of decision criteria.

b) Formation of the decision. It is about identifying and justifying the constraints and identifying alternatives. The cause of the problem can be both internal and external environment. It is necessary to highlight the source, the essence of the restrictions, and then identify possible actions that eliminate the causes of the problem.

c) Choosing a solution. At this stage, a decision is made on alternative options; its evaluation is given.

d) Execution, control over the implementation of the decision. At this stage, steps are taken to specify the solution and bring it to the executors. In the process of control, deviations are detected, corrections are made. Control establishes feedback between the system controlled (object) and the system controlled (subject) [9-11].

Finding alternative solutions is as follows.

a) Find the possible scope and nature of the solution. The area refers to a specific subsystem of management of production and economic activity of the enterprise: management of economic activity, material and technical resources, provision of personnel, social development, finances, etc. All enterprise management subsystems contain a specific set of functions for managing factors of production that relate to them (tools, labour, personnel, technology, finance, etc.), and a complete management cycle within which decisions are made and executed.

b) Determine the type of solution to the problem. It depends on the issue for which the answer is formed. The whole set of solutions can be conditionally represented in the form of standard, typical problem situations and original [12].

In the international economy, most problematic situations are standard; that is, they are often repeated and have analogues in the past. But each case has its peculiarities. The usual solution should be specified, considered concerning the characteristics of the current situation.

Original solutions are needed in situations where a fundamentally new approach is required.

c) Search for extreme solutions. The search process should only outline the area in which alternatives are being developed.

d) Formulate options - the mean between the worst and the best. It is necessary to correlate the expected effect of the selected solution with the cost of its search.

e) Assess the likelihood of implementation of alternative solutions. They exclude explicitly unacceptable options, leaving only those that can be used further and are capable of producing an effect.

e) Carry out a feasibility study of the decisions (comprehensive assessment of the advantages of each choice separately) and choose a single solution from all options.

In the practice of the international economy, the ranking of variants of decisions on each separate index is carried out. Comparing the estimates of all indicators, the expert evaluates each decision (comparative effect) and makes a single.

At the stage of choosing the optimal solution, perform the following operations:

a) determine the feasible solutions from the alternative solutions found at the search stage that satisfy many constraints;

b) assess the effectiveness of decisions by narrowing down many possible solutions to the subset of effective choices based on selection and analysis of benefits. The choice of effective solutions can be formal and informal. The structured approach is used when it is possible to measure the benefits of decisions over multiple performance targets quantitatively. In a casual approach, completeness of achievement of goals is determined by expert estimates;

c) choose a single solution from the set of effective ones by attracting additional information that helps to evaluate the goals and indicators of their achievement.

To obtain a single solution, detailed development of each variant of a solution is made from a subset of effective solutions, including goals, options for action, clarification of the solution; study of the main directions, ways and means in achieving the goals; production facilities and resources; study of possible options for interaction between structural units and contractors; assessment of the consequences of the implementation of the decision.When choosing the final solution, the last word should always belong to the manager.And, of course, another prerequisite for making a decision is having a decision-maker (DM) . In addition to DM, other individuals are involved in the decision-making process: problem owner, experts, analysts, and active groups (Fig. 1).

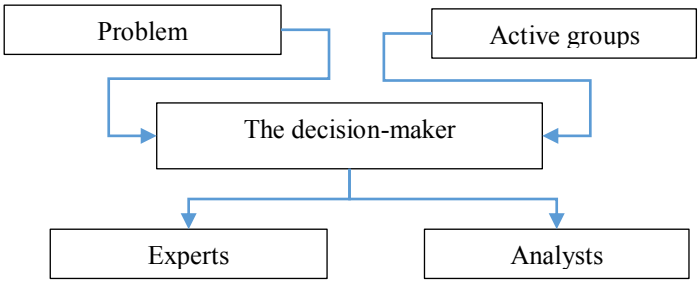
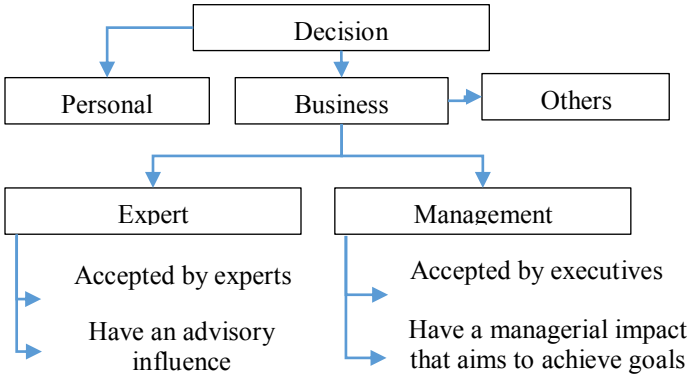


Fig. 1. Decision-makers.

If a person, in accordance with his job responsibilities, manages any organizational processes at the enterprise or organization, his decisions are relevant to a lot of people. Such choices, due to their importance, are divided into a separate class and called managerially (Fig. 2).

Fig. 2. The specificity of management decisions.



Management decision-making should be seen not as a separate stage of the management cycle, but as a joint process (Fig. 3) that permeates:

- all areas of activity of the organization (international cooperation, production, marketing, finance, personnel, logistics, etc.);
- all management functions (control, analysis, forecasting, planning, etc.).

Evaluation and selection of decision support methods

A model is an analogue of an original object that reflects its essential properties and replaces it in the course of the study. For example, a graphical model of the problem under investigation is a problem map.A mathematical model of an object is a description of the purpose by precise semantic means in the form of a system of expressions, equations, inequalities, and logical relationships.

Examples of economic and mathematical models are models of the mathematical economy (production functions and intersectoral balances), models of mathematical programming, game theory, statistical, probability and simulation models.

The methods and models used in making poorly structured decisions are shown in Fig. 4 and Fig. 5.

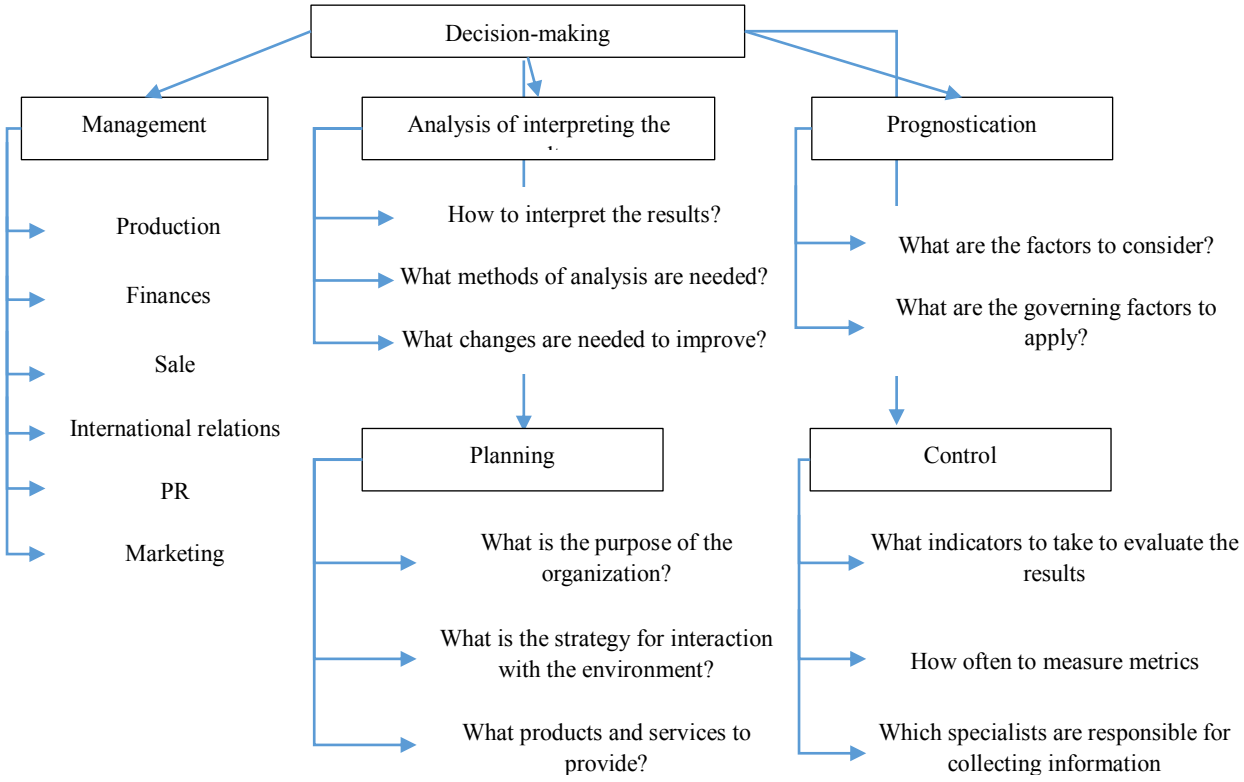


Fig. 3. Areas of management decision making.

The normative decision-making model is a means of presenting the correct decision-making process and its outcome. Regulatory models show how to make decisions. Models developed by normative decision-making theory are particularly needed in situations where a person lacks the information to make correct choices on many alternatives. Such conditions are called situations of uncertainty.

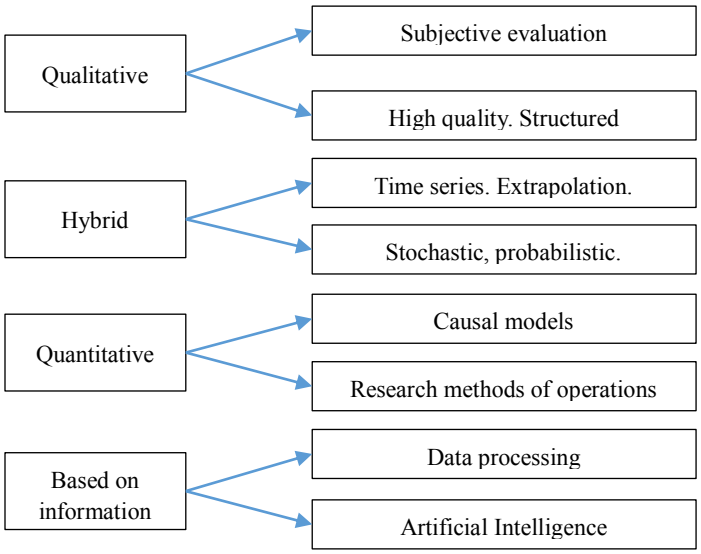


Fig. 4. Methods and models used in the international economy in making poorly structured decisions.

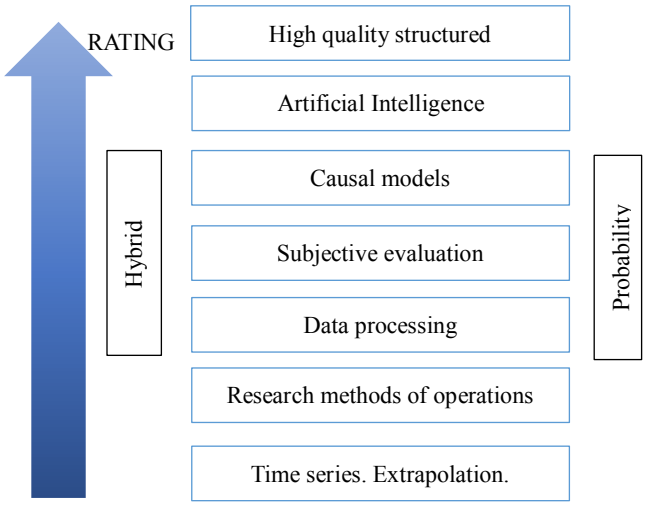


Fig. 5. Rating methods and models in terms of their suitability for solving poorly structured tasks.

3 METHODOLOGY

Models of decision making under uncertainty. Background information for decision making in situations of uncertainty and risk is presented in the form of a basic model of decision making, also called the payout table (Table 1).

The payout table uses the following notation:

A = {Ai} is the set of alternatives;

S = {Sj} is the set of possible states of the environment;

Pj is the probability of occurrence of the j-th state of the medium;

Yij - the consequences of the i-th alternative in the event of

the j-th state of the environment;

Ki is the expected effect of choosing the i-th alternative, calculated taking into account the consequences of this alternative in each of the probable states of the environment.

As can be seen from the table. 1.1, in a task with elements of uncertainty or risk, in the general case there is no clear the best alternative: in different variants of environmental development, the best result is provided by various options. In such cases, there is no unambiguous approach to choosing the best solution.

TABLE 1

THE BASIC MODEL OF DECISION MAKING IN RISK

Alternative	State of the environment					Expected effect
	Condition S1 Probability P1		Condition Sj Probability Pj		Condition Sm Probability Pm	
A_1	Y_{11}		Y_{1j}		Y_{1m}	K_1
…	…		…		…	…
A_i	Y_{i1}		Y_{ij}		Y_{im}	K_i
…	…		…		…	…
A_n	Y_{n1}		Y_{nj}		Y_{nm}	K_n

The standard set of decision-making models in uncertainty and risk includes models based on Bayes, Wald and "optimism" criteria.

The Bayesian decision-making model looks like this:

$$A_b = arg\,max_i\, K_i$$

$$K_i = \sum_j Y_{ij}\, xP_j \qquad (1)$$

where A_b is an alternative, Bayesian optimal;

K_i - the expected effect of choosing the i-th alternative, calculated taking into account the consequences of this alternative in each state of the environment;

Yij are the consequences of the i-th alternative in the event of the j-go state of the environment;

Pj is the probability of occurrence of the j-go state of the environment.

The formula (1) means that the alternative that is characterized by the highest value of mathematical expectation of winning is considered optimal.

A decision model based on Wald's maximum criterion (often called the pessimistic criterion) has the form:

$$A_B = arg\,max_i\, K_i$$

$$K_i = min_j\, Y_{ij} \qquad (2)$$

where A_B is an alternative that is optimal by the criterion of pessimism.

The formula (2) means that the alternative with the worst result is the best among the worst options.

An optimism-based decision-making model looks like:

$$A_0 = arg\,max_i\, K_i$$

$$K_i = min_j\, Y_{ij} \qquad (3)$$

whereA_0 is an optimally optimal alternative.

The formula (3) means that the alternative is proposed as the optimal one, the best result of which is the highest of the best results of all alternatives.

To answer the question of which of these models should be applied in each case, experts offer some rules:the Bayesian criterion is recommended to be used in cases of repeated repetition of a selection situation with known probabilities. In such cases, due to a large number of realizations, the value of the gain will gradually stabilize, and the risk will be virtually eliminated;the criterion of extreme optimism should be applied when the price of risk is relatively low compared to available resources;the pessimism criterion should be used when extreme caution is required. This criterion allows you to choose a solution that delivers a guaranteed result.Within the framework of normative decision-making theory, various models of choosing the optimal alternative under uncertainty have been developed. Each of these models has its pros and cons, its scope. DM accepts the right model depending on the source information, its experience, intuition and risk attitude.Models of decision making in multicriteria conditions. Background information for decision making in situations of target uncertainty related to the presence of multiple conflicting goals is presented in the base model given in Table. 2.

TABLE 2

THE BASIC MODEL OF DECISION MAKING UNDER MULTICRITERIA CONDITIONS

Alternative	State of the environment					Expected effect
	Criterion D1 Score V1		Criterion Dr Score Vr		Criterion Dg Score Vg	
A_1	Y_{11}		Y_{1r}		Y_{1g}	K_1
…	…		…		…	…
A_i	Y_{i1}		Y_{ir}		Y_{ig}	K_i
…	…		…		…	…
A_p	Y_{p1}		Y_{pr}		Y_{pg}	K_p

Table 2 uses the following notation:

A = {Ai} is the set of alternatives;

D = {Dr} is the set of criteria for evaluating alternatives;

Ki is the final assessment of the i-th alternative, which takes into account its evaluation by each of the criteria;

Vr - evaluation of the importance of the rth criterion in terms of achieving the common goal $\sum_r V_r = 1$;

Fir - evaluation of the preference for the i-th alternative by the rth criterion $\sum_r F_{ir} = 1$.

The most common regulatory model for multicriteria decision making is a model based on the criteria of cumulative effectiveness:

$$A_{CE} = arg\,max_i\, K_i$$

$$K_i = \sum_j F_{ir}\, xV_r \qquad (4)$$

where A_{CE} is an alternative that is optimal by the criterion of overall performance.

Formula (4) means that the alternative that is characterized by the highest value of the criterion of total efficiency is chosen as the optimal solution for the multicriteria problem.

Development of decision-making mechanism in the system of safety-oriented strategic management of industrial enterprise development.

4 RESULTS AND DISCUSSION

Therefore, the first task in creating a project (mechanism) is to identify the real needs and wishes of the user (enterprise).

When developing the architecture of the mechanism, it is necessary to follow the generally accepted principles, which include the following:

- consistency - this principle means that good architecture is consistent when partial knowledge of the system allows for predicting both;
- orthogonality - this principle requires that the functions be independent of each other and specified separately;
- compliance means that only features that meet the essential requirements of the system should be included in the architecture;
- cost-effectiveness - no function in the description of the architecture should in any way duplicate another;
- transparency - the tasks found in the execution process must be known to the user;
- community - the newly introduced role must be introduced in such a way that it meets as many purposes as possible;
- openness - the user should be able to specify the specification and content of the system's functions during its use;
- completeness - the specification of the services must meet all the requirements and wishes of the user.

We will develop a decision-making mechanism that meets these criteria and takes into account the security-oriented strategic management of enterprise development and its specificity (industry) (Fig. 6).

5 CONCLUSION

Of course, in practice, things may not go as smoothly:

- sub-stages may not take place in such a sequence; they can break, jump, obey feedback, overlap, parallel movement;
- the decision-making process is more individual than the more difficult decision;
- limited amount of information limits the rationality of the decision, the role of intuition grows;
- Pre-installed alternatives affect the choice of the solution;
- there is no desire for an optimal solution if there is something that satisfies;
- participation of several persons and organizational conditions change the order of passing sub-stages;
- Managers interfere differently in the structure and decision-making process, thus affecting their quality.

The key to the successful implementation of the mechanism is the efficient allocation of responsibilities and decision-making powers.

There are two areas of authority distribution:

- delegation of powers,
- centralization of the solution.

The most typical is the posterior distribution of decisions (for Western enterprises). High centralization:

- investment decisions,
- financial decisions,
- personal appointments in senior management.

Limited centralization:

- R&D decision.

Limited delegation:

- budget investment decisions,
- personnel decision.

High delegation:

- current production issues,
- decision to sell products.

Delegation decisions contribute (positive correlation):

- size of enterprises,
- product nomenclature,
- management computerization,
- the dynamics of NTP,
- variability of the environment,
- acceptability of demand prices,
- inter-production cooperation.

Thus, the recommendations proposed in the article allow increasing the efficiency of managing the development of decision support system in the international economy, as well as to enable more effective conduct of the enterprise as a whole.

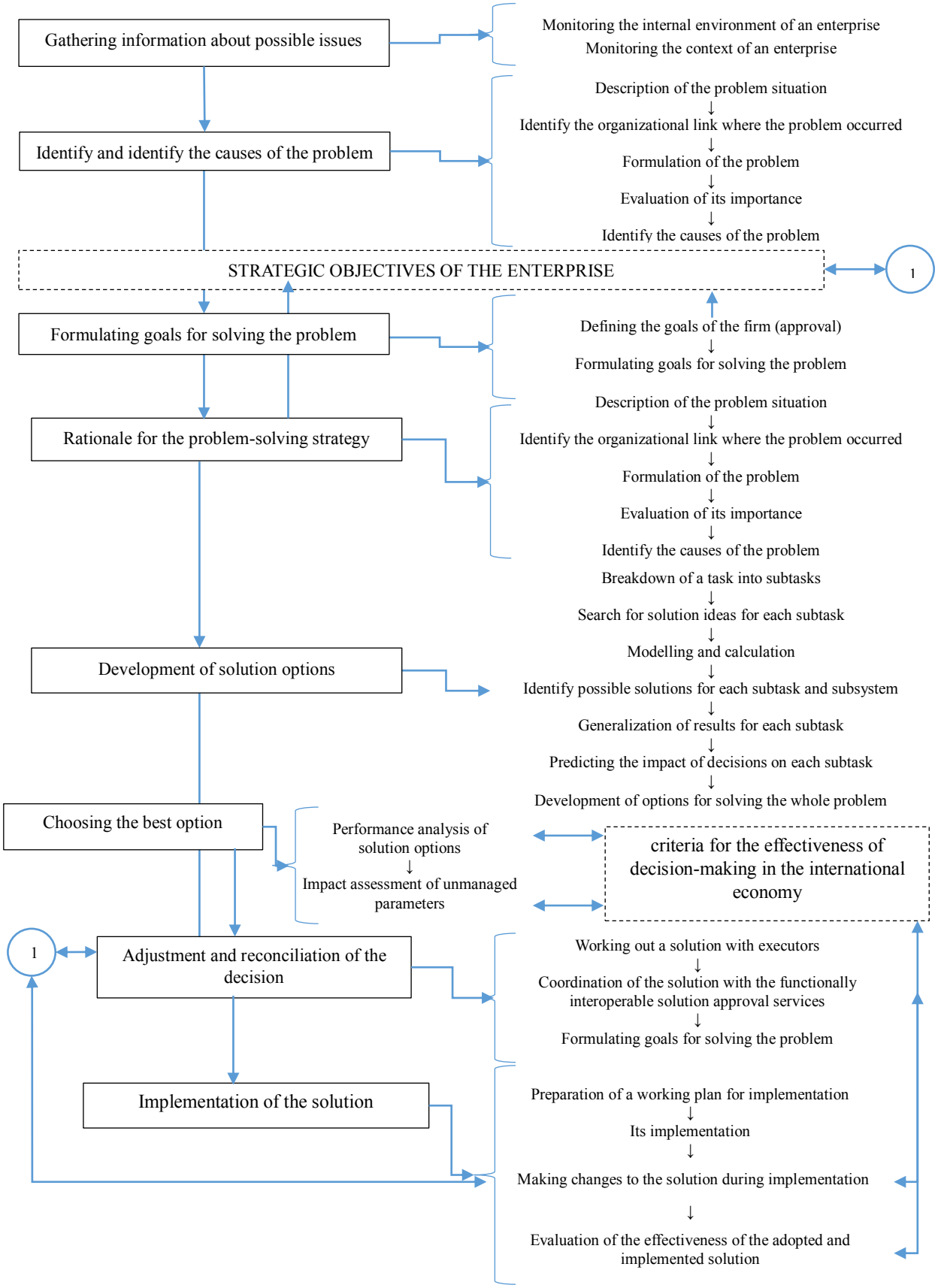


Fig. 6. The proposed decision support mechanism in the international economy based on economic and mathematical models.

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