EFFECTIVENESS EVALUATION MODEL AND SELECTION OF AUTOMATED INFORMATION SYSTEMS FOR IMPROVING SAFETY OF ENTERPRISES

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Abstract: The model of evaluation of efficiency and choice of automated information systems of decision making for the sake of improvement of the security of the activities of enterprises with the theory of fuzzy quantities application has been worked out/created. This model accounts the uncertainty of the input data, the specifics of functioning of area of operation of automated information system of solutions and evaluates effectiveness of fixed criteria according to the international standard ISO 25010:2011.
Keywords: evaluation, multicriterial choice, automated information systems, enterprise security international standard of evaluation

1. INTRODUCTION

Modern technologies allowed to simplify the development and operation of automated information systems (AIS) and made possible the creation of complex corporate systems worldwide. Nowadays the process of implementation and use of information systems and technologies by almost all market participants is a logical, reasonable and objectively necessary because serious competitive advantages in this market get exactly those companies that are able to effectively manage information owever, on the information market there is a huge offer of AIS decisions for business management.

Today, information systems and technologies - are the tools for successful functioning of any sphere of activity. To ensure the safety of the company an important role has the implementation and use of AIS. To do this, AIS must be able to assess and choose the most efficient available among available.

In such a case arises the urgent task: the model of effectiveness evaluating and AIS choice development under fuzzy conditions that will improve the security of the enterprise. The developed model considers the uncertainty of the input data, the specific operation field of AIS and evaluates the effectiveness by fixed criteria according to the international standard ISO 25010:2011. The implementation of this model in the software will be a useful tool for organizations when selecting the most effective on the AIS market.

2. CORRELATION OF AIS SELECTION EFFECTIVENESS AND ENTERPRISE ACTIVITY SECURITY

In general, basic consumer characteristics to any information system include such as: functional completeness; performance; level requirements for complex equipment; degree and ease of setting up the technical environment; value; the ability to customize the new conditions of use; opportunity to work in network; quality of user help in the working process; quality of user interface; information security and others. Unfortunately, at this time to achieve the satisfaction of all of these qualities in the development of information systems is difficult. The further effectiveness of AIS functioning depends on the quality of development.

In the technical documentation the majority software offered in the market, there is no information, which allows assessing the characteristics of incoming programs and their dynamics by changing the amount of incoming information. Without such information it is difficult to assess the quality of AIS, economic efficiency and security.

The relevance of the study is determined by the fact, that the most interested one in AIS is the consumer i.e. the user of the software product. To select a software system that automates the decision of its tasks, the potential customer is trying to assess in advance the efficiency and quality of automated information systems presented on the market. The safety of the enterprise depends in the correct AIS selection. If the purchased AIS during work doesn't give the best performance, or even sometimes gives false results, then it directly affects the adoption of ineffective or erroneous decisions. Such decisions negatively impact on economic security. In a case if AIS allows the fraudster to penetrate the system, does not provide confidentiality of information, or is designed, so that its decision-making can be influenced - it reduces the physical security of the enterprise.

For many companies the information and information technology is the most valuable and the most incomprehensible asset. Successful businesses realize the benefits of information technologies and use them to increase their cost, but they realize the economic and physical security connected with these technologies [1-2].

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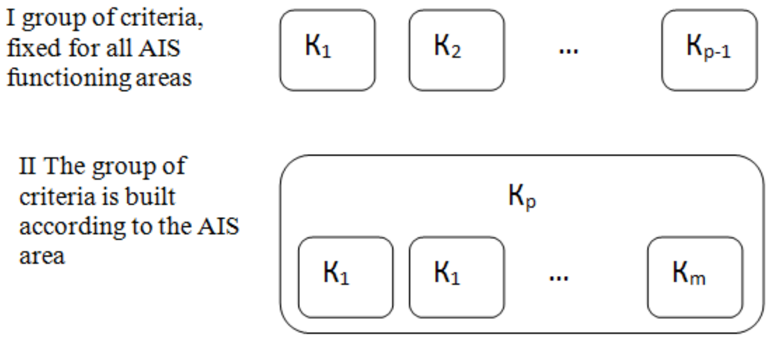
3.MATHEMATICAL MODEL OF PROBLEM SOLUTION

The task of evaluating the effectiveness of AIS and its choice to improve the safety of the company can be attributed partially to the multicriterial choice of alternatives problem.

The set of evaluation criteria are classified into two groups:

- General, fixed criteria group for assessing ISO 25010: 2011 standards for all areas of operation of AIS decision-making;
- Set of criteria for assessing, that depends on the area of operation of AIS decision.

In such a case a two-level set of criteria is considered, pic. 1.



Pic. 1. Two-level set of criteria

Let us consider the case where there is uncertainty in their expert opinions, or inability to evaluate certain criterion. Then we use the method of formalizing causal relationships between input and output variables in the case of fuzzy input data. It consists in describing these relationships in natural language on the base of fuzzy sets and linguistic variables.

Let a set of alternatives is – $X = \{x_1, x_2, ..., x_n\}$, i.e. AIS of decision-making. We will assess all the alternatives by effectiveness criteria groups of $\{K_1, K_2, ..., K_{p-1}\}$, where each group will have its own set of assessment criteria: $K_1 = \{G_1^1, G_2^1, ..., G_{m_1}^1\}$, $K_2 = \{G_1^2, G_2^2, ..., G_{m_2}^2\}$, …, $K_{p-1} = \{G_1^{p-1}, G_2^{p-1}, ..., G_{m_{p-1}}^{p-1}\}$. Also depending on the specific field of operation of AIS we will assess alternatives by their own set of criteria $K_p = \{K_1^p, K_2^p, ..., K_m^p\}$ [3].

The first group includes the following criteria:

1. K_1 – Functional suitability (G_1^1 - Functional completeness; G_2^1 - Functional correctness; G_3^1 - Functional appropriateness);
2. K_2 – Performance efficiency (G_1^2 - Time behaviour; G_2^2 - Resource utilization; G_3^2 - Capacity);
3. K_3 – Compatibility (G_1^3 - Co-existence; G_2^3 - Interoperability);
4. K_4 – Usability (G_1^4 - Appropriateness recognizability; G_2^4 - Learnability; G_3^4 - Operability; G_4^4 - User error protection; G_5^4 - User interface aesthetics; G_6^4 - Accessibility);
5. K_5 – Reliability (G_1^5 - Maturity; G_2^5 - Availability; G_3^5 - Fault tolerance; G_4^5 - Recoverability);
6. K_6 – Security (G_1^6 - Confidentiality; G_2^6 - Integrity; G_3^6 - Non-repudiation; G_4^6 - Accountability; G_5^6 - Authenticity);
7. K_7 – Maintainability (G_1^7 - Modularity; G_2^7 - Reusability; G_3^7 - Analysability; G_4^7 - Modifiability; G_5^7 - Testability);
8. K_8 – Portability (G_1^8 - Adaptability; G_2^8 - Installability; G_3^8 - Replaceability).

The second group includes evaluation criteria that take into account the specific operation of AIS. For example, the following criteria for decision making in the financial industry are: the cost of the product; analysis of cash flows; analysis of company solvency; analysis of financial results and others. The problem of choice is as follows: to choose the best alternative from the set X when known at this set of evaluation criteria. That is, to evaluate the effectiveness of the proposed set of AIS and to choose the best. Model problem can be presented in tabular form (Table 1.).

Table 1. Table of assessments by criteria

	x_1	x_2	$\cdots$	x_n
K_1	O_{11}	O_{12}	$\cdots$	O_{1n}
K_2	O_{21}	O_{22}	$\cdots$	O_{2n}
$\vdots$				
K_{p-1}	O_{p-11}	O_{p-12}	$\cdots$	O_{p-1n}
K_p	O_{p1}	O_{p2}	$\cdots$	O_{pn}

Or as a matrix of solutions:

$$O = (O_{lj}),\ l = 1, \ldots, p;\ j = 1, \ldots, n; \quad (1)$$

where O_{lj} – is the assessment of j alternative by l criterion. Each column of the matrix – is a vector of assessments, which characterizes the alternative, and each line of the matrix is a criterion. $O_{p1}, O_{p2}, ..., O_{pn}$ – are aggregated assessments of alternatives for a concrete area of AIS functioning.
Set the problem of selection consists of 3 stages [4]:
1). On the first stage of problem solution, we have to find the aggregated assessments of $O_{p1}, O_{p2}, ..., O_{pn}$ alternatives including the specifics of AIS decision-making area functioning and its security;
2). On the second stage we have to find the aggregated assessments of each fixed criteria group;
3). On the third stage, with all the criteria by evaluating alternatives, build a ranking range for the decision matrix (1).
On the first stage of problem solution find aggregated assessments of $O_{p1}, O_{p2}, ..., O_{pn}$ alternatives including the specifics of AIS area functioning by the set of criteria $K_p = \{K_1^p, K_2^p, ..., K_m^p\}$. The model of such problem can be presented in tabular form (Table 2).

Table 2. Table of alternative assessments by criteria including the AIS functioning area.

	x_1	x_2	$\cdots$	x_n
K_1^p	H_{11}	H_{12}	$\cdots$	H_{1n}
K_2^p	H_{21}	H_{22}	$\cdots$	H_{2n}
$\vdots$				
K_m^p	H_{m1}	H_{m2}	$\cdots$	H_{mn}

Or as a matrix of solutions:

$$Z = (H_{ij}), i = \overline{1,m};\ j = \overline{1,n}; \quad (2)$$

Where H_{ij} – is the assessment of j-alternative by i-criterion.

The construction of aggregated assessments $O_{p1}, O_{p2}, ..., O_{pn}$ on the basis of solutions matrix (2), we complete as follows.
1 step. Assessment rationing of the Z matrix of solutions.
These estimates are built by expert, they carry subjectivity and uncertainty and can be quantitative and qualitative.
If the assessments are quantitative then for their general comparison we normalize then in a set of a power unit [5].
In a case, when the criteria has qualitative assessments, then we have to build a term-set by its usage: $K_i = (a_i^1, a_i^2, ..., a_i^l)$, where a_i^k – is a κ component of linguistic term-criterion $K_i, i = \overline{1,m}.$
The fuzzy term-sets, for example, can consist of three terms: <bad criterion indicator> (B), <the criterion indicator is fine> (F), <good criterion indicator> (G), then the term-set is as follows: $U' = (B, F, G)$.

Each linguistic term a_i^k should be put in line spacing for normalized numerical values of the power unit. Then, a variable belonging to a particular of term can be defined as follows, for example: [0;0,4) – we refer to the term B; [0,4;0,8) refer to the F term; [0,8;1] – refer to the term G.

After the input fuzzy criteria assessments were standardized, that is presented in quantitative form for comparisons, thereby revealing their uncertainty, we proceed to the next step. Moreover, the matrix Z will be rewritten in the following matrix:

$$C = \left(C_{ij}\right), i = \overline{1, m};\ j = \overline{1, n}; \quad (3)$$

Where C_{ij} – is a normalized assessment of *j* alternative by *i* criterion.

2 step. Weight coefficients normalizing by criteria.

Let the expert can set weights to each criterion of efficiency $\{p_1, p_2, ..., p_m\}$ from [1;a] interval. Then, let us determine the normalized weight coefficients for each criterion [6]:

$$\alpha_i = \frac{p_i}{\sum_{i=1}^{m} p_i}, i = \overline{1, m};\ \alpha_i \in [0;1]; \quad (4)$$

Which respond to the $\sum_{i=1}^{m} \alpha_i = 1$ condition.

3 Step. Let us construct a aggregated assessment $O_{p1}, O_{p2}, ..., O_{pn}$.

For this we build membership functions as one of the bundle: pessimistic, cautious, moderate or optimistic. For example, the average convolution will look like:

$$\mu^3(O_{pj}) = \sum_{i=1}^{m} \alpha_i \cdot C_{ij},\ j = \overline{1, n}. \quad (5)$$

Once we get aggregated assessment of $O_{p1}, O_{p2}, ..., O_{pn}$ alternatives including the specifics of AIS area functioning, we proceed to the next stage of problem solution. Let us find the aggregated assessments of each fixed criteria group as follows. Let us present the criteria assessments by alternatives for each group in tabular form (Table 3).

Table 3. Table of alternative assessment by fixed criteria groups

K_g	x_1	x_2	$\cdots$	x_n
G_1^g	E_{11}^g	E_{12}^g	$\cdots$	E_{1n}^g
G_2^g	E_{21}^g	E_{22}^g	$\cdots$	E_{2n}^g
$\vdots$				
$G_{m_g}^g$	$E_{m_g 1}^g$	$E_{m_g 2}^g$	$\cdots$	$E_{m_g n}^g$

Where $\{G_1^g, G_2^g, ..., G_{m_g}^g\}$ is a set of g- group criteria of fixed criteria. E_{ij}^g - is an assessment of *j* alternative by *i* criterion of *g* group, *g* = 1, …, *p-1*; *j* = 1, …, *n*.

On the basis of such assessments, let us calculate the aggregated assessments of alternatives by criteria groups K_g. Without generality reducing we assume, that alternative assessments by E_{ij}^g (*g* =1, …, *p-1*; *j* = 1, …, *n;*) criteria are normalized. Otherwise, let us use the normalization methods given above. Let us evaluate aggregated assessments according to the formula:

$$O_{gj} = \frac{\sum_{i=1}^{m_g} E_{ij}^g}{m_g}, g = \overline{1, p-1};\ j = \overline{1, n}. \quad (6)$$

After receiving the aggregated assessments of alternatives by groups of criteria, we proceed to the third stage.

Let the expert for each group of criteria $\{K_1, K_2, ..., K_p\}$ sets weight coefficients $\{\overline{p_1}, \overline{p_2}, ..., \overline{p_p}\}$ from [1; a] interval. Then, analogically we determine the normalized weight coefficients for each criterion:

$$\overline{\alpha_l} = \frac{\overline{p_l}}{\sum_{l=1}^{p} \overline{p_l}}, \; l = \overline{1,p}\,; \; \overline{\alpha_g} \in [0;1]; \tag{7}$$

Which respond to the condition $\sum_{l=1}^{p} \overline{\alpha_l} = 1$.

To construct a ranking range of $X = \{x_1, x_2, ..., x_n\}$ alternatives, we set up the function of belonging as follows:

$$\mu^3(A_j) = \sum_{l=1}^{p} \overline{\alpha_l} \cdot O_{lj}\,, \; j = \overline{1,n}\,. \tag{8}$$

On the basis of $\mu(A_j)$ we build a ranking range of AIS functioning effectiveness:

$$A = (A_1, A_2, ..., A_n)\,. \tag{9}$$

Therefore, a method has been introduced, with the assistance of which we can build a ranking range of AIS alternatives for selecting the most effective alternative by a two-level set of criteria: The first level is a group of fixed criteria, based on standards, each of which is consists of its own set of criteria; The second level- is a group of criteria, which is built according to the area of AIS functioning.

4. CONCLUSIONS

Every day the IT industry increasingly develops, by producing a large number of modern technological solutions, which are presented in the form of automated information management systems and decision-making, Nowadays the right choice, among the large number of existing automated informational systems is a very urgent problem for any sphere of application. The right choice of effective AIS relies on the security of the company and its successful performance in different spheres. The result of this research is the evaluation model of efficiency development and the choice of automated informational systems of decision-making for security increase in the company functioning (activity). The creation of software, based on created mathematical model will allow companies to improve their own security when purchasing and implementing AIS decision-making (solutions).

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