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INFORMATION MODEL OF SYSTEM OF SUPPORT OF DECISION MAKING DURING MANAGEMENT OF IT COMPANIES

Abstract

An information model has been carried out, with the help of which it is possible to implement methods that ensure the growth of competitiveness of IT companies. Growth conditions for companies provide mergers and acquisitions (M&A). The analysis of the data obtained as a result of the P&L financial report is mainly based on current indicators and can be partially used to prolong economic indicators for a certain (most often limited) period. The authors propose using methods for assessing stochastic indicators of IT development processes based on the solution of a number of problems: (1) Development of models to assess the impact of indicators in the analysis of the financial condition of companies; (2) Creation of an information model and methods for processing current stochastic data and assessing the probability of the implementation of negative and positive outcomes.

1. INTRODUCTION

The development of information technology projects includes procedures based on a special project-driven approach to all stages of the project life cycle (Darnall & Preston, 2016). At the same time, such projects are among the most risky investments.

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The current business climate is characterized by continuous competition, profit-shifting and rapidly changing technologies. Moreover, the instability in the market of IT services is often caused by a random cause independent of enterprise management (Pagach & Warr, 2011). The use of mergers and acquisitions (M&A) to manage the market for services and production in the field of information technology can significantly stabilize the risks of financial investments in the IT market (What are the Main Valuation Methods?, 2019). One of the important components of mergers and acquisitions is a qualitative assessment of the value and condition of the company associated with the development of IT. The main objective of mergers and acquisitions is to increase the value of objects created by the company. At the same time, the cost of a business combination should be greater than the total values of the merger component. Violation of this rule is possible if the risk assessment of the state of companies is incorrect. Of course, first of all, from the indicators of the "value" of the company, it is necessary to determine its financial value and solvency. In this case, it is necessary to analyze simultaneously indicators that affect the financial condition. It is necessary to try to achieve the highest possible synergies (additional value resulting from M&A).

The solution of these problems is associated with the use of a more complex methodological database of data processing, a wide range of variables, the use of various models and algorithms for assessing values and costs (What are the Main Valuation Methods?, 2019).

However, even in this case, obtaining reliable estimates in the analysis of the data, provided that there are a large number of different factors, may be questioned in connection with the stochastic nature of the input data. It is in connection with the above that a number of important scientific and technical problems can be distinguished that can be solved by combined methods of mergers and acquisitions and methods of assessing the probability of occurrence of consequences from mergers and acquisitions.

2. GENERAL REPRESENTATION OF MODELS AND METHODS FOR ASSESSING THE STATUS OF IT COMPANIES

To solve the problems of assessing the status of IT companies, a simulation-stage modeling method is proposed, based on the sequential formalization of logical causal relationships of events that may be present in the structural model of the associated scenario development processes when introducing organizational, economic, technical and other solutions during the implementation of M&A.

Processes of mergers and acquisitions give rise to many technological, organizational, economic, psychological, informational events that can lead to both positive and negative consequences. The main task of modeling is to select such solutions, leading to an integrated positive effect. For effective modeling, it is proposed to create a set of models that meet the following requirements:

– normative – from the reference (description of the class of the object) to a specific object;
– dynamic (imitation);
– material and procedural;
– stochastic and substantial.

When solving the problems of simulation-step-by-step modeling, M&A processes are combined with methods of rationalizing company resources according to their importance (economic effect). The authors propose the introduction of a hybridization of ARIS (Architecture of Integrated Information System) and structural modeling methods of the IDEF class and the principles of ABC analysis (Ultsch & Lötsch, 2015; Kringel et al., 2017; Iovanella, 2017; Pawelek, Pociecha & Baryla, 2017).

Structural methodologies are represented by the following models:
– Function Modeling – functional modeling using graphical tokens IDEF0 combining a set of interconnected functions (blocks). Typically, IDEF0 is used in the first step in the analysis of any structured system. This method is the next stage in the development of the well-known language for the description of functional systems SADT (Structured Analysis and Design Technique) (Draft Federal Information Processing Standards Publication 183, 1993);
– Information Modeling – IDEF1 modeling of information flows inside systems, allowing to display and analyze their structure and mutual relations. IDEF1 Extended – Data Modeling – database modeling methods based on the entity-relationship model. The IDEF1 method allows you to build a structural data model equivalent to the relational model in the 3rd normal form. IDEF1X diagrams are used by many CASE tools (in particular, ERwin, Design/IDEF) (Draft Federal Information Processing Standards Publication 184, 1993).
– Process Description Capture (documentation of technological processes) – methods for documenting processes that occur in a system or projects that describe the scenarios and logical sequence of operations for each important process or event. IDEF3 has a direct investigation sequence associated with IDEF0 so that each function can be decoded in the form (protocol) of a separate IDEF3 process;
– Object-Oriented Design – the methodology for building object-oriented systems (IDEF4) is proposed to be replaced by the methods of "fault trees" (FTA) (IEC 60300-3-9:1995; SS-IEC 1025:1990);
– Ontology Description Capture – It is proposed to replace the standard of ontological research of complex systems (IDEF5 methodology) with the methods of "event trees" (ETA).

In parallel with structural modeling methods, you can use ABC analysis.

For each stage of the life cycle of companies, the development and combination of structural models of different levels and purposes is carried out. Their combination into one logical form makes it possible to create a digraph of the state of companies on the convolution / development of chains of the graph to the level of tree branches.

The general approach to simulation-stage modeling shown in Fig. 1.

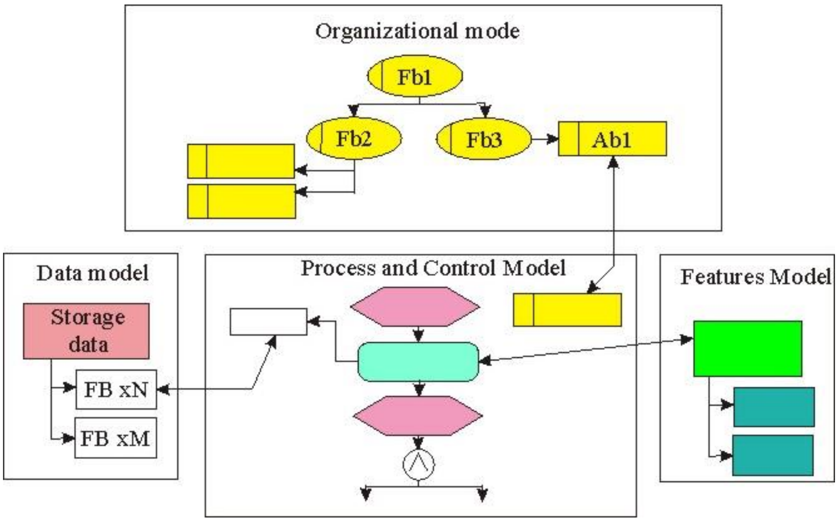

Fig. 1. Synthesis of the simulation-stage model

The following sequence is formed into a common integrated model: Organization chart (Organizational chat) ‖→ Function Tree ‖→ process / control models (diagram eEPC (extended Event driven Process Chain) → IDEF0 → IDEF1X → IDEF3 → FTA → ETA. In parallel, ABC analysis methods are being implemented to determine the financial consequences of structural events.

In the described structures:

– the IDEF0 model consists of sets of hierarchical linked diagrams. In the diagram, the blocks are combined by arcs (a subgraph of the functional model) and the output arcs of some blocks can be inputs of others. Arcs with one free end have a coil or a receiver outside the diagram. To determine the external arcs use the following notation: I (Input), C (Control), O (Output) M (Mechanism);
– the data is represented by a model of the IDEF1 Extended class in such a way that all input data and output variables must be normalized and fully defined in other models;
– IDEF3 – models are used to document technological (information) processes where it is important to take into account the sequence and logical direction of the process.

The development of a simulation-stage model (SSM) of the studied companies, in contrast to the existing methods of discrete-event modeling, allows one to take into account causal relationships between events and processes that are stochastic. The simulation-stage model allows you to analyze the probability of the implementation of events and processes, and also, thanks to the step-by-step examination of these processes, take into account the dynamic characteristics.

First, based on the analysis of event and process structures, experts formalize and link cause-effect chains of events of the SSM model in the FTA format, using the top-down analysis method. The number of "failure trees" reflects the complete set of events that have consequences ("upper events", for example: implementation of development at a given time).

The top event can be either a specific achievement with a positive effect, or the failure of this achievement. The difference in this case is the probability of failure P_f, or the probability of success $Ps = 1 - P_f$.

For each "fault tree" reaching the "upper event", one can concatenate this event as the initial condition of the "event tree". Starting with the initiating event, the binary branching of the "tree of events" is built, which reflects the logic of the development of various scenarios, taking into account stochastic indicators and the effectiveness of the means of influence (decisions). In this case, scenario analysis branches are formed by an upward analysis, which result in positive or negative consequences.

Integral indicators of risk that are created by various scenarios include:

1. The probability of negative development scenarios (total n), which are due to *j*-processes of *i*-solutions:

$$P_t^n = \sum_i \sum_j P_{ij}^n \tag{1}$$

2. The probability of a positive development scenarios (total p):

$$P_t^p = 1 - P_t^n \tag{2}$$

3. Expected total loss:

$$ED = \sum_i \sum_j P_{ij}^n \cdot Us_{ij} \tag{3}$$

where: P_{ij}^n – the probability of implementing the *j*-th negative scenario that occurs when making the *i*-th decision; Us_{ij} – loss from the *j*-th process of the *i*-th solution.

4. Expected total profit:

$$EP = \sum_i \sum_j P_{ij}^p \cdot In_{ij} \tag{4}$$

where: P_{ij}^{p} – probability of implementation of the *j*-th positive scenario, which is realized when the *i*-th decision is made; In_{ij} – profit from the *j*-th process of the *i*-th solution.

To determine an acceptable level of risk, an overall expected effect is proposed. That is, if the sum of the expected damage and the expected profit is positive, then consider that the overall risk as such does not pose a threat. However, if the expected total income is less than that obtained before the introduction of mergers and acquisitions, this confirms the assumption that such procedures do not make sense (more harmful).

An assessment of the risk of financial consequences is determined on the basis of an analysis of their likelihood, as well as anticipatory risk actions in the company and the restoration of positive processes.

3. INFORMATION MODEL OF EVALUATION OF THE PROBABILITY OF EVENT DEVELOPMENT IN IT COMPANIES

Support for solutions that are optimal in the sense of Pareto is based on the likelihood of implementing scenarios for the development of IT companies in situations of conflict and uncertainty. By "conflict" is meant the competitive development of various indicators (positive and negative, profit and loss) of the current state of the analyzed objects.

In this case, the risk is considered as the occurrence of certain events with a certain probability. Moreover, all events can be quantitative (for example, cost) or qualitative (for example, permissible, unacceptable) indicators.

Using the concepts of game theory, the state of the analyzed objects was presented as a matrix of possible states obtained on the basis of event trees. Each strategy Sj, represented by a proposed or predictable set of impacts on an object, is evaluated either quantitatively through profitability or loss indicators, or qualitatively by characteristic indicators of levels of positive or negative consequences. At the same time, mixing ratings is unacceptable.

To determine the quantitative values of the probability of initiating events that determine the initial state of the subsystem, FTA analysis methods were implemented, and to determine the development of scenarios of probable results, it was used in the upward ETA analysis.

The above is implemented by formatting information and data conversion processes in such a way that:

- to obtain criteria parameters of limiters of risk indicators;
- evaluate current indicators of risk due to processes within the companies under study;

– establish a correspondence between risk indicators and input events of influence on the state of companies and state changes in connection with disturbances;
– determine the set of scenarios of events taking into account the probability of occurrence of x conditions;
– determine the impact of events that constitute a negative scenario;
– analyze the cause-and-effect processes of the emergence and development of scenarios and identify the many solutions leading to this, for the analysis of solutions that can increase the positive effect of mergers and acquisitions;
– perform the search process for Pareto optimal solutions based on risk indicators and economic consequences, and determine the set of optimal solutions.

In structural step-by-step modeling, chains of a state graph are formed and separated that simulate scenarios of the occurrence and development of events, for which it is possible to determine the consequences taking into account the probability, which is mathematical modeling of stochastic processes.

Each chain that is defined is directional, connected, fully defined, eulerian and allows you to get all the risk indicators. The sets of chains intersect with the subsets of states and form parts of the graph indicated in formula 5.

The synthesis of the simulation-stage model is implemented by connecting the input and output parameters at the nodes of the chain of cause-effect relationships. The harmonization of information presentation formats is ensured through a structured presentation of data presented in xml format.

The synthesis mechanism proposed in the work allows combining the logical modeling of events and processes and the modeling and analysis of economic indicators into a single information technology. This technology, unlike the existing ones, allows you to use a simulation-stage model of the state of companies and introduce consistent calculations to determine the integrated risk indicators, and analyze these events to determine and comparative analysis of the consequences.

4. MATHEMATICAL MODEL OF PRACTICAL EVALUATION OF COMPANIES

The generalized mathematical model of the yaw assessment is based on the specific processing of data represented by a tuple:

$$MTR = \langle Ep, R.Inv, M_n, M_p \rangle \quad (5)$$

where: $Ep = \{ep_j\}$ – many events occurring in companies; $R = \langle \vartheta, P, D \rangle$ – tuple of risk specific to the processes under consideration; $Inv \subseteq W(O) \times P$ – correspondence between input events and the probability of transition to different states by impact; $M_p = \{mp_z\}$ – many positive consequences of the development of events $z \in 1 \ldots A$ in monetary terms; $M_n = \{ma_c\}$ – many negative consequences in monetary terms.

The task is formalized as follows:

The risk function has the form:

$$R = \langle \vartheta, P, D \rangle \quad (6)$$

where: ϑ – many influences that defines scenarios; $P = [P_n, P_p]$ – set of probabilities of possible consequences (negative and positive);

Let n companies that have *i* states be considered, then for any *i*-th state the risk D of consequences is determined: $R_i = \langle \vartheta, P, D \rangle_i$.

Believed to be known:

– deterministic models of the development of processes that can lead to the *i*-th state:

$$Fne_{ij}: \overrightarrow{S_{ij}} \rightarrow \overrightarrow{\Phi_{ij}}, j = 1 \ldots J \quad (7)$$

where: j – (a set of elementary events leading to certain states), $\overrightarrow{S_{ij}}$ – vector of parameters that defines the initial state for the *j*-th event; $\overrightarrow{\Phi_{ij}}$ – vector of phase variables of elementary processes in the system that may occur in the *i*-th state;

– model for assessing the probability of the development of stochastic elementary events: $Pa_{ij}: (\vec{S}, \vec{\Phi})_{ij} \rightarrow \overrightarrow{P_{ij}},\ j = 1 \ldots J,$ where $\overrightarrow{P_{ij}} = \left[P_{ij}^{p}, P_{ij}^{n}\right]$ – vector of probabilities of positive and negative consequences.

The model of determining the influence of events on the state of the system from decisions made to analyze and predict economic consequences containing:

– model for assessing the probability of occurrence of rare events in the *i*-th system in the form FTA (total *k* trees)

$$\gamma_k: \left(\{\overrightarrow{P_{ij}}\}, \overrightarrow{P_{ki}}\right) \rightarrow \overrightarrow{P_{ki}}, \quad (8)$$

– model simulating the development of events in the form ETA

$$\mu_k: \left\{\left(S, \Phi, \overrightarrow{P_k}\right)_i, \overrightarrow{\vartheta_k}\right\} \rightarrow M_{ki} \quad (9)$$

where: $S_i = \{\overrightarrow{S_{ij}}\}$, $\Phi_i = \{\overrightarrow{\Phi_{ij}}\}$, M_{ki} – integral indicators of profit from the *k*-th state of the scenario.

The total set of FTA and ETA associations for all *i*-subsystems of the companies under investigation, as well as indicators of expected loss and profit can be represented by a generalized graph *MTR*. The graph is subject to analysis and processing of indicators to search for branches of scenarios and assess their consequences. This is the basis for a comparative analysis when making decisions optimized in the Pareto sense for multicriteria indicators.

Models of the final scenarios of accident development are based on mathematical modeling of sequential processes and events and are contained in the state graph by setting up a serial connection of input and output events, which are determined by experts. Moreover, the graph chains have weight indicators that reflect the level of stochasticity of certain events. It should be noted that the different goals of the processes in multi-parameter estimates are directed in different directions. In this regard, it is necessary to apply methods of distributing the importance of various sinks of events for the benefits that are established by experts and make up the meaning of Pareto optimization as a sequence of dominant decisions.

The task for optimization according to many criteria is considered as an optimization problem at the same time for all isolated criteria. Searching for a set of solutions $\vec{x} \in X$, such that are minimized by all these criteria in a sense. That is, we consider a sequential optimization problem corresponding to the conditions: $g^{(k)}(x) \to min, k = \overline{1, N}$, on condition $x \in X$. In this case, the criteria $g^{(k)}(x)$ there are *partial criteria*. Their sets can be considered "vector criteria" $G(\vec{x}) = \left(g^{(1)}(\vec{x}), \dots, g^{(N)}(\vec{x})\right)$ which are subject to optimization for the benefits of components established by experts.

4. CONCLUSIONS

As a result of the research, a mathematical information model and methods for analyzing the stochastic and determinate components of the risk of consequences that affect events on the development of the life cycle of the development of IT companies were developed and agreed. These methods are based on the construction of a directed graph with sequences of logical cause-effect relationships of initial and subsequent events and influences.

The mathematical model is proposed for processing information flows that reflect the state of IT companies. The model takes into account the probability of the development of positive or negative consequences of decisions. The novelty of this approach lies in the proposed mechanism for the joint use of FTA and ETA, as well as a comparative analysis of the expected extent of the consequences. Unlike existing information models for analyzing the state of IT companies, this model takes into account stochastic characteristics of processes that have a significant impact on the consequences of decisions regarding mergers and acquisitions.

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