SWOT-analysis of digital technologies for an industrial enterprise

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Abstract. In the article, methods of SWOT-analysis of digital technologies for industrial enterprises are considered. It is shown that existing methods have disadvantages associated with obtaining objective and reliable expert estimates. To solve this problem, an approach is proposed to implement the idea of SWOT-analysis of technologies. This approach is based on the theory of system regularity and information assessments of A. A. Denisov. The research found that idea of SWOT-analysis of technologies that is based on the theory of system regularity and information assessments of A. A. Denisov, has a number of advantages, such as a convenient processing of estimates, the ability to combine probabilistic estimations with quantitative deterministic characteristics, which contributes to an increase in objectivity and reliability of estimates. Furthermore, it allows, based on changing measured deterministic parameters, to obtain the dynamics of changes in the degree of influence of sub-goals, factors, and means for the realization of the objectives of the enterprise.

1. Introduction

The purpose of the work is to develop a method for implementing the idea of SWOT analysis of digital technologies on the basis of regularities in the theory of systems and the information approach of A. A. Denisov.

The subject of the study is the methods for evaluating digital technologies for an industrial enterprise.

The innovative development of an industrial enterprise is the basis for the implementation of the economic policy of the state [1]. At the present stage, the most significant factor in the development of the national economy are the innovative technologies of the third industrial revolution proposed in the works of D. Rifkin [2] and the fourth industrial revolution proposed in the works of K. Schwab [3]. In Russia the Decree of the President of the Russian Federation “About the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030” is a guide for the introduction of new technologies. The Strategy defines the tasks, objectives and measures for the implementation of Russia’s foreign and domestic policies in the field of the application of communication and information technologies [4].

SWOT analysis of technologies in these sources is not considered, however, K. Schwab analyzes positive and negative effects in the development of technologies. There are various methods for conducting SWOT-analysis in textbooks on strategic management [5] and production planning [6]. As will be shown below, these methods have a significant disadvantage, namely, the problematic of obtaining reliable expert estimates, as well as their processing. To solve this problem, it is proposed to
use SWOT-analysis with the application of the regularities of the theory of systems and information estimates of A. A. Denisov [7].

The topic of the article is relevant, because during the introduction of innovations in the enterprise, a thorough analysis of the proposed innovations is required. There are various techniques for the analysis, including SWOT-analysis. However, none of the considered methods of conducting SWOT-analysis allows to guarantee obtaining reliable estimates from experts in the conditions of an industrial enterprise. Therefore, the author proposes a technique for conducting SWOT-analysis using the regularity of the theory of systems.

2. Overview of SWOT-analysis methods
SWOT-analysis using SWOT diagrams or matrices are a key part of any planning activity of an organization.

SWOT is an abbreviation of strengths, weaknesses, opportunities, and threats. Strengths and weaknesses are internal factors, and opportunities and threats are external. SWOT-chart (scheme) allows analyzing an innovative project, taking into account every factor on which the development of the organization depends. The information field of SWOT-analysis can be formally represented in the following form:

\[ I = <S, W, O, T> \]  

(1),

where \( S \) is the set of information related to the field of strengths, \( W \) is the set of information relating to the field of the weaknesses, \( O \) is the set of information related to the opportunity field [8].

To implement the SWOT-analysis there are different approaches, the most preferable are the “assessment-importance” method [9] and the “portfolio analysis” method [10].

2.1. The “assessment-importance” method
The following notations are used in the “assessment-importance” method: \( S \) – strengths, \( W \) – weaknesses, \( O \) – opportunities, \( T \) – threats. Assessments: \( Z \) – assessment, \( P \) – importance for us, \( V \) – significance (calculated as \( Z \ast P \)).

Each factor is evaluated taking into account its importance \( V \) – an assessment of its importance in the implementation of technology.

For each of the fields of the matrix SWOT, the arithmetic mean of \( U \) is output. The introduction of these assessments allows, among other things, to display in the diagrams the significance of strengths and weaknesses, opportunities and threats, compare them among themselves and visually assess the attractiveness of the starting position when implementing technology.

2.2. The “portfolio analysis” method
The method provides logical structuring and visualization of information about the problem, the relative simplicity of the presentation of results when using qualitative analysis criteria [10]. The method is based on the construction of two-dimensional matrices, one axis of which fixes the values of internal factors (assessment of the competitiveness of organizational departments), on the other – external (assessment of the prospects for market development). Using these matrices, organizations can be compared against each other for a number of SWOT-analysis criteria. The most famous and universal is the matrix of Ackoff [11]. The next stage in the development of portfolio analysis was the work of Bruce Henderson. In the future, on the ideas of the BCG matrices, three-dimensional matrices [12] are proposed, whose axes form complex indicators: the attractiveness of the market for the organization, the competitive position of the enterprise, the competitiveness of the product.

The main disadvantage of the SWOT-analysis methods considered is the impossibility of taking into account the space of goals and functions of the enterprise. Obtaining objective and reliable estimates is impossible. It is also impossible to find qualified experts who are able to estimate the factors of analysis by such methods.
Obtaining objective and reliable estimates is a problem. To solve the problem, it is proposed to use methods of system theory, system analysis and a combination of these methods.

3. The method of SWOT analysis taking into account the regularities of the theory of systems
For the SWOT-analysis, it is proposed to use the regularity of communicativeness [13] and using this technique based on the concept of the system, taking into account the environment and goal setting [14]. The method is based on the definition of V. N. Sagatovsky's system [15]. According to this methodology, the sub-objectives of the system under investigation are formed, initiated by the requirements and needs of the environment, which influences the production of the end product of the system. It is proposed to apply the first sign of the structuring of this methodology – the “goal initiation space” – when researching sources of digital technology assessments for an industrial enterprise.

The basis for the decomposition of the system based on the “space for initiating goals” (figure 1) is the regularity of communication (dividing the complex environment into the super system, the subordinate systems, the actual environment, and the internal environment – the system itself, which is constantly changing in the developing system).

![Figure 1. The space for initiating goals.](image)

To select and evaluate technology for an industrial enterprise, it is proposed to use the Presidential Decree “About the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030”. The Strategy defines tasks, goals and measures for the implementation of Russia’s foreign and domestic policies in the field of the application of communication and information technologies. These technologies are aimed at three branches:
- on the formation of the national digital economy
- on the development of the information society
- on the implementation of strategic national priorities and ensuring national interests [4].

For an industrial enterprise, the strategy involves the following technologies:
1) creation of new generation communication networks and convergence of communication networks;
2) artificial intelligence;
3) processing large amounts of data;
4) trusted technologies of electronic authentication and identification;
5) cloudy and foggy calculations;
6) robotics and biotechnology;
7) industrial Internet and Internet of things;
8) information security;
9) electronic component base and radio engineering.

To evaluate the proposed technologies for the enterprise, it is proposed to use the following scale:
1 – technology is included in the strategy of the president of the Russian Federation,
0 – technology is not part of the strategy of the Russian president.

The obtained estimates refer to the super system, because the super system forms the main requirements for the final product.

The next step in technology assessment is the analysis by K. Schwab [3]. K. Schwab explores and analyzes the technologies of the fourth industrial revolution. Of the 23 technologies offered by the author, it is proposed to allocate the following digital technologies for an industrial enterprise:
• Distributed Computing;
• “Big Data” for decision making;
• Artificial Intelligence and Decision Making;
• 3D printing and 3D production.

The method of technology evaluation by K. Schwab suggests the following. A positive effect, a negative effect, an indeterminate or simultaneous positive and negative effect and a profound change in action are determined. According to this factor, data is proposed to be entered into the SWOT-table for further analysis.

The considered method of K. Schwab's estimation refers to the actual environment that relates to the production of the final product of the system under investigation, i.e. to the analysis of sources of technology assessments.

The latest stage of the SWOT-analysis is to use information assessments by A. A. Denisov, which offers the basics of analysis of heterogeneous systems of arbitrary structure, based on a consistent dialectical disclosure of the material and information dualism of all that exists. The author considers the approach and method for further independent systemic knowledge of the world [16].

The basis for information assessments is based on 3 models.

The application of information models of the first type is based on an assessment of the degree of technology influence on the implementation of the enterprise's objectives in the analyzed period of development. In accordance with the information approach, assessments of the degree of feasibility \( p' \) (i.e. the probability of achieving the goal) and the probability of using \( q \), are introduced to evaluate each technology and the potential \( H \) (significance) of the technology is calculated as:

\[
H = -\sum_{i=1}^{n} q_i \log(1 - p')
\]  

Information models of the second type are based on a comparative analysis of complex systems during a certain initial period of their design (implementation, development) by comparing the changes in information assessments in time. At the same time, assessments are received from individual experts competent in the relevant field of activity of the enterprise. When applying information models of the second kind, based on a comparative analysis of complex systems during a certain initial period of their design by comparing the change in information estimates in time, two methods of measuring \( H_i \) are used:

1) through the probability \( p_i \);
2) through deterministic characteristics of perceived information.

The latter method includes two approaches.

In static at some point in the introduction of technology (taking the average arithmetic averaging \( \gamma = 1 \)).

\[
H_i = J_i / n_i
\]  

\( J \) – information on the number of innovations, measured in relative units, i.e.

\[
J_i = A_i / \Delta A_i,
\]  

where \( \Delta A_i \) – is the minimum number of technologies of the \( i \)-th type, which defines the unit of measurement [17].

Models of the third type describe the assessment of situations described by information equations taking into account the mutual influence of technologies:

\[
H_1 = f(H_{11}, H_{12}, H_{13}),
\]

\[
H_2 = f(H_{21}, H_{22}, H_{23}),
\]
\[ H_3 = f(H_{31}, H_{32}, H_{33}) \]

- the importance of the 1st, 2nd, 3rd, etc. technologies,

- the intrinsic importance of technology in the absence of other technologies that affect its value,

- the change in the value of \( i \)-th technology in the presence of the \( j \)-th technology on the market [18].

Information assessments Denisov's allow to carry out technology assessment at the subsystem level and the system itself, the sub-goals of which are initiated by their own (internal) needs, motivations and programs constantly arising in the developing system [19].

The advantage of information assessments is that information evaluations provide convenient processing of estimates, the ability to combine probabilistic estimations with quantitative deterministic characteristics, which contributes to an increase in objectivity and reliability of estimates. In addition, it allows, on the basis of changing measured deterministic parameters, to obtain the dynamics of changes in the degree of influence of sub-goals, factors and means for the realization of the objectives of the enterprise (organization) [20].

The results of the obtained estimates are recommended to be presented in the form of histograms for further processing.

4. Conclusions

In the course of the work, a method for SWOT-analysis of digital technologies for an industrial enterprise was proposed. The method is based on the regularities of the theory of systems, the technique of structuring the “space for initiating goals” and the information approach to the analysis of the systems of A. A. Denisov. The analysis of technologies of the fourth industrial revolution, as well as the “Strategy for the development of the information society in the Russian Federation for 2017–2030” was conducted. The proposed method makes it possible to take into account various sources of technology assessments and the purpose of the enterprise, which allows obtaining objective estimates for a specific enterprise in the relevant period of its development.

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