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Assessment of the Index of the Influence of External Factors on the Sales Activity of An Enterprise in the Information Society

Sergey Ivanov[1], Mykola Ivanov[2] and Nataliia Maksyshko[3]

Abstract

In the information society, one of the pressing issues today is management of sales activity. Due to this issue the construction and development of methods for assessing indices of the influence of external factors on the sales activities of an enterprise is actual problem which is considered in this article. To solve presented problem in this article is proposed method for assessing indices of the influence of external factors on the sales activities of an enterprise. This method include analysis of identify strengths and weaknesses, analysis of opportunities and threats for the enterprise with the construction of a cause-and-effect diagram. The result of the use of developed method is the possibility modeling the sales activities of an enterprise due to impulse influence on a weighted oriented graph, which made it possible to solve the problem of assessing the indicators of the influence of factors on the sales activities of an enterprise.

Keywords: *Economics, Sales Activities, SWOT Analysis, Cognitive Map Model, Weighted Directed Graph.*

INTRODUCTION

A number of works are aimed at studying the activities of enterprises and companies in the information society, which present the results of an analysis of the relationship between access to information and their use to achieve sustainable development in both the social and economic spheres of activity today are of great interest (Lucendo-Monedero et al., 2023). The authors of the work noted that the choice of indicators and indices in the methodology used can be applied to economic entities, including the viable system model (VSM). This solution will provide a good basis in the process of research and diagnosis of enterprises to survive and improve their efficiency in the information society (Lowea et al., 2020).

The Viable System Model (VSM) was first proposed by Stafford Beer (Beer, 1984), in which he presented how economic actors can adapt to the external environment using management principles. This method is also applicable in the information society. The proposed conditions for a viable system are valid not only for the work of organizations, but also for the state as a whole.

The widespread use of indicators covers all available economic data (Brás, 2023). Despite some limitations, the use of indices to assess the state of countries over time, gross national income per capita in current US dollars, NASDAQ Indices reflect conditions in the US high-tech markets and the reaction of the business community to the political and economic events of the country and others are relevant in the process management.

In a research paper (Muñoz et al., 2024), has received a new application for the index, which is the implementation of a circular economy measurement system designed to overcome the limitations and shortcomings inherent in existing indicators and indices. From a theoretical perspective, the methodologies proposed in this article not only provide discovery but also enable quantitative assessment. From a practical point of view, this article provides a reliable basis for assessing the performance of an economic entity and gives stakeholders the opportunity to monitor progress across multiple indicators. This comprehensive monitoring tool is vital for developing and improving enterprise strategy.

Research (Anjaria, 2024) has applied metrics and indices that have begun to improve the integration of sustainability capabilities in S-ERP systems. This use of indicators was the basis for analyzing and optimizing resources, as well as time spent on the sustainable operation of enterprises.

[1] Department of Economics, Zaporozhye National University, Zaporizhzhia, Ukraine, Email: flydaiver@gmail.com, (Corresponding Author)

[2] Department of Economics, Zaporozhye National University, Zaporizhzhia, Ukraine
[3] Department of Economics, Zaporozhye National University, Zaporizhzhia, Ukraine

In the studies conducted (Ivanov et al., 2021) discusses the use of indicators and indices when using neuro-fuzzy control systems as a tool for managing non-deterministic objects in real time. According to the proposed solution, in an automated real-time control system it is proposed to use a neuro-fuzzy control system depending on the object and the gear ratio of the system.
In addition, the measurement approaches under consideration showed existing gaps in assessing the index of the influence of external factors on the sales activities of an enterprise in the information society.
Purpose of the article. The article is devoted to the development of a methodology and assessment of the index of the influence of external factors on the sales activities of an enterprise in the information society.

Theory

The task of identifying factors that influence sales activities and their connections in the form of a weighted oriented graph is extremely important for the enterprise management process. It should also be said that the process of constructing a method based on the use of a weighted directed graph relates to cognitive modeling and requires new research. Thus, in cognitive modeling, cause-and-effect relationships are used, which are used to solve the problem of managing sales activities. Within the framework of this approach, the model will be represented through a set of vertices of a weighted oriented graph, where each vertex reflects the corresponding factor influencing the sales activities of the enterprise.
The following method is suggested the assessment of the index of the influence of external factors on the sales activities of the enterprise is presented in Fig. 1.

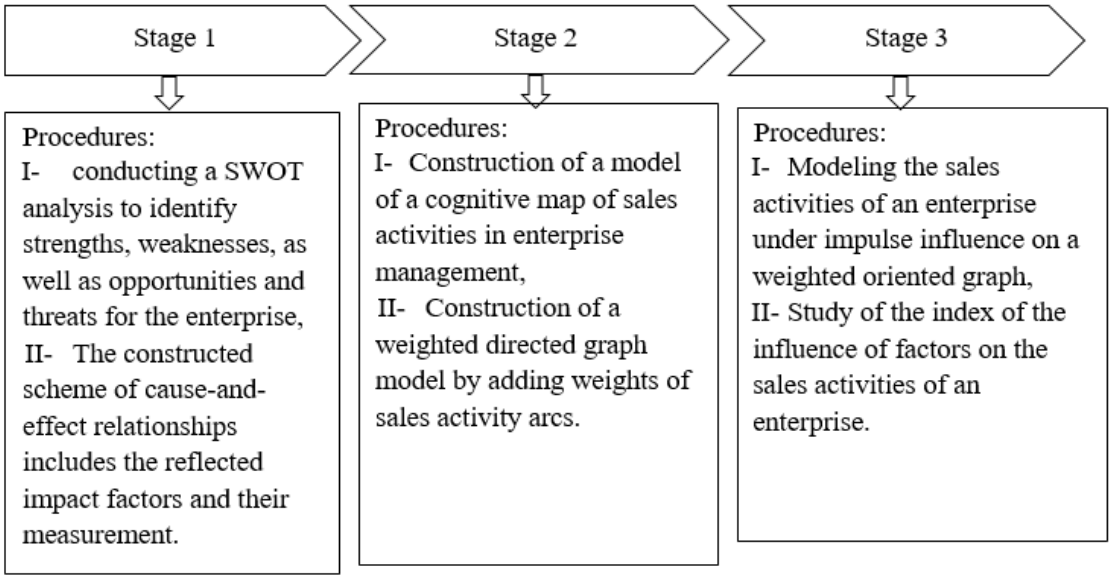

Figure 1. A method for assessing the index of the influence of external factors on the sales activities of an enterprise

Proposed the method includes three stages. At the first stage - analytical, the task of identifying factors that determine the strengths and weaknesses of sales activities is solved, as well as cause-and-effect their connections.
First (I) the procedure for analyzing the sales activities of an enterprise is based on conducting a SWOT analysis to identify strengths, weaknesses, as well as opportunities and threats for the enterprise. This SWOT analysis procedure allows you to identify the strengths, weaknesses, as well as opportunities and threats in the sales activities of the enterprise. The SWOT analysis method has also found application in research (Puyt et al., 2023).
The strengths of the enterprise (strengths (S)) include: the competitive environment (S1), the presence of replacement of goods (S2) and market segmentation (S3).
Weaknesses of the enterprise (weaknesses (W)): product reliability (W1), product quality (W2) and maintenance (repair) (W3).

Table 1: SWOT analysis of the company's sales activities

Strengths (S)	Weaknesses (W)
The competitive environment (S1) The presence of replacement of goods (S2) The market segmentation (S3)	The product reliability (W1) The product quality (W2) The maintenance (repair) (W3)
Opportunities (About)	Threats (T)
improving the quality of advertising work (O1) using digital marketing techniques (O2) expanding the circle of regular customers (O3)	decrease in sales volumes of goods (T1) decrease in enterprise efficiency (T2) decrease in production of goods (T3)

Enterprise capabilities (Opportunities (O)) define favorable circumstances that can be used to gain an advantage in the market, namely, achieve sales growth by improving the quality of advertising work (O1), using digital marketing tools (O2) and expanding the circle of regular customers (O3).

Threats to the company (Threats (T)) may include a decrease in the size of product sales (T1), a decrease in the efficiency of the company (T2), and a decrease in the production of products (T3).

It should be noted that opportunities from the point of view of SWOT analysis are not general existing opportunities, but only those that an enterprise can take advantage of to operate effectively.

To develop a marketing strategy to increase the level of sales activity, it is important to highlight the main connections between the factors of SWOT analysis, which can be done by constructing an adjacency matrix.

At the second step of the first stage of the method of cognitive modeling of the enterprise's sales activities, a matrix of SWOT analysis of the enterprise's sales activity is constructed (Table 2).

The matrix (graph adjacency matrix) indicates the most significant connections between the factors influencing sales activities, indicated by 1 or 0 in the case of the existence or absence of a connection, respectively. The resulting matrix allows you to identify important intersections of strengths and weaknesses of opportunities, as well as threats to sales management.

The constructed matrix forms squares as a combination of the following factors: "Strengths-Opportunities" (SO), "Strengths-Threats" (ST), "Weaknesses-Opportunities" (WO), "Weaknesses-Threats" (WT).

At the third step of the first stage, the most significant intersections of factors are analyzed.

At the same time, in the "Strengths-Opportunities" (SO) square, the intersections of the following factors are important:

S1O1 – improving the competitive environment will increase the sales activity of the enterprise by improving the quality of advertising;

S1O2 – improving the competitive environment will contribute to the sales activity of the enterprise through the use of digital marketing tools, in particular to expand the target market;

S2O2 – the presence of inter-product substitution necessitates the use of digital marketing tools, which will lead to an expansion of the target market and an increase in the sales activity of the enterprise;

S2O3 – the presence of inter-product substitution requires the enterprise to additional costs associated with expanding the circle of regular customers, which in turn is aimed at increasing the sales activity of the enterprise;

S3O1 – market segmentation is considered as a process of searching for optimal parts of the market in order to place goods taking into account the quality of advertising, which in turn is aimed at increasing the sales activity of the enterprise.

Table 2: Matrix of SWOT analysis of the enterprise's sales activity

		O			T		
		O1	O2	O3	T1	T2	T3
S	S1	1	1	0	1	0	0
	S2	0	1	1	0	0	0
	S3	1	0	0	1	0	0

W	W1	0	1	1	1	1	1
	W2	0	0	0	1	0	0
	W3	0	0	0	1	0	0

In the Strengths-Threats (ST) square, the intersections of the following factors are important:
S1T1 – underestimation of the competitive environment within the company can lead to a decrease in product sales;
S3T1 – dividing potential market users into different groups without taking into account their interests lead to a decrease in product sales.
In the Weaknesses-Opportunities (WO) square, the intersections of the following factors are important:
W1O2 – increasing the reliability of the product allows you to expand the target market by introducing digital marketing tools;
W1O3 – increasing the reliability of the product allows you to expand the circle of regular users.
In the Weaknesses-Threats (WT) square, the intersections of the following factors are important:
W1T1 – a decrease in product reliability reduces the company's sales activity;
W1T2 – low product reliability reduces the company's performance;
W1T3 – low product reliability leads to a decrease in product production;
W2T1 – a decrease in the quality of the product may lead to a decrease in sales of the product;
W3T1 – an increase in maintenance (repair) costs can lead to a decrease in product sales, which in turn will reduce the efficiency of the enterprise.
Based on the analysis of the squares of the SWOT matrix, four types of strategy can be proposed:
CO type strategies are development strategies that take into account the high level of the competitive environment and the availability of between commodity substitution, which leads to the need to use digital marketing tools to expand the circle of regular customers and search for optimal market segments in order to place goods on them;
ST type strategies are strategies aimed at minimizing the negative impact of the competitive environment through segmentation of regular customers in the market;
WO-type strategies take into account management weaknesses, namely, they are aimed at increasing the reliability of the product, which will expand the target market using digital marketing tools and the circle of regular customers;
WT type strategies are strategies built on restrictions that take into account product reliability, quality and additional costs to prevent a decrease in sales activity and the efficiency of the enterprise.
Second (II) the procedure is aimed at solving the problem of formalizing cause-and-effect relationships using a diagram Ishikawa. The resulting diagram of the cause-and-effect relationships of influencing factors with the sales activities of the enterprise.
The determination of the causes and effects in the diagram was carried out on the basis of analysis and expert assessment of the factors influencing sales activities. The constructed diagram of the cause-and-effect relationships of the enterprise's sales activities includes the reflected impact factors and their measurement, which is presented in Fig. 2.
As a result, the diagram (Fig. 2) shows the cause-and-effect relationships of influencing factors with sales activities, which affect the efficiency of the enterprise and its functioning. Factors influencing the sales activities of an enterprise are divided into the competitive environment, market segmentation, advertising quality, digital marketing tools and product quality. Each factor is represented by a corresponding assessment, which is made on the basis of expert analysis.

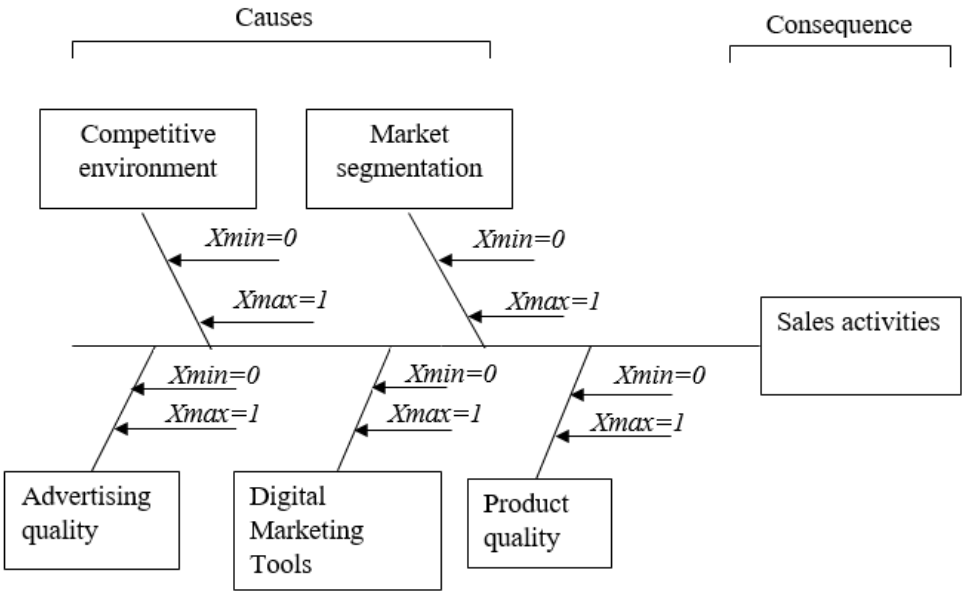

Figure 2. Cause-and-effect diagram of sales activities

At the second stage, model building, two procedures are performed. When executing pfirstvoy (I) procedures the results of changes in the value of sales activities (V6) are determined when influencing factors change: competitive environment (V1), market segmentation (V2), advertising quality (V3), digital marketing tools (V4), product quality (V5).

At the same time, management of sales activities is associated with determining the impact weights (V1-V5) of factors. Therefore, enterprise sales resource planning is based on the implementation of a model in the form of a cognitive map.

Unlike existing cognitive modeling approaches, the developed model is a weighted directed graph, the nodes of which correspond to the input influencing factors and sales activities of the enterprise. So, the developed model of a weighted indicative graph reflects not only the cause-and-effect relationship between influencing factors and sales activities, but also determines its weight.

The next step is to build a cognitive map. A cognitive map is a graph G=(V,W) containing a set of vertices *V*={Vi} and a set of edges reflecting connections between vertices..$W = \{w(u_i, v_j)\}$

Establishing a connection between the incoming (V1,...,V5) and output (V6) vertices allows us to build a cognitive map of sales activities in enterprise management in the form of a directed graph based on the adjacency matrix (Fig. 3).

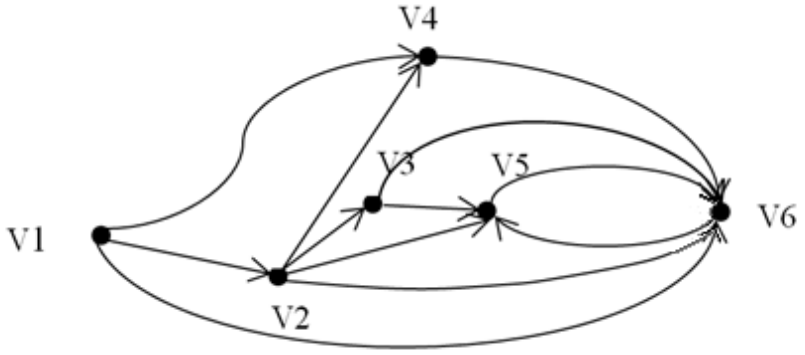

Figure 3. Model of a cognitive map of sales activities in enterprise management

Based on the developed cognitive map of sales activities (Fig. 3), an adjacency matrix C was constructed, where the matrix element stands at the intersection of the i-th row and the j-th column and characterizes the influence of a factor on a factor:$u_{i,j}$ $u_i v_j$

$$C = \begin{vmatrix} 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{vmatrix}.$$

RESULTS

However, the model of a cognitive map as a directed graph (Fig. 3) suggests that the influence of factors (vertices) on each other should be within the range [0; 1]. Consequently, this model can be considered as a structural model of the process of managing the sales activities of an enterprise.

The article proposes a method in which two procedures are performed at the third stage. As a result of the first (I) procedure, a model of a weighted directed graph is constructed. The result of the study of the model will be an assessment of the sales activities of the enterprise under impulse influence on a weighted oriented graph.

In the process of finding the shortest paths in a directed graph with negative edge weights, a model of an equivalent directed graph was built to study the cause-and-effect relationships of the influence of factors on the trading activities of an enterprise.

As a result of the second (II) procedure, a model of an equivalent directed graph with non-negative edge weights was constructed, which also made it possible to obtain an assessment of the indicator of the influence of factors on the sales activities of the enterprise. company.

To perform the first (I) procedure, the opinions of experts were taken into account when choosing the weights of the graph arcs, given in Table 3.

Table 3: Weight of arcs of a weighted directed graph

Arc	Weight	Experts' conclusions on the choice of weights
1	2	3
$(V_1^{\square}, V_2^{\square})$	+0.22	As market segmentation increases, the competitive environment will increase. According to expert data, the value will be +.0,22
$(V_1^{\square}, V_4^{\square})$	+0,41	As the competitive landscape increases, the influence of digital marketing tools will increase. According to expert data, the magnitude of the influence will be.+0,41
$(V_1^{\square}, V_6^{\square})$	-0.1	As the competitive environment increases, the company's sales activities are miniaturized. According to expert data, the magnitude of the influence will be. −0,1
1	2	3
$(V_2^{\square}, V_3^{\square})$	+0,6	As market segmentation increases, the quality of advertising will change. According to expert data, the value will be.+0,6
$(V_2^{\square}, V_4^{\square})$	-0.2	As market segmentation increases, the influence of digital marketing tools will change. According to expert data, the value will be.−0,2
$(V_2^{\square}, V_5^{\square})$	+0.15	As market segmentation increases, product quality will increase. According to expert data, the value will be.+0,15
$(V_2^{\square}, V_6^{\square})$	+0.15	With increasing market segmentation, the sales activities of the enterprise will change. According to expert data, the value will be.+0,15
$(V_3^{\square}, V_5^{\square})$	-0.25	As the quality of advertising increases, the quality of the product will decrease. According to expert data, the value will be.−0,25
$(V_3^{\square}, V_6^{\square})$	+0.55	As the quality of advertising increases, sales activities will increase. According to expert data, the value will be.+0,55
$(V_4^{\square}, V_6^{\square})$	+0.4	With the increasing use of social media, sales activities will change. According to expert data, the value will be.+0,4
$(V_5^{\square}, V_6^{\square})$	+ 0.3	As the properties of the product increase, sales activities will also increase. According to expert data, the value will be.+0,3
$(V_6^{\square}, V_5^{\square})$	−0.1	As sales activities increase, the quality of the product will also change. According to expert data, the value will be.−0,1

In Figure 4 shows a weighted directed graph model developed by adding arc weights to the model cognitive map of sales activities in enterprise management. The new model has the form of a directed graph with negative edge weights.

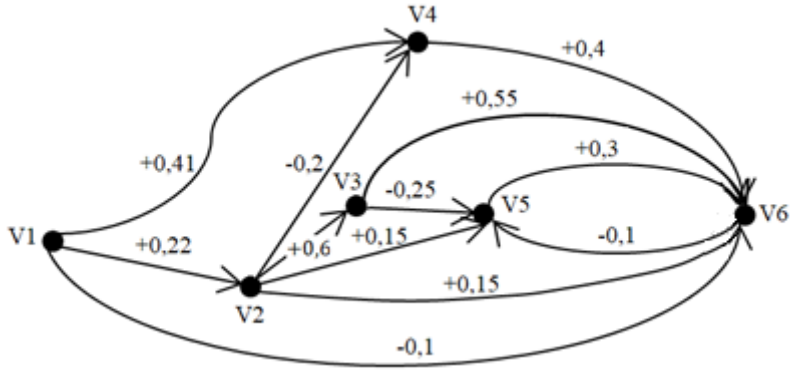

Figure 4. Model weighted directed graph

At the resulting stage of the first (I) procedure for modeling the sales activities of an enterprise with an impulse effect on a weighted oriented graph, a matrix of weights of the arcs of the oriented graph is constructed in accordance with the model of the weighted oriented graph (Fig. 4)

The arc weight matrix of a directed graph looks like this:

	V_1	V_2	V_3	V_4	V_5	V_6
V_1	0.0000	0.2200	0.0000	0.4100	0.0000	-0.1000
V_2	0.0000	0.0000	0.6000	-0.2000	0.1500	0.1500
V_3	0.0000	0.0000	0.0000	0.0000	-0.2500	0.5500
V_4	0.0000	0.0000	0.0000	0.0000	0.0000	0.4000
V_5	0.0000	0.0000	0.0000	0.0000	0.0000	0.3000
V_6	0.0000	0.0000	0.0000	0.0000	-0.1000	0.0000

The initial values of the parameters at each vertex of the directed graph shown in Figure 4 will be equal to 0. It is assumed that each vertex at discrete times t = 0,1,2,3,4,5 will acquire the value (t).

The value (t+1) is determined by the pulses and arc values of adjacent vertices at a given time t.

The change, called impulse, is specified by the difference in values at the i-th vertex: (t) - (t-1)), for t ≥ 0.$p_i(t)V_iV_i$

The change in values for an impulse process in a weighted directed graph looks like this:

$$v_j(t+1) = v_j(t) + \sum_{i=1}^{n} w(u_i, v_j)p_i(t), \quad (1)$$

where is the weight of vertex j at time$v_j(t)$,

$w(u_i, v_j)$ is the weight of the arc cat time t.u_iv_j.

Since the momentum is at the j-th vertex: then from expression (1) the value of the momentum can be written in the following form: $v_j(t+1) - v_j(t) = p_j(t)$

$$p_j(t) = \sum_{i=1}^{n} w(u_i, v_j)p_i(t). \quad (2)$$

In directed graph in Figure 4 shows the results of a study of the dynamics of five impulse processes, each of which begins regardless of the other at the vertices V_1, , …,V_2V_5 and the influence of impulses of influencing factors on sales activities in enterprise management is highlighted.

So, there are five vectors of initial impulses:

$$P_1(0) = (1\,0\,0\,0\,0\,0),$$
$$P_2(0) = (0\,1\,0\,0\,0\,0),$$
$$P_3(0) = (0\,0\,1\,0\,0\,0),$$
$$P_4(0) = (0\,0\,0\,1\,0\,0),$$

$$P_5(0) = (0\ 0\ 0\ 0\ 1\ 0).$$

The target task in each impulse process will be to determine the change in the level of sales activity of the enterprise at the top. The results of calculations of the dynamics of values at the vertex for various initial impacts of impulse processes are presented in Table. 4. determines the value of the impulse at the vertex at the moment t of the action of the impulse process with the beginning at the i-th vertex.$V_6V_6P_i(t)V_6$.

Table 4: Dynamics of the value at the vertex for different initial impact impulses

t	$V_1(t)$	$V_2(t)$	$V_3(t)$	$V_4(t)$	$V_5(t)$
0	0	0	0	0	0
1	-0.1000	0.1500	0.5500	0.4000	0.3000
2	0.1970	0.2950	-0.0750	0.0000	0.0000
3	0.0679	-0.0495	-0.0165	-0.0120	-0.0090
4	-0.0158	-0.0089	0.0023	0.0000	0.0000
5	-0.0020	0.0015	0.0005	0.0004	0.0003

The result of modeling the dynamics of the pulse at the vertex during a response pulse action is presented in Fig. 5.

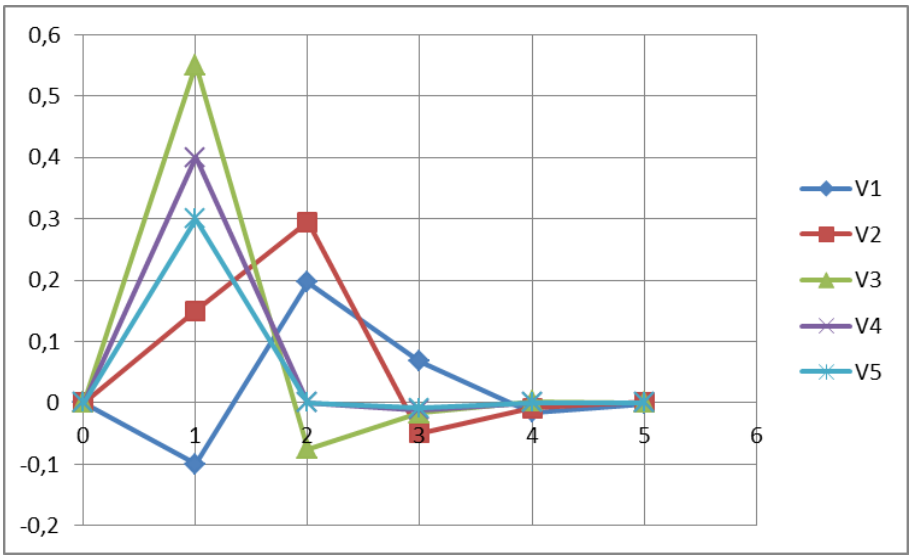

Figure 5. Modeling of the sales activities of an enterprise under impulse influence on a weighted oriented graph.

The result of calculations of the dynamics of the weight values at the vertex for various initial impulse impacts is presented in Table. 6, where it determines the value of the weight at a vertex at a moment in time as the influence of a pulse process starting at the i-th vertex.

Table 6: The result of calculating the values at the vertex for different initial impact impulses V_6

t	V_1 (t)	V_2 (t)	V_3 (t)	V_4 (t)	V_5 (t)
0	0	0	0	0	0
1	-0.1000	0.1500	0.5500	0.4000	0.3000
2	0.0970	0.4450	0.4750	0.4000	0.3000
3	0.1649	0.3955	0.4585	0.3880	0.2910
4	0.1491	0.3867	0.4608	0.3880	0.2910
5	0.1471	0.3881	0.4612	0.3884	0.2913

The result of modeling the dynamics of weight values at the vertex under impulse action is presented in Fig. 6.

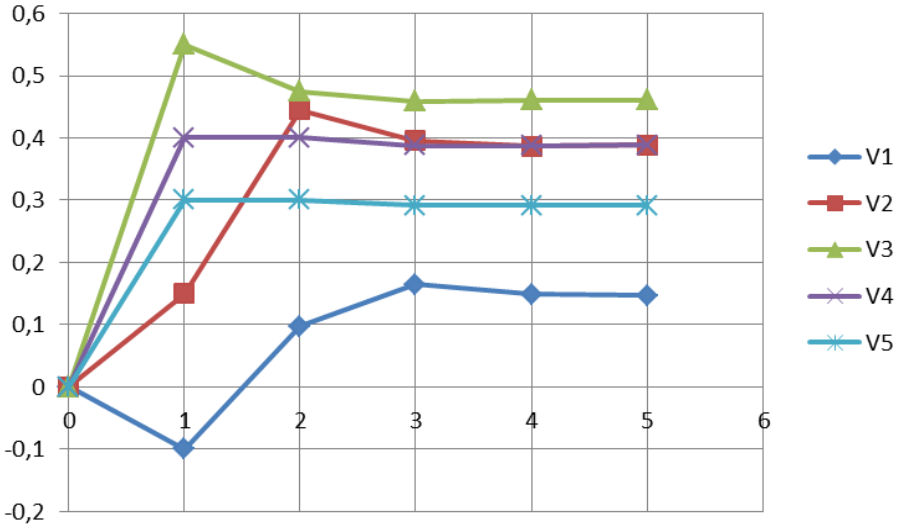

Figure 6. The result of modeling the dynamics of weight values at the vertex under impulse action

The next stage of the research is the process of modeling and determining the shortest paths in a directed graph with negative edge weights, which allows us to explore the cause-and-effect relationships of the influence of factors on sales activities. To do this, Johnson's algorithm was applied to find shortest paths in a weighted directed graph with negative edge weights. The job of an algorithm is to use algorithms Bellman Ford and Dijkstra's algorithm (Dinitz et al., 2017).

A distinctive feature of this algorithm is that the weights of the edges of a directed graph are changed in such a way that the specified vertices and edge weights are integral. Then we apply the well-known algorithm Dijkstra (Jasona et al., 2023) finding shortest paths in a weighted directed graph with integral edge weights.

In the process of changing edge weights in the algorithm, the following conditions must be met:

the shortest paths in the graph do not change, that is, for any pair of vertices, the shortest path for the original weight function W coincides with the shortest path for the new weight function;$S = \langle v_0, \dots, v_p \rangle u, v \in VW^0$,

all new edge weights obtained will be integral.$w^0(u, v)$.

So, Johnson's algorithm includes a way to change the edge weights using specified conditions.

For a directed graph with negative edge weight, construct an equivalent directed graph with a virtual vertex that has only output arcs with zero weight to all other vertices.$G^0 = (V^0, W^0)V^0$

Inputting a new vertex will not change the path in the new graph, since a vertex cannot be intermediate on any path since it has no input arcs. Therefore, this vertex can only be the initial vertex of the graph.V^0V^0

An equivalent model of a directed graph can be represented in this form (Fig. 7).

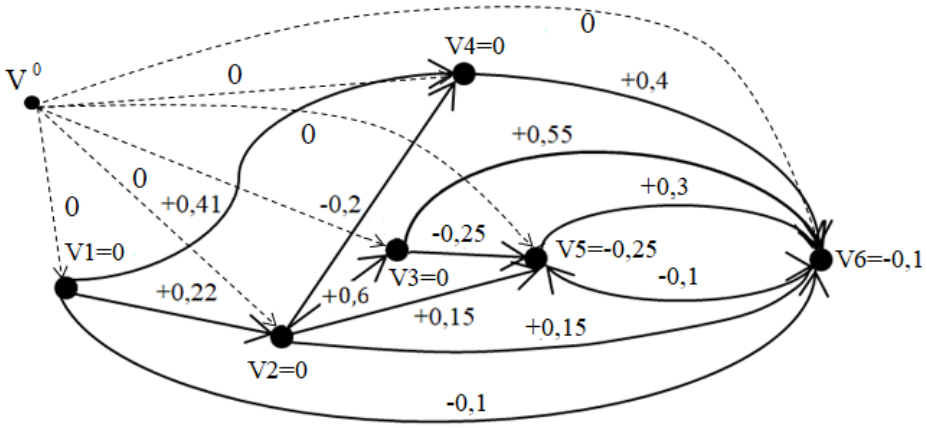

Figure 7. Model of equivalent directed graph

Then the weight of each vertex is equal to the weight of the shortest path to the vertex. $V_i S = \langle v_0, \ldots, v_p \rangle V^0$.

An approximate graph with calculated vertex weights will look like shown in Fig. 8.

Thus, the weight function of the edges W will coincide with the shortest path relative to the new function, where $W^0 w^0(u,v) = w(u,v) + q(u) - q(v) q(u)$ and – the value of the weights of the vertices and accordingly =0 ($q(v)uv$V1V6).

For all paths with a fixed start and end, the difference between the original weight and the new weight will be constant, and the new weight is the path with the maximum impact for the original weight function. To find the level of influence of factors on the sales function, we define the index of total influence as w_V^+.

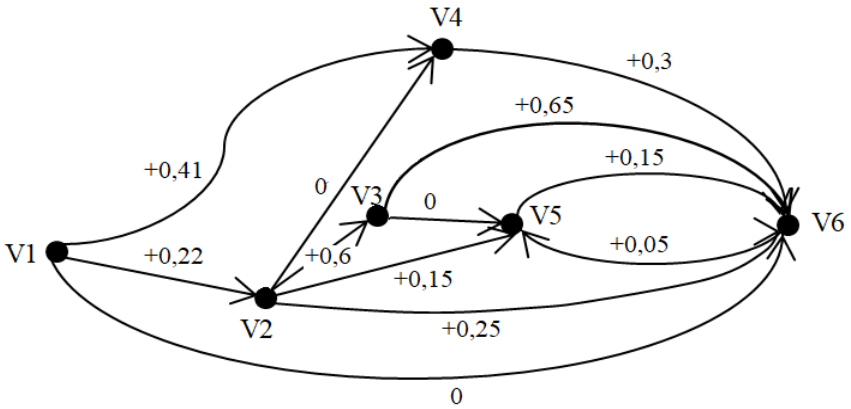

Figure 8. Equivalent model of a directed graph with non-negative edge weights

The calculated values of the index of the joint influence of factors on the sales activities of the enterprise are presented in table. 6.

Table 6 Index of influence of factors on the sales activities of the enterprise

	V1	V2	V3	V4	V5	V6
V1	0	0.22		0.41		0
V2	0.22	0	0.6	0	0.15	0.25
V3		0.6			0	0.65
V4	0.41	0				0.3
V5		0.15	0			0.15
w_V^+	0	0.25	0.65	0.3	0.05	0

The result of the study of the index of the influence of factors on the sales activities of the enterprise is presented in the diagram in Fig. 9.

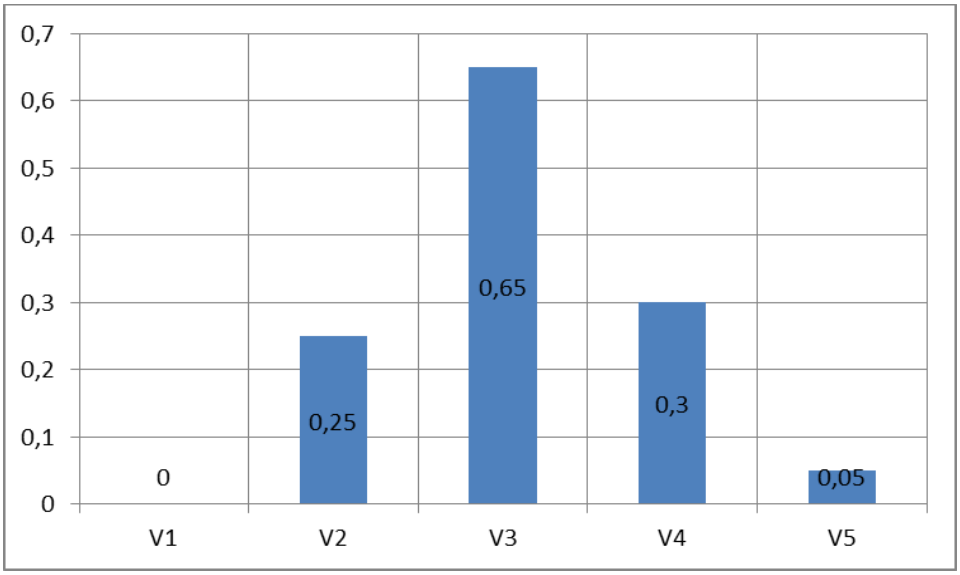

Figure 9. Assessment of the index of the influence of factors on the sales activities of the enterprise

From the results of assessing the index of the influence of factors on the sales activities of the enterprise in the diagram (Fig. 9), the factor "Advertising Quality" V3 has the maximum impact on sales activities and is equal to the next two factors with an average level of impact on the sales activities of the enterprise are$w_3^+ = 0{,}65 w_2^+ = 0{,}25$ "Market Segmentation" V2 and "Digital Marketing Tools" V4 with meanings respectively. Factors $w_4^+ = 0{,}3$ "Competitive environment" V1 and "Product quality" V5 have a low impact on sales activities, respectively $w_1^+ = 0,\ w_5^+ = 0{,}05$.

CONCLUSIONS

The developed method and models of a weighted directed graph with a weight of edges, which are based on a diagram of the formalization of cause-and-effect relationships (Ishikawa diagram), make it possible to determine the influence of factors of the competitive environment (V1), market segmentation (V2), advertising quality (V3), digital marketing tools (V4) and product quality (V5) on the sales activities of the enterprise (V6) and explore factor influence index.

The results of modeling for solving problems in the sales process of an enterprise make it possible to evaluate the use of a weighted directed graph model to determine the factors influencing the sale of goods, as well as studying the relationships between different factors influencing the sales activity of an enterprise.

For further research it is important to solve question of wider use and implementation of cloud data storage (Big Data) and cloud computing in to management of sales activity which will make it possible to evaluate a greater number of factors for the sales activities of an enterprise.

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