Теоретично обґрунтовується і вирішується проблема формування системного підходу до застосування маркетинг-менеджменту в діяльності машинобудівних підприємств. Розроблено систему маркетинг-менеджменту діяльності промислових підприємств. Запропоновано модель оптимізування системи маркетинг-менеджменту підприємства, яка враховує кластеризацію підприємств за ознакою виконання маркетингових функцій; удосконалено процес прийняття управлінських рішень стосовно вибору оптимальної структури організування маркетинг-менеджменту на підприємстві

Ключові слова: маркетинг-менеджмент, системний підхід, кластеризація, машинобудівне підприємство

Теоретически обосновывается и решается проблема формирования системного подхода к применению маркетингового управления. Разработана система маркетингового управления деятельностью промышленных предприятий. Сформирована модель оптимизации системы маркетинг-менеджмента предприятия, которая основывается на кластеризации предприятий по признаку выполнения маркетинговых функций; усовершенствован процесс принятия управленческих решений по выбору оптимальной структуры организации маркетинг-менеджмента

Ключевые слова: маркетинг-менеджмент, системный подход, кластеризация, машиностроительное предприятие

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FORMATION OF A SYSTEM APPROACH TO THE OPTIMIZATION OF MARKETING MANAGEMENT AT AN ENTERPRISE

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1. Introduction

Activity of an enterprise today is largely determined by the changes taking place in the external environment. This concept began to be used recently for the characteristics of those factors of direct and indirect influence that affect the functions of an enterprise. These include the emergence and dramatic growth of fundamentally new tasks, unpredictable conditions and dramatic growth of instability, probability of the occurrence of strategic surprises. Therefore, a reliable basis for the survival of a company under difficult conditions of external environment is the formation of a system of marketing management, focused not on existing conditions only, but on those that have yet to develop. The marketing approach to the management of development of enterprises' activities is to provide them with sustainable competitive advantages. One of the directions of its implementation is the approach that gives the company an opportunity to adapt the system of marketing management by using the cluster approach.

The relevance of the work in this area of research is determined primarily by the following circumstances: first, by a special relevance to the country's economy of the development of machine-building enterprises, and therefore, the market for machine-building production; secondly, by the necessity to develop efficient management concept and the mechanism of its practical application at the machine-building enterprises of Ukraine.

2. Analysis of scientific literature and the problem statement

Significant contribution to the development of scientific approaches in the study of the subject of adaptive systems has been made by foreign and Ukrainian scientists. Thus, the classic definition of adaptive model of the management system of an object is such a model, in which as a result of changes in the characteristics of the internal and external properties of an object, corresponding change of structure and parameters of the regulator of management occurs, in order to ensure its sustainable development relative to the set goals [1]. However, today the goals of business organizations significantly differ, which is marked by the influence of changing market environment on them, that is why in the formation of a system of adaptive management, the marketing component of enterprises activity should be taken into account.

British scientists regard adaptation in the broad sense as an adaptation of a system to a change in conditions [2].

Detailed definition of adaptation relates to the goals of the study, which does not fully match the formation of organizational management systems.

Some researchers [3] make an attempt to analyze the advantages and disadvantages of marketing organizational structures, to generalize and expand an understanding of how firms use their organizational structural elements to achieve marketing goals. However, in their papers, they do not sufficiently substantiate the application of one or another kind of organizational management structure regarding the marketing management of an enterprise.

Other scholars [4] try to approach the definition of organizational structures through the analysis of consumer behavior and determining the drivers that affect the behaviour of consumers and their purchasing decisions. Given the fact that this article explores machine-building enterprises, their type of consumer behavior for the most part is limited by B2B relationship, and so the formation of a system of marketing management of such enterprises can be quite formalized.

The paper [5] assumes that it is necessary not only to explore the needs of consumers, but also to create them. Accordingly, the marketing structure of a company should be directed towards creation of new needs of consumers and, in this case, towards satisfying them.

Representatives of the Welsh school [6] explore the advantages and disadvantages of centralized and decentralized organizational structure of enterprises. They believe that the organizational structure of an enterprise should be evolving according to the life cycle of the product: for companies that produce products with a short life cycle they recommend decentralization, for the enterprises with the products with a long life cycle – centralized organizational structure.

The paper [7] investigates a possibility to delegate certain marketing functions to outsourcing on the basis of the analysis of the relationship between the optimal organizational structure of the company and the competition on the market. Finnish researchers [8] propose to delegate to consulting companies a certain part of business processes, including marketing functions.

Korean scientists [9] explore possibilities of CRM technologies to increase the efficiency of the execution of the marketing functions and performance of enterprises in general.

However, despite a significant number of papers, which examine the issue of the marketing organizational structure of an enterprise, in the scientific literature there has not been formed a clear-cut approach to theoretical and practical aspects of determining the optimal system of marketing management at industrial enterprises, which is why the chosen direction of research requires more detailed study.

3. The purpose and objectives of the study

The aim is to create a system approach to modeling an optimal system of marketing management at an enterprise.

To achieve the set goal, the following tasks were tackled:

– to identify and determine conformity of organizational structures of marketing to the functional tasks of marketing management of machine-building enterprises;

– to develop a system of marketing management activity of an industrial enterprise;

– to build a simulation of optimization of the system of marketing management of machine-building enterprises using economic-mathematical modeling and applying a cluster approach;

– to improve a process of management decision-making regarding the choice of a particular organizational structure of marketing management or implementation of marketing activities without creating a rigid organizational structure.

4. Materials and methods of the modeling an optimal system of marketing management at an enterprise

For the purpose of qualitative analysis and quantitative evaluation of the level of organization of marketing activities at the machine-building enterprises of Khmelnytska Region (Ukraine) we conducted a survey of 47 enterprises of different forms of ownership and size of business. This group of enterprises includes PAT "Temp", TOV NVF "Advismash", DP "Novator", TOV "Europa-Export Plus" and DP Shepetivka Repair Plant".

The research was carried out by the following directions:

1) analysis of availability of marketing department at an enterprise;

2) determining the type of organizational structure or the (lack of) subordination to perform marketing functions at an enterprise – a logical correlation of the levels of management and functional areas, organized so as to ensure efficient achievement of the goals;

3) identification of the presence and level of marketing information resources at an enterprise – the information required for the management of economic processes stored in the information systems databases, and creating information conditions of functioning of the system, providing with necessary information;

4) study of the existing system of material incentives for specialists who perform marketing functions, – a system of economic forms and methods of encouraging people to work, enhancing their labour activity and engagement in improving end results.

The performed analysis of the organizational structures of enterprises and the units that perform marketing functions allowed differentiating the four typical organizational structures of marketing activities.

Cluster 1. The enterprises at which marketing activities boiled down mainly to operational marketing (the cluster and the corresponding type of organizational structure is conditionally named "Stochastic marketing").

Cluster 2. The enterprises at which the functions on both operational and tactical leves are performed, marketing activities are carried out under the guidance of several deputy directors, who do not have the status of chief deputy and by units that perform marketing functions, but this is not their main activity (conditionally named "Uncoordinated marketing".

Cluster 3. The enterprises at which the functions are performed on both operational and tactical levels, marketing activities are carried out under the leadership of one deputy director, who does not have the status of chief deputy of the enterprise, while the units that perform marketing functions are grouped by the types of marketing activities (conditionally named "Coordinated marketing").

Cluster 4. The enterprises at which the functions are performed on the operational and tactical levels and partly strategic, moreover, marketing activities are in the competence of the director or chief deputy (conditionally named "Marketing Management").

When giving score to those or other organizational decisions and assigning appropriate point ratings to them (the level of organization), we thought it relevant that the "poorer" a marketing unit in the functional sense, the lower is its status in the system of management and the highest degree of inconsistency among separate marketing functions and levels, then in a general case (at equal conditions) the lower is the level of organization of marketing activities in the aspect of organizational structure and, therefore, the lower quality of adopted marketing decisions, the worse are achieved marketing results and lower is the efficiency of the company. In this sense it is obvious that, for example, the organizational structure conditionally named "Stochastic marketing" has less quantitative evaluation than organizational structure conditionally named "Marketing management".

We arrived at the following conclusions based on the performed research:

1) the vast majority of machine-building enterprises of Khmelnytskaya Region (by a 10-point scale) are characterized by low and medium level of organization of marketing activities, and, therefore, these enterprises have potential to improve the level of organization of marketing activities;

2) level of organization of material stimulation of marketing activities is 3.33 points, which is lower than the level of its information provision (4.00), which, in turn, is lower than the level of organization by the aspect of organizational structure (5,83);

3) the biggest shortcomings (and consequently, and the biggest potential) in the organization are observed in the area of indicators of bonuses, reflecting the internal differentiation of marketing functions (0.77 points), the use of methods of analysis and decision making (1.48) while the highest marks are characteristic of cross-functional coordination (8.06) and automation of marketing logistics (5,94);

4) there is a need to develop the main directions of improving the organization of the marketing activities of the machine-building enterprises of Khmelnytskaya Region in all these aspects, namely: improvement and development of an optimal marketing organizational structure; enhancing the role of information support of marketing activities (including efficient operation of the internet sites of enterprises); improvement in the system of material incentives for specialists who perform marketing functions.

As the main directions of improving the organization of marketing activities, the following may be recommended:

1. To extend the functionality of the marketing departments (especially the functions of strategic marketing) with a concentration of all marketing functions in the hands of one "specialized" leader, giving him/her a status of the 1st Deputy Director. To form an organizational structure that best suits the tasks of the enterprise in the area of marketing.

2. In case it is inexpedient to form an organizational structure of marketing, to create adaptive system of marketing management to address specific marketing tasks or to outsource marketing functions to specialized consulting agencies.

The ability to adapt is determined by the availability in the system of a number of properties, the most important of which include the following [10]:

1. Capability for self-regulation, i. e., to independently change the parameters of performance of the system. The simplest example for production systems may be increased, decreased, or changed range of products in accordance with the changes in demand.

2. Capability for self-organization, i. e., to independently change the system structure while maintaining its inherent qualitative characteristics. An example for economic systems may be the emergence of new industries, generated by scientific and technical progress, and the corresponding destruction of the old, training different kinds of production-economic subsystems due to the changes in labour distribution.

3. Capability for self-study, i. e., to independently find the conditions under which the system satisfies the quality criteria of its functioning.

Based on the previously conducted studies, we formed a system approach to optimizing marketing management of an enterprise.

5. The results of modeling an optimal system of marketing management at an enterprise

Formation of a system approach to optimizing the marketing management of an enterprise is based on strategic, tactical and operational management of marketing activities, implies constructing an algorithm of selection of organizational structures of marketing, and the result of its implementation is the design of a scenario-based approach to substantiate decisions regarding increase in the efficiency of marketing management of machine-building enterprises. A system approach to the optimization of marketing management at an enterprise is presented in Fig. 1.

Theoretically, the choice of an optimal organization marketing structure of an enterprise is based on the analysis of the expert procedures of evaluation of significance, reliability, and efficiency (speed) of connections in an organization construction (configuration) of a marketing structure. These procedures include multiple modeling and evaluation of each scheme of organizational-management interaction at an enterprise.

Let $\left\{E_j\right\}_{j=1}^{N}$ is the set $N \in \mathbb{N} \setminus \{1\}$ of all possible (permissible or acceptable) organizational marketing structures, where E_j is the j-th variant of an organizational marketing structure of the given company. Of course, the number of structures N depends on the type of an enterprise, the back-story of its performance on the market, competitiveness, financial resources, profitability and other factors. For example, there is no point to include those structures in the set $\left\{E_j\right\}_{j=1}^{N}$, the costs of which are not provided for in the funds of the company or which may be used only after a long time (in particular, because of the difficulties of technical implementation or lack of information support).

If $v_j = \mu\left(E_j\right)$ is the point estimate of the j-th variant of a structure by some reflection μ, then the optimal organizational marketing structure of the enterprise will be

$$E_* \in \arg \operatorname*{extr}_{\substack{\{E_j\}_{j=1}^{N} \\ j=\overline{1,N}}} v_j, \tag{1}$$

where the type of extremum depends on the type of reflection μ. When this reflection correlates every organizational marketing structure of an enterprise with, for example, the cost of maintaining this structure in the course of its operation (short-term or long-term), the problem (1) will be written down like a normal minimization problem:

$$E_* \in \arg \min_{\substack{\{E_j\}_{j=1}^{N} \\ j=\overline{1,N}}} v_j. \tag{2}$$

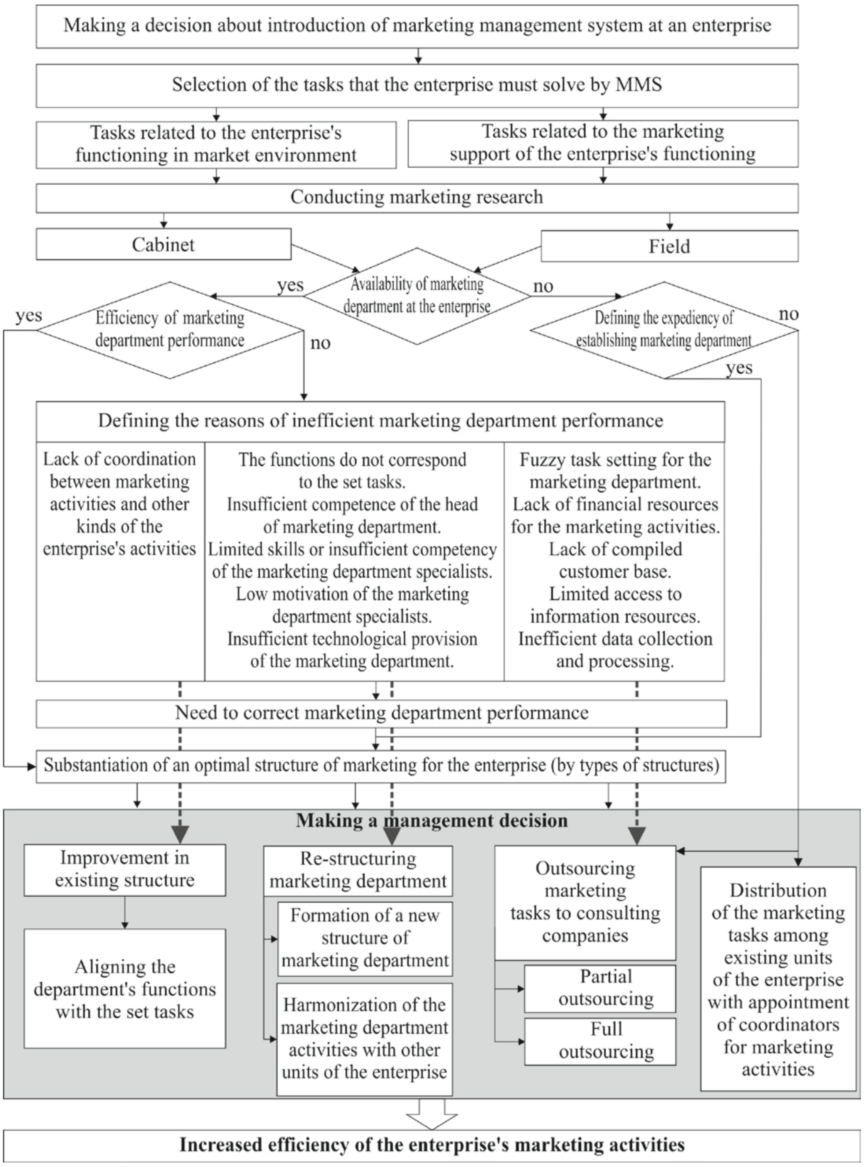

Fig. 1. A system approach to the optimization of marketing management at an enterprise

If the reflection μ correlates every organizational structure of marketing management of an enterprise with, for example, its resources or potential, then the problem of maximization is solved:

$$E_* \in \arg\max_{\substack{\{E_j\}_{j=1}^{N} \\ j=\overline{1,N}}} v_j . \qquad (3)$$

Full reflection

$$\left\{ v_j = \mu\left(E_j\right) \right\}_{j=1}^{N}$$

as N values

$$\left\{ v_j \right\}_{j=1}^{N}$$

is based on the expert procedures of assessment. Such evaluation may involve both the opinions of an expert on an aggregate (integrated) quality of a specific variant of the organizational marketing structure of the given enterprise, and the sequence of computational procedures. However, the latter is only possible when each of N structures has a small number of specific differences from the rest, and the whole set $\{\ \}_{j\ 1}$ of permissible structures has a shared infrastructure with obligatory inclusion of resource (expendable) components. In general, experts assess variants of a marketing structure by using the experience and knowledge of the importance of the eight known marketing functions for industrial enterprises.

Therefore, the first variant with the direct (one-step) evaluation is more realistic. It is also quite pragmatic, because not all structures are common in characteristics, and the evaluation of the two structures may be inadequate.

At the one-step assessment, ranking is usually performed. This is due to the fact that we are not interested in the value $\mu(E_*)$ as it is, but only the corresponding structure E_* by (2) or (3). As a result of ranking, the problem (2) or (3) is solved automatically.

Before performing the ranking of all variants of the organizational marketing structure of the given enterprise $\{E_j\}_{j=1}^{N}$, a group of experts is formed. Formally there are $A \in \mathbb{N} \setminus \{1\}$ of them, but in reality those are tens, hundreds and even thousands of competent persons. There may be less competent specialists among the experts – just respondents, however, their competence weight will be correspondingly lower, which will not distort the results of the ranking [11, 12].

There are several methods of obtaining generalized ranking of a group of objects. The most common is the processing of matrix rankings and voting data processing. They use both algebraic and statistical processing of matrix rankings. Data processing of voting involves the work with individual orders of less competent experts (respondents or some sample). In this case it is possible to use the rule of “first places”, the phase rule of “first places” with elimination, the rules of Borda, Condorcet, Copeland, Simpson and others.

Matrix ranking [10] admits inclusion of a small number of experts. The result of the matrix ranking is usually the most impartial. Let

$$\mathbf{E}_a(N) = \left[m_{ij}^{\langle a \rangle} \right]_{N \times N}$$

is a matrix ranking of a-th expert on the structures $\{E_j\}_{j=1}^{N}$, where $a = \overline{1, A}$. The following properties of square matrices of the N-th order $\left\{\mathbf{E}_a(N)\right\}_{a=1}^{A}$ are known:

$$m_{jj}^{\langle a\rangle}=0 \quad \forall\ j=\overline{1,N} \ \text{ and }$$

$$\forall\ a=\overline{1,A} \ \text{ at } \ m_{ij}^{\langle a\rangle}=\pm 1 \ \text{ and } \ m_{ij}^{\langle a\rangle}=-m_{ji}^{\langle a\rangle}, \tag{4}$$

that is, the ranking $\{\mathbf{E}_a(N)\}_{a=1}^{A}$ is the skew-symmetric matrices [11] of the N-th order with the obvious property of that

$$\mathbf{E}_a(N)=-(\mathbf{E}_a(N))^{T}. \tag{5}$$

We put the following model as a basis. Organizational marketing structure of an enterprise with number i has a higher rank than the structure with number j, if $m_{ij}^{\langle a\rangle}=1$. In other words, $m_{ij}^{\langle a\rangle}=1$ means that, in the opinion of the a-th expert, organizational marketing structure of an enterprise with number i is better than the structure with number j. If, however, $m_{ij}^{\langle a\rangle}=-1$, then the structure with number i, in the opinion of the a-th expert, has a lower rank (is worse) than the structure with number j.

Naturally, cyclical nature and breach of transitiveness in the experts rankings is not excluded if an expert "fills in" the matrix at once (evaluates its elements above or below the main diagonal). Define through the $\Theta_N^{(\pm1)}$ the set of all skew-symmetric matrices of the N-th order with elements ±1 outside the main diagonal. It is clear that if there are only M elements over the main diagonal, then the number of such matrices $\left|\Theta_N^{(\pm1)}\right|=2^M$. Cyclic rankings (with breach of transitiveness) are also included in the set $\Theta_N^{(\pm1)}$. It is obvious that

$$\{\mathbf{E}_a(N)\}_{a=1}^{A}\subset\Theta_N^{(\pm1)}. \tag{6}$$

Using the algebraic approach, generalized matrix ranking $\tilde{\mathbf{E}}(N)$ is defined as the Kemeny-Snell median [11, 13]. Of course, the matrix $\tilde{\mathbf{E}}(N)\in\Theta_N^{(\pm1)}$. It is the solution to the following problem of minimization:

$$\tilde{\mathbf{E}}(N)\in\arg\min_{\mathbf{E}^{\langle q\rangle}(N)\in\Theta_N^{(\pm1)},\ q=\overline{1,\left|\Theta_N^{(\pm1)}\right|}}\left\{\sum_{a=1}^{A}\zeta_a\cdot\rho_{\Theta_N^{(\pm1)}}\left(\mathbf{E}_a(N),\mathbf{E}^{\langle q\rangle}(N)\right)\right\}, \tag{7}$$

where ζ_a is the known indicator of competence or expertise (statistical reliability) of the a-th expert [10], and at that

$$\left\{\zeta_a:\zeta_a\in(0;1),\ a=\overline{1,A},\ \sum_{a=1}^{A}\zeta_a=1\right\}. \tag{8}$$

Integral values

$$\rho_{\Theta_N^{(\pm1)}}\left(\mathbf{E}_a(N),\mathbf{E}^{\langle q\rangle}(N)\right) \tag{9}$$

are the distances in the space $\Theta_N^{(\pm1)}$ between the matrices $\mathbf{E}_a(N)\in\Theta_N^{(\pm1)}$ and $\mathbf{E}^{\langle q\rangle}(N)\in\Theta_N^{(\pm1)}$ of this space.

As the distance for determination the Kemeny-Snell median, let us take the known Hamming distance [11, 14, 15], which in the general form for the matrix

$$\mathbf{E}^{\langle q\rangle}(N)=\left[r_{ij}^{\langle q\rangle}\right]_{N\times N}\in\Theta_N^{(\pm1)} \tag{10}$$

is written down with the power indicator $\eta>0$:

$$\rho_{\Theta_N^{(\pm1)}}^{\langle\eta\rangle}\left(\mathbf{E}_a(N),\mathbf{E}^{\langle q\rangle}(N)\right)=\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|^{\eta}. \tag{11}$$

For most problems, in practice the distance (7) is simplified to the version without power weighting:

$$\rho_{\Theta_N^{(\pm1)}}^{\langle 1\rangle}\left(\mathbf{E}_a(N),\mathbf{E}^{\langle q\rangle}(N)\right)=\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|. \tag{12}$$

Therefore, in an explicit form, the Kemeny-Snell median (7) to determine the ranks N of organizational marketing structures of an enterprise is calculated:

$$\tilde{\mathbf{E}}(N)\in\arg\min_{\mathbf{E}^{\langle q\rangle}(N)\in\Theta_N^{(\pm1)},\ q=\overline{1,\left|\Theta_N^{(\pm1)}\right|}}\left\{\sum_{a=1}^{A}\zeta_a\cdot\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}=$$

$$=\arg\min_{\mathbf{E}^{\langle q\rangle}(N)\in\Theta_N^{(\pm1)},\ q=\overline{1,\left|\Theta_N^{(\pm1)}\right|}}\left\{\sum_{a=1}^{A}\zeta_a\sum_{i=1}^{N}\sum_{j=1}^{N}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}. \tag{13}$$

Further, by using generalized ranking (9), the sequence of structures in descending order (growth) of their integrated quality (values, practical significance, etc.) is written down. This directly leads to the solution of problem (2) or (3) [16].

These problems can be solved using also a statistical approach for data processing of rankings $\{\mathbf{E}_a(N)\}_{a=1}^{A}$. If the values

$$p_{ij}=\frac{1}{A}\sum_{a=1}^{A}\zeta_a m_{ij}^{\langle a\rangle} \ \ (i=\overline{1,N} \ \text{ and } \ j=\overline{1,N}) \tag{14}$$

are integral, the value (14) is interpreted as the statistical probability of that the i-th structure is better than the j-th structure of [11]. Then we solve the equation

$$p_{ij}=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z_{ij}}e^{-\frac{\tau^2}{2}}d\tau \quad \forall\ i=\overline{1,N} \ \text{ and } \ \forall\ j=\overline{1,N} \tag{15}$$

relative to the value z_{ij} and find the average:

$$z_j=\frac{1}{N}\sum_{i=1}^{N}z_{ij} \quad \forall\ j=\overline{1,N}. \tag{16}$$

The average value (16) is a preliminary assessment of the structure E_j. In the case of incoherence of expert ratings, these evaluations should be reviewed.

To test the expert ratings on coherence, they perform the following steps. First, the values are determined

$$\overline{p}_{ij}=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z_j-z_i}e^{-\frac{\tau^2}{2}}d\tau \quad \forall\ i=\overline{1,N} \ \text{ and } \ \forall\ j=\overline{1,N}. \tag{17}$$

Second, the deviations are calculated

$$\delta_{ij}=\left|p_{ij}-\overline{p}_{ij}\right| \ \ (i=\overline{1,N} \ \text{ and } \ j=\overline{1,N}). \tag{18}$$

Third, we determine the average deviations (14)

$$\delta=\frac{1}{2N(N-1)}\sum_{i=1}^{N}\sum_{j=i+1}^{N}\delta_{ij}. \tag{19}$$

If for (19) the condition is valid

$$\delta<\delta_{max} \tag{20}$$

for the δ_{max} set in advance, then the experts' assessment is coherent.

Subject to the agreed expert assessment:

$$v_j=z_j=\mu(E_j) \quad \forall\ j=\overline{1,N}, \tag{21}$$

that immediately provides the solution to the problem (2) or (3). However, not only the values of (16) can be used for constructing the reflection μ. One can use normalized values

$$p_j^* = \frac{\overline{p}_j}{\sum_{i=1}^{N} \overline{p}_i} \quad (j = \overline{1, N}), \tag{22}$$

where

$$\overline{p}_j = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z_j} e^{-\frac{\tau^2}{2}} d\tau \quad \forall\ j = \overline{1, N}. \tag{23}$$

So instead of (21) for the reflection μ one can take also ratings (22):

$$v_j = p_j^* = \mu(E_j) \quad \forall\ j = \overline{1, N}. \tag{24}$$

Note that for the number of objects larger than five (even more so, for 10), the described algorithms of constructing reflection μ with the following solution of the problem (2) or (3) are inefficient. Therefore, another variant is possible. Before one performs ranking $\{\mathbf{E}_a(N)\}_{a=1}^{A}$ and finds the Kemeny-Snell median (13) or performs calculations (14)–(24), it is necessary to perform screening-off of certain structures. In this case we will use the respondents (these may be less competent experts, the weight of the expertise of whom we will consider equal), who will estimate each structure by putting 1 or 0. Let $w_j^{\langle u \rangle}$ is the estimate of the j-th structure, given by the u-th respondent, where $w_j^{\langle u \rangle} \in \{0, 1\}$ at $u = \overline{1, U}$ with the total number of respondents U. Compute the argument

$$j_* \in \arg\min_{j=\overline{1,N}} \sum_{u=1}^{U} w_j^{\langle u \rangle}, \tag{25}$$

which points to the j_*-th structure, which is the least qualitative for the studied enterprise. Then according to (25), the structure E_{j_*} is excluded from further consideration. If the set

$$\arg\min_{j=\overline{1,N}} \sum_{u=1}^{U} w_j^{\langle u \rangle} \tag{26}$$

consists of more than one element, then all they correspond to structures that are excluded from further consideration (if only their quantity does not exceed N–2).

The specified procedure is repeated until there remain two structures or the difference between the values

$$\left\{ \sum_{u=1}^{U} w_j^{\langle u \rangle} \right\}_{j=1}^{N}$$

is minimal. This difference is calculated as

$$\beta_N = \max_{j=\overline{1,N},\, i=\overline{1,N}} \left\{ \left(\sum_{u=1}^{U} w_j^{\langle u \rangle} \right) \cdot \left(\sum_{u=1}^{U} w_i^{\langle u \rangle} \right)^{-1}, \right.$$

$$\left. \left(\sum_{u=1}^{U} w_j^{\langle u \rangle} \right)^{-1} \cdot \left(\sum_{u=1}^{U} w_i^{\langle u \rangle} \right) \right\}. \tag{27}$$

If $\beta_N > \beta_*$ for N>2, where $\beta_* \in \{1.1, 1.25, 1.5, 2\}$ (the enumeration corresponds to the practice of processing statistical data of expertises), then the problem (25) is solved, and the work starts with the structure $N-1$. Otherwise, pass on to the matrix ranking.

The result of the matrix ranking in the form of the Kemeny-Snell median (13) does not necessarily have to coincide with the general ranking of the structures $\{E_j\}_{j=1}^{N}$. However, if the reflection μ had not been obtained (in particular, algebraic or statistical approach in the processing of matrix ranking) and no matter which it was, E_* as the solution to the problems (2) or (3) is expected to be invariable. Therefore, this solution must appear with the use of other approaches, too. An important condition is attracting a sufficient number of experts. For the ranking using the Borda rule, there should be more experts (less professional experts in this field of knowledge and experience are allowed). In this case the a-th expert, by providing to the j-th structure the n-th rank (place) $x_j^{\langle a \rangle}$, where $x_j^{\langle a \rangle} \in \{\overline{1, N}\}$ at $j = \overline{1, N}$, generates his/her own expert individual order. For example,

$$\underbrace{E_4 \succ E_1 \succ E_{10} \succ \ldots \succ E_8}_{\text{Nstructure}}. \tag{28}$$

The system of points (evaluations) will be put by a simple monotonic, where $x_j^{\langle a \rangle}$ place is assigned with $N - x_j^{\langle a \rangle} + 1$ point. Then the assessment giving the j-th structure

$$v_j = \sum_{a=1}^{A} \left(N - x_j^{\langle a \rangle} + 1 \right) = \mu(E_j) \quad \forall\ j = \overline{1, N}. \tag{29}$$

It follows from the ratio (29) that $A \cdot N \geq v_j \geq A$. Here again, by obtaining the reflection μ in explicit form by the values (29), we solve the problem (2) or (3), determining an optimal organizational marketing structure of the considered enterprise.

If the following is fulfilled for the optimal structure with number j_{**}

$$\sum_{u=1}^{U} w_{j_{**}}^{\langle u \rangle} > W_1 \tag{30}$$

at all stages of getting rid of "weak" structures for some total

$$W_1 \in \left(\frac{U}{2}; U \right],$$

then this structure is adopted for functioning at the considered enterprise. If (30) is not carried out at all or not performed at some stages of screening, then the principle of outsourcing applies. The algorithm of determining an optimal marketing structure of an enterprise is presented in Fig. 2.

Let us consider practical application of the described algorithm by the example of DP "Novator." After the polling of executives (heads of departments of marketing) of the machine-building enterprises of Khmelnytska Region (Ukraine), out of 11 potential organizational marketing structures, the seven structures were successively rejected, where U=114 and W_1=60. For the rest of the four structures, which turned out to be functional, product, market and matrix ones, the inequality (30) was performed in all seven stages of screening off "weak" structures.

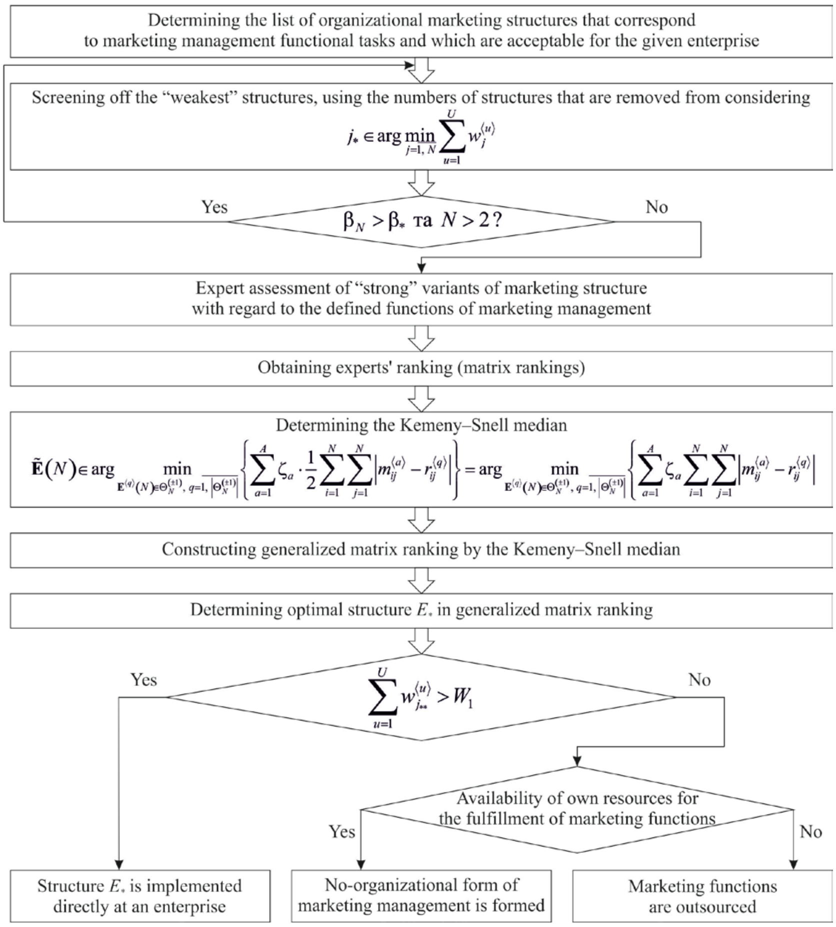

Fig. 2. Algorithm of selection of organization of marketing management of an enterprise

6. Discussion of the results of the modeling an optimal system of marketing management at an enterprise

For the ranking of the four structures, we involved 32 experts, 10 of whom are highly qualified. Their competence weight was put by one and a half times larger than the weight of the rest of the 22 experts (with less experience). Of course, such assumption is rather conditional. However, further we will be given evidence that by changing the ratio of weights (in certain, of course, range) of 10 experienced experts against 22 experts with less experience, the result of optimization of organizational marketing structure of the DP "Novator" will not change.

The numbering of the experts begins with those highly qualified ones. So, if each of the 10 experienced experts is assigned the weight of his/her expertise (competence) so that the sum of all these weights is greater by one and a half times than the sum of all weights of the remaining 22 experts, we will receive the following competence weights of 32 experts:

$$\zeta_a = 0.06 \text{ at } a = \overline{1,10} \text{ and } \zeta_a = \frac{1}{55} \text{ at } a = \overline{11,32}. \tag{31}$$

During the expert procedures we found 11 variations of different matrix rankings:

$$2431\ \mathbf{E}_{a_1}(4) = \begin{bmatrix} 0 & -1 & -1 & -1 \\ 1 & 0 & 1 & 1 \\ 1 & -1 & 0 & -1 \\ 1 & -1 & 1 & 0 \end{bmatrix},$$

$$2341\ \mathbf{E}_{a_2}(4) = \begin{bmatrix} 0 & -1 & -1 & -1 \\ 1 & 0 & 1 & 1 \\ 1 & -1 & 0 & 1 \\ 1 & -1 & -1 & 0 \end{bmatrix},$$

$$1432\ \mathbf{E}_{a_3}(4) = \begin{bmatrix} 0 & 1 & 1 & 1 \\ -1 & 0 & -1 & -1 \\ -1 & 1 & 0 & -1 \\ -1 & 1 & 1 & 0 \end{bmatrix},$$

$$2143\ \mathbf{E}_{a_4}(4) = \begin{bmatrix} 0 & -1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ -1 & -1 & 0 & -1 \\ -1 & -1 & 1 & 0 \end{bmatrix},$$

$$1423\ \mathbf{E}_{a_5}(4) = \begin{bmatrix} 0 & 1 & 1 & 1 \\ -1 & 0 & 1 & -1 \\ -1 & -1 & 0 & -1 \\ -1 & 1 & 1 & 0 \end{bmatrix},$$

$$4123\ \mathbf{E}_{a_6}(4) = \begin{bmatrix} 0 & 1 & 1 & -1 \\ -1 & 0 & 1 & -1 \\ -1 & -1 & 0 & -1 \\ 1 & 1 & 1 & 0 \end{bmatrix},$$

$$1324\ \mathbf{E}_{a_7}(4) = \begin{bmatrix} 0 & 1 & 1 & 1 \\ -1 & 0 & -1 & 1 \\ -1 & 1 & 0 & 1 \\ -1 & -1 & -1 & 0 \end{bmatrix},$$

$$4132\ \mathbf{E}_{a_8}(4) = \begin{bmatrix} 0 & 1 & 1 & -1 \\ -1 & 0 & -1 & -1 \\ -1 & 1 & 0 & -1 \\ 1 & 1 & 1 & 0 \end{bmatrix},$$

$$2134\ \mathbf{E}_{a_9}(4) = \begin{bmatrix} 0 & -1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ -1 & -1 & 0 & 1 \\ -1 & -1 & -1 & 0 \end{bmatrix},$$

$$3241\ \mathbf{E}_{a_{10}}(4) = \begin{bmatrix} 0 & -1 & -1 & -1 \\ 1 & 0 & -1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & -1 & -1 & 0 \end{bmatrix},$$

$$2314\ \mathbf{E}_{a_{11}}(4) = \begin{bmatrix} 0 & -1 & -1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & -1 & 0 & 1 \\ -1 & -1 & -1 & 0 \end{bmatrix}. \tag{32}$$

Indexing of the matrices' numbers (32) is carried out according to the following dependency of lower indices in the names of these matrices:

$$a_1 \in \{1, 3, 20, 21, 28\},\ a_2 \in \{2, 4, 5\},\ a_3 \in \{22, 32\},\ a_4 \in \{7, 13\},$$

$$a_5 \in \{6, 18\},\ a_6 \in \{11, 19, 27\},\ a_7 \in \{16, 23, 25\},\ a_8 \in \{9, 17\},$$

$$a_9 \in \{8, 12, 29, 30\},\ a_{10} \in \{14, 15\},\ a_{11} \in \{10, 24, 26, 31\}. \tag{33}$$

To determine generalized ranking of the structures for DP "Novator", let us use the Kemeny-Snell median (13), taking into account the indexing (33) and the weights (31):

$$\tilde{\mathbf{E}}(4)\in\arg\min_{\mathbf{E}^{\langle q\rangle}(4)\in\Theta_4^{(\pm1)},\,q=1,\left|\Theta_4^{(\pm1)}\right|}\left\{\sum_{a=1}^{32}\zeta_a\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}=$$

$$=\arg\min_{\mathbf{E}^{\langle q\rangle}(4)\in\Theta_4^{(\pm1)},\,q=\overline{1,64}}\left\{0.06\cdot\sum_{a=1}^{10}\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|+\right.$$

$$\left.+\frac{1}{55}\cdot\sum_{a=11}^{32}\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}=$$

$$=\arg\min_{\mathbf{E}^{\langle q\rangle}(4)\in\Theta_4^{(\pm1)},\,q=\overline{1,64}}\left\{\left(2\cdot0.06+3\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_1\rangle}-r_{ij}^{\langle q\rangle}\right|+\right.$$

$$+(3\cdot0.6+0\cdot0.4)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_2\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$\left.+(0\cdot0.6+2\cdot0.4)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_3\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}+$$

$$+\left(3\cdot0.06+0\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_2\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(0\cdot0.06+2\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_3\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_4\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_5\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(0\cdot0.06+3\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_6\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(0\cdot0.06+3\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_7\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_8\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left(1\cdot0.06+3\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_9\rangle}-r_{ij}^{\langle q\rangle}\right|+$$

$$+\left\{\left(0\cdot0.06+2\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_{10}\rangle}-r_{ij}^{\langle q\rangle}\right|+\right.$$

$$\left.+\left(1\cdot0.06+3\cdot\frac{1}{55}\right)\cdot\sum_{i=1}^{4}\sum_{j=1}^{4}\left|m_{ij}^{\langle a_{11}\rangle}-r_{ij}^{\langle q\rangle}\right|\right\}=$$

$$=\arg\min_{\mathbf{E}^{\langle q\rangle}(4)\in\Theta_4^{(\pm1)},\,q=\overline{1,64}}\left\{\left(2\cdot0.06+3\cdot\frac{1}{55}\right)\cdot8+\right.$$

$$\left.+\left(3\cdot0.06+0\cdot\frac{1}{55}\right)\cdot12\right\}+\left(0\cdot0.06+2\cdot\frac{1}{55}\right)\cdot12+$$

$$+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot16+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot16+$$

$$+\left(0\cdot0.06+3\cdot\frac{1}{55}\right)\cdot12+\left(0\cdot0.06+3\cdot\frac{1}{55}\right)\cdot20+$$

$$+\left(1\cdot0.06+1\cdot\frac{1}{55}\right)\cdot8+\left(1\cdot0.06+3\cdot\frac{1}{55}\right)\cdot20+$$

$$+\left(0\cdot0.06+2\cdot\frac{1}{55}\right)\cdot8=$$

$$=\arg\min_{\mathbf{E}^{\langle q\rangle}(4)\in\Theta_4^{(\pm1)},\,q=\overline{1,64}}\left\{+\left(1\cdot0.06+3\cdot\frac{1}{55}\right)\cdot16\right\}=$$

$$=\left\{\mathbf{E}^{\langle 33\rangle}(4),\,\mathbf{E}^{\langle 34\rangle}(4)\right\}, \qquad (34)$$

where $\mathbf{E}^{\langle 33\rangle}(4)=\mathbf{E}_{a_9}(4)$ (these two minima are presented in Fig. 3).

In (28), depending on the number q of the matrix in the set $\Theta_4^{(\pm1)}$, to determine generalized (optimal) matrix ranking (a circle and an arrow show two received minima with their respective numbers in the set $\Theta_4^{(\pm1)}$)

$$^{\langle 34\rangle}(\ )\ \begin{bmatrix}0 & 1 & 1 & 1\\ 1 & 0 & 1 & 1\\ -1 & -1 & 0 & -1\\ -1 & -1 & 1 & 0\end{bmatrix}. \qquad (35)$$

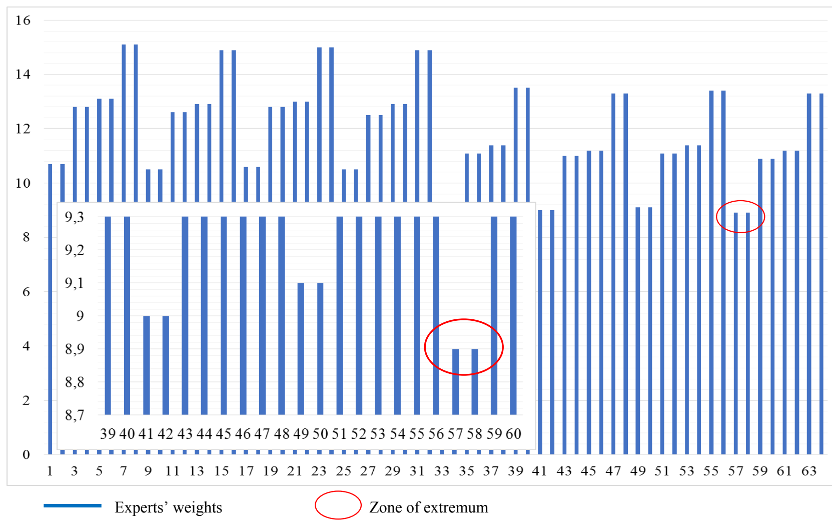

Fig. 3. Histogram of the distribution of values of distances under the sign of minimum

As we can see, for the DP "Novator", according to the Kemeny-Snell median, we found two variants of the ranking of the four organizational marketing structures (by prior indexing – 11 original structures) $\{E_1, E_2, E_3, E_7\}$.

The first variant

$$2134\ E_2\succ E_1\succ E_3\succ E_7 \qquad (36)$$

corresponds to the ranking $\mathbf{E}_{a_9}(4)$, the second – the ranking (29):

$$2143\ E_2\succ E_1\succ E_7\succ E_3. \qquad (37)$$

According to generalized rankings (36) and (37) of organizational marketing structures, which are optimal for DP "Novator", market and matrix structures happen to be difficult to associate or compare. In one case, which corresponds to the ranking (36), a market structure dominates, and in the other one – the ranking (37), which is a matrix structure. Probably, in a way, these structures are equivalent. However, there is more important thing. The first two best structures (functional and product) are invariable. And the ratio between them does not change – a product structure dominates over a functional one. This means that the product organizational marketing structure is optimal for the DP "Novator".

Remarkable is the fact that when changing the ratio of the weights $\{\zeta_a\}_{a=1}^{10}$ and $\{\zeta_a\}_{a=11}^{32}$, the result of optimization of organizational marketing structure of the DP "Novator" does not change. Moreover, such a change can be performed in any range. This means that when engaging specialists with any experience for the expertise, the result in the form of optimal product structure will remain unchanged: every matrix $\tilde{\mathbf{E}}(4)$ will have the same second row, i. e.

$$\tilde{\mathbf{E}}(4)=\begin{bmatrix} 0 & * & * & * \\ 1 & 0 & 1 & 1 \\ * & * & 0 & * \\ * & * & * & 0 \end{bmatrix}, \tag{38}$$

which, in turn, means overall advantage of E_2 (product structure) over the rest of the variants of organizational marketing structure for the DP "Novator".

7. Conclusions

1. An approach to identifiy and establish conformity of organizational structures of marketing to the functional tasks of marketing management was proposed, based on conducting marketing research and expert polls.

2. Clusterization of machine-building enterprises was performed, by the characteristic of marketing functions fulfillment, into those where marketing is stochastic; uncoordinated; coordinated; and where there is harmonisation of marketing and management.

3. A system approach to optimizing marketing management of the industrial enterprises was formulated, which provides for alternativity of choice among creation, reengineering, improvement of organizational structure of marketing, a form of fulfillment marketing activities without creating rigid organizational systems and/or delegating part of marketing functions to outsourcing.

4. The process of management decision-making was improved regarding the selection of an optimal structure of organization of marketing activities, based on economic-mathematical modeling and provides for alternativity of choice among creation, reengineering, improvement of organizational structure of marketing, a form of fulfilling marketing activities without creating rigid organizational systems and/or delegating part of marketing functions to the outsourcing by specialized consulting company.

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