MECHANISM FOR DETERMINING OPTIMAL MANAGEMENT OF USE OF PRODUCTION CAPACITY AT THE TEXTILE ENTERPRISES

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Abstract: *This article attempts to create a mechanism for determining the optimal management of the use of production capacity in the textile industry. The peculiarity of this mechanism is that it is based on the hierarchy method using the choice of a Pareto-effective set of alternatives. The method of analyzing hierarchies in such systems has two rather important advantages. On the one hand, it allows stakeholders to express their subjective view on the system of values of the enterprise. On the other hand, on the contrary, the method minimizes subjectivity (including lobbying) in relation to specific alternatives. Indeed, after defining specific criteria with a system, it is rather difficult to present an essentially non-objective comparison of alternatives on them. Based on the proposed methodology, has been developed the software that allows you to calculate alternatives and making the best decision. The proposed methodology is universal and can be used in all types of industry for selecting the optimal strategy and for further improving of an enterprise development strategy.*

Keywords: *textile industry, optimal management, hierarchy analysis method, internal material flows, capacity utilization, evaluating alternative solutions, multistep decision choice.*

1 INTRODUCTION

Despite the fact that rich experience has been accumulated in the history of the world economy in organizing industrial production and managing the efficient use of production capacities, the possibilities of rational use of production capacities in large industrial companies have not been fully utilized. Textile products account for 5.0% of world trade and 6.4% of industrial exports [26]. At the end of 2017, the use of production in this industry amounted to 88.0% in India, 81.2% in the Netherlands, 81.0% in China and 78.9% in Turkey [27]. In other developing countries with lively labor, an even lower rate is observed.

World scientific research centers conducted research in the field of optimizing the use of production capacities at textile enterprises, managing resources at an enterprise, and improving the supply chain of products at textile enterprises. Currently, research is being carried out in priority areas for making managerial decisions to increase the efficiency of capacity utilization, the introduction of modern automatic control systems MRP II, ERP in the management of capacity utilization, strategic planning of capacity utilization, developing an enterprise development strategy and improving management efficiency at textile enterprises.

In recent years, Uzbekistan has pursued a policy of accelerated modernization of the textile industry. However, the level of utilization of production capacities of textile enterprises in the republic remains low. Incomplete use of available production capacities at textile enterprises negatively affects the financial condition of the enterprise, which leads to a decrease in the return on investment. The Strategy for Action on Five Priority Directions of Development of the Republic of Uzbekistan in 2017-2021 defines priority tasks for “further modernization and diversification of the industry by moving it to a qualitatively new level, aimed at accelerating the development of high-tech manufacturing sectors, primarily for the production of finished products with high added cost based on deep processing of local raw materials” [28]. The effective implementation of these tasks requires the development of proposals and recommendations to improve the efficiency of use of production capacities at textile enterprises of the country.

2 LITERATURE REVIEW

The last twenty years have been studies in the study of production capacity, the organization of production at industrial enterprises and the management of production processes were analyzed by Y. Levin, et al [1], A. Sebastiano, et al [2], A. Golmohammadi, et al [3], C. Chien, et al [4], M. Davis, et al [5], Kupriyanov Sergey V., et al [6], Dadalova MV [7], K.S. Kryvyakin [8], E. Milewska [9]. D. Huang, et al [10], Jingfeng Shao,

et al [11] and T. Koltai, et al [12]. The foundations of production management were laid by P. F. Drucker [13], R. Mayer [14], W.R. Chestnut, et al [15], and the strategic management of production capacity in enterprises has been deeply studied by scientists Y. Khojasteh [16], J. H. Blackstone, et al [17], J. V. Bon, et al [18] and A. A. Thompson, et al [19].

On the part of M. Dadalova, the concept of "capacity management" has been investigated, interrelated functions have been examined, the implementation of which is the management of production capacity. In his work, the author analyzed the stages of development of production capacity management strategies and types of production capacity management strategies in accordance with the capabilities of the enterprise related to its current activities and future plans. He proposed a methodology for integrated assessment of production capacity management, which is based on qualitative and effective indicators of production capacity management. Methodology for assessment the efficiency of production capacities management at textile enterprises were investigated by B. O. Tursunov in other works [25] and this research is a logic continue of last research part.

K.S. Krivyakin studied the organization of the use of production capacity at machine-building enterprises, proposed a model and algorithm for the effective organization of the use of production capacity, developed a methodological approach to the organization of the balance of use of production capacity, based on an analysis of the balance of components of production capacity in the scale of the workshop. But the author did not take into account the goals of the head and stakeholders of the enterprise, which would significantly complicate the implementation of the developed methods if the stakeholders could not come to a unified consensus.

The Saaty method was successfully applied by T. Tsibizova and A. A. Karpunin [20] in assessing the quality of management processes, in particular to assess the quality of the work of teachers. The proposed approach provides an objective assessment of the quality of the daily work of a teacher associated with the current performance and student attendance, and not only with the results of intermediate final assessments.

But in all the above-mentioned research papers, the mechanism for determining the optimal management of the use of production capacity at the textile industry enterprises was not considered, and we made an attempt to develop a mechanism for determining the optimal management of the use of production capacity, which was tested on the textile industry. The mechanism is based on a hierarchy method that uses the choice of a Pareto-effective set of alternatives, which allows interested parties to express a subjective view of an enterprise's value system. On the other hand, on the contrary, the method minimizes subjectivity with respect to specific alternatives.

3 METHODOLOGY

The hierarchy analysis method (MAI) is a mathematical tool for a systematic approach to complex decision making problems. This method was developed by the American mathematician Thomas L. Saaty [21], who wrote books about him, developed software products and has been conducting ISAHP symposia for 20 years (the International Symposium on Analytic Hierarchy Process). MAI is widely used in practice and actively developed by scientists around the world. Along with mathematics, it is also based on psychological aspects. MAI allows to structure the complex problem of decision making in the form of a hierarchy in a clear and rational way, to compare and quantify alternative solutions. The hierarchy analysis method is used throughout the world to make decisions in a variety of situations: from management at the interstate level to solving industry and private problems in business, industry, health care and education [22].

4 ANALYSIS AND RESULTS

In conditions of globalization economy, an important activity of the enterprise is the constant analysis of the requirements of the consumer market and the use of the information obtained to develop corrective measures aimed at the effective management of the use of production capacity.

It should be noted that the efficiency of industrial production directly depends on the volume, structure, technical condition and level of use of fixed production assets. It is an increase in capital productivity and ensuring full utilization of facilities and equipment is an important direction in improving the efficiency of enterprises and a condition for ensuring its competitiveness.

The current state of the economy of Uzbekistan and all currently existing problems confront enterprises, the need to formulate strategies to increase the efficiency of using production capacity corresponding to the specifics and characteristics of a market economy, pursuing a balanced, reasonable policy to produce products of adequate quality and the necessary volumes required by the consumer market.

The development of market relations, the need to adapt the enterprise to changes in the external environment brings to the fore the solution to the problem of the effective management of the use of production capacity [8].

Industrial enterprises are systems of high complexity, the elements of which at the entrance and at the exit are subsystems of a great variety. The whole complex of activities within the enterprise is so complex that it cannot be fully interpreted. Therefore, the formation of a mechanism to control the use of production capacity uses only a systematic approach and analysis.

The mechanism for managing the use of production capacity of an enterprise should solve the main and complex problem - the realization of the functions of enterprise management as a mechanism of equilibrium of the internal components of the enterprise under the influence of environmental conditions. The solution to a complex problem is its decomposition in aspects of consideration [24].

The object of the proposed mechanism for managing the use of production capacity is the production potential of the enterprise.

Improving the efficiency of capacity utilization requires continuous planning. Moreover, the plans are needed, of course, both operational and strategic. The formation of the mechanism for controlling the use of production capacity takes its basis in strategic planning, since the achievement of the desired result depends on a number of interdependent decisions.

The basis of the proposed mechanism for managing the use of production capacity (Figure 1) is the process of forming a strategy to improve the efficiency of the use of production capacity, implemented through a method of analyzing hierarchies.

The strategy to improve the efficiency of the use of production capacity is based on the results of coordinated actions in the field of planning, organizing and monitoring activities for the use of production capacity of the enterprise. The above activities are cyclical in nature, according to the result of which the management entity makes decisions on making the appropriate changes, focusing on the achievement of planned indicators and factors of the external and internal environment of the enterprise.

The subject of management of the process of using production capacity in an enterprise in order to make a rational managerial decision requires the decomposition of a complex problem into simpler particular tasks. This is the focus of the hierarchy analysis method (analytic-hierarchical process). The method is based on ordinal processing, i.e. “Soft” information that comes to the decision maker (DM), and on the basis of this incomplete information, allows us to determine a number of alternative solutions [20].

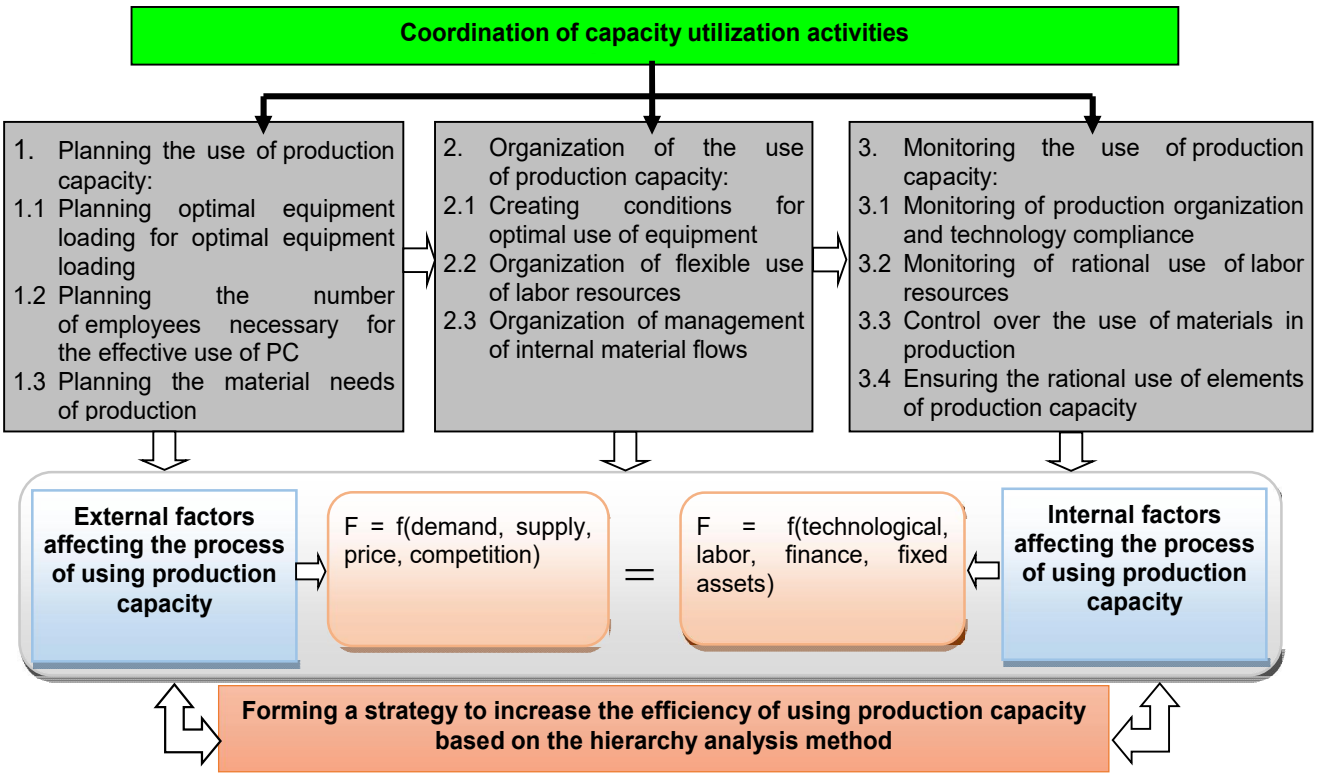

Figure 1 Mechanism of managing the use of production capacity of a textile enterprise (Source: author`s elaboration)

The whole mechanism is focused on the choice of the strategy of the enterprise; here the formation of a strategy to improve the efficiency of the use of production capacity is a key element. It should be noted that external and internal factors influence the formation of a strategy for increasing the efficiency of production capacity utilization.

The system of goals for making strategic decisions does not always have a specific form; moreover, it is first necessary to develop the targets required for making a decision. In the course of the sequential identification and formulation of the main goals through the definition of sub-goals, a hierarchical target system is created. At the same time, it is also necessary to establish differences in the importance of goals of one hierarchical level. However, with the growing number of criteria taken into account when evaluating alternative solutions, the ability of the decision maker (DM) to analyze problems decreases [23].

For optimization, it is reasonable to use a multistep decision choice using a modified hierarchy analysis method [13] using rapid estimates of dominance and different weights of experts depending on their qualifications and consistency. Such approaches allow to exclude the least significant variants of the criteria and get rid of the analysis of obviously losing alternatives. A fairly large number of papers are devoted to theoretical methods for substantiating such approaches [4-19]. An interesting example of using the combined multi-stage method to simplify the management of competitiveness is given in [20].

In this article, we will call the “analysts” a group of experts working on the adoption of an optimal mechanism for managing an enterprise. “Stakeholders” will name all interested persons whose opinion will be taken into account when searching for the appropriate solution. All together we will call "experts."

In some cases it is important to take into account the different significance of the opinions of experts. For this purpose, we introduce the concept of the weight of the expert, v_i, $i = 1,\ldots,m$, where m - the total number of experts. For simplicity, further calculations will assume that the weights of the experts are normalized: $v_1 + v_2 + \ldots + v_m = 1$.

To select the optimal solution in these systems, it is proposed to use the following multi-stage mechanism for choosing the optimal solution, built on a combination of survey methods, analysis of dominance and analysis of hierarchies.

Stage 1 Formation of a preliminary extended list of alternatives and criteria and their rapid assessment.

Stage 2 Optimization of the number of alternatives based on the choice of their Pareto-effective set.

Stage 3 Determining the weights of the significance of the criteria and optimizing their number by eliminating the extremely insignificant.

Stage 4 Stakeholder survey with a view to pairwise comparison of alternatives by criteria. Determination of the final weights of alternatives using the Saaty method and various weighting factors of the stakeholders, adjusted to the consistency of the assessment. [24]

If necessary, alternative leaders obtained in the final stage can be analyzed using more labor and financially costly methods.

Stage 1 Analysts present their options for criteria and alternatives for management decisions

A set of criteria and alternatives are proposed to complement the stakeholder. After offering their options, they also give a preliminary assessment on a 5-point scale to the criteria and alternatives for the tables (see below). Having collected all the offers, a similar 5-point evaluation is carried out by analysts.

Table 1 Criteria rating scale

Score	The importance of the criterion
5	Very important criterion
4	Important criterion
3	Criterion can be considered
2	Criterion can be ignored
1	The criterion is not worthy of consideration or the criterion is not named by this stakeholder

Table 2 Scale of preliminary assessment of alternatives

Score	Quality alternatives
5	One of the best management solutions
4	Good management decision
3	Acceptable management decision
2	Bad management decision
1	Very bad management decision option or Alternative not named by the respondent stakeholder

As a result, after the end of the first stage, we obtain two matrices of preliminary estimates:

$$\mathbf{A}_0 = \left(a_{ij}\right) \quad (1)$$

where a_{ij} – evaluation of the j-th alternative by the i- expert; $j = 1,\ldots,N_a$, N_a - total number of alternatives.

$$\mathbf{C}_0 = \left(c_{ik}\right) \quad (2)$$

assessment of the k-th criterion by i-the expert; $k = 1,\ldots,N_c$; N_c - total number of criteria.

If it is clearer, you can write: We get two tables of rapid assessment:

Table 3 Scale of preliminary assessment of alternatives

$\mathbf{A_0}$	Alternative 1	Alternative 2	…	Alternative N_a
Expert 1	a_{11}	a_{12}	…	a_{1N_a}
Expert 2	a_{21}	a_{22}	…	a_{2N_a}
...	…	…	…	…
Expert *m*	a_{m1}	a_{m2}	…	a_{mN_a}

$\mathbf{C_0}$	Criterion 1	Criterion 2	…	Criterion N_c
Expert 1	c_{11}	c_{12}	…	c_{1N_c}
Expert 2	c_{21}	c_{22}	…	c_{2N_c}
...	…	…	…	…
Expert *m*	c_{m1}	c_{m2}	…	c_{mN_c}

Stage 2 A Pareto-optimal set of alternatives is selected

An alternative string p is considered to be dominated if there is another row in the same table such *q* that all its indicators are not worse than the indicators of the row k and there is at least one better:

$$\forall i : a_{qi} \geq a_{pi}; \quad \exists l : a_{ql} > a_{pl} \tag{3}$$

Dominated alternatives can be removed from consideration. Indeed, they are inferior to other alternatives in the opinion of all experts. As a result of the stage, the matrix of alternatives can significantly decrease and take the form:

$$\mathbf{A} = \left(a_{ij}\right) \tag{4}$$

$j = 1,\ldots,n_a$, where n_a – new number of alternatives, $n_a \leq N_a$.

It should be noted that it is impossible to do the same with criteria because even less significant criteria can influence the choice if the indicators of alternatives are equal by the leading criteria.

Stage 3 Determined by the weight criteria

In this case, the comparison of criteria according to the Saaty method [21] is carried out with the only difference that pairwise comparison of criteria based on an expert survey is not carried out, and previously obtained express estimates are used for comparison matrices. To translate the assessments of each expert into quantitative points of comparisons, it is proposed to use the following relationships:

Table 4 Scale schedule for the assessments of each expert into quantitative points of comparisons

Difference between estimates	Qualitative interpretation	Number indicator
$c_{iq} - c_{ip} = 0$	The criterion *q* is equivalent to the criterion *p*	1
$c_{iq} - c_{ip} = 1$	The criterion *q* is a little more important than the criterion *p*	3
$c_{iq} - c_{ip} = 2$	The criterion *q* is a little more important than the criterion *p*	5
$c_{iq} - c_{ip} = 3$	The criterion is much more important than the criterion	7
$c_{iq} - c_{ip} = 4$	The criterion *q* is fundamentally more important than the criterion *p*	9

If the ratio is inverse, the quantitative indicators are set accordingly: $1, 1/3, 1/5, 1/7, 1/9$.

Thus, for each i-expert, a matrix of pairwise comparisons is constructed:

$$\mathbf{B^i} = \left(b_{kl}^i\right) \tag{5}$$

where always $b_{kk}^i = 1$ and $b_{lk}^i = 1/b_{kl}^i$; $k,l = 1,\ldots,N_c$.

As a result, according to the standard formulas for determining the approximate eigenvalues of this matrix, weights w_k^i of each criterion k are determined according to the i-expert of the:

$$W_k^i = \left(b_{k1}^i \cdot b_{k2}^i \cdot \ldots \cdot b_{kN_c}^i\right)^{1/N_c} \tag{6}$$

$$S_W^i = W_1^i + W_2^i + \ldots + W_{N_c}^i \tag{7}$$

$$w_k^i = W_{ik} / S_W^i \tag{8}$$

It can be shown that with this definition of comparisons they will all be consistent. Based on the weights obtained for each expert, we construct a common weight column for the criteria as a weighted average of experts with regard to their weights:

$$w_k = v_1 w_k^1 + v_2 w_k^2 + \ldots + v_m w_k^m \tag{9}$$

If there are a lot of criteria, then it is possible to carry out a screening procedure. It is proposed to assume unimportant and in the future not to use criteria for which the weights satisfy the following system of restrictions:

$$\begin{cases} w_k < \varepsilon \\ w_k^i < \delta, \quad \forall i \end{cases} \tag{10}$$

where ε and δ are the criteria for screening criteria.

We recommend taking $\varepsilon = 0,05$ and $\delta = 0,1$, but these parameters can be adjusted upwards with too many remaining criteria and downward in the opposite case. After screening off unimportant criteria, it is necessary to repeat the procedure for determining the weights of criteria, starting with the construction of comparison matrices $\mathbf{B^i}$. As a result, we obtain a set of n_c significant criteria ($n_c \leq N_c$) with a weight column *w*:

$$\mathbf{w}^T = \left(w_1, w_2, \ldots, w_{n_c}\right) \tag{11}$$

Stage 4 With an optimized set of alternatives, we perform a pair-wise comparison procedure using significant criteria.

The classical procedure of the Saaty method with a 9-point scale [22] is used. We conduct a survey of experts and compile matrices of pairwise comparisons of alternatives for each criterion for each expert:

$$\mathbf{D^{ki}} = \left(d_{pq}^{ki}\right) \tag{12}$$

where superscripts denote *i*-th expert's opinion on the k-th criterion.

$d_{pq}^{ki}=1$	if, in i -the expert's opinion, the alternative p and q alternative are indifferent from the point of view of the k -th criterion;
$d_{pq}^{ki}=3$	if, in i -the expert's opinion, the alternative p is slightly better than the alternative q in terms of k -the roth criterion;
$d_{pq}^{ki}=5$	if, in i -the expert's opinion, the alternative p is better than the alternative q in terms of the k -th criterion;
$d_{pq}^{ki}=7$	if, in the opinion of i -the expert, the alternative p is significantly better than the alternative q in terms of the k _th criterion;
$d_{pq}^{ki}=9$	If, in the opinion of i -the expert, the alternative p is fundamentally better than the alternative q in terms of the k -th criterion;

always:

$$d_{pp}^{ki}=1,\quad d_{pq}^{ki}=1/d_{qp}^{ki} \tag{13}$$

Next is the procedure for determining the weights of alternatives:

$$G_p^{ki}=\left(d_{p1}^{ki}\cdot d_{p2}^{ki}\cdot\ldots\cdot d_{pn_a}^{ki}\right)^{1/n_a} \tag{14}$$

$$S_G^{ki}=G_1^{ki}+G_2^{ki}+\ldots+G_{n_a}^{ki} \tag{15}$$

$$g_p^{ki}=G_p^{ki}/S_G^{ki} \tag{16}$$

In addition, consistency relationships are defined to compare each expert for each criterion [22]:

$$\Sigma_q^{ki}=d_{1q}^{ki}+d_{2q}^{ki}+\ldots+d_{n_aq}^{ki} \tag{17}$$

$$L^{ki}=\Sigma_1^{ki}\cdot g_1^{ki}+\Sigma_2^{ki}\cdot g_2^{ki}+\ldots+\Sigma_{n_a}^{ki}\cdot g_{n_a}^{ki} \tag{18}$$

$$CI^{ki}=\frac{L^{ki}-n_a}{n_a-1} \tag{19}$$

$$CR^{ki}=\frac{CI^{ki}}{RI} \tag{20}$$

where RI - random index of consistency, which is determined depending on the number of alternatives on the table:

Table 5 Values of the random consistency index

n_a	3	4	5	6	7	8	9	10	11	12	13	14
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57

As is known, comparisons are considered consistent if *CR ≤0.1*; poorly matched comparisons for *0.1<CR≤0.2* and inconsistent for large values *CR*.

In order to take into account consistency, it is proposed, when weighing the weights of alternatives, to multiply i -the expert's weight v_i by an additional "coefficient of consistency" z^{ki} of his opinion on the k -th criterion, defined as follows:

$$z^{ki}=\begin{cases}1 & , \quad CR^{ki}\le 0,1\\ 0,5 & , \quad 0,1<CR^{ki}\le 0,2\\ 0 & , \quad CR^{ki}>0,2\end{cases} \tag{21}$$

So, the weights of alternatives according to all criteria are obtained as weighted average by weight of experts, taking into account the consistency of their opinions:

$$g_p^k=g_p^{k1}\cdot v_1\cdot z^{k1}+g_p^{k2}\cdot v_2\cdot z^{k2}+\ldots+g_p^{km}\cdot v_m\cdot z^{km} \tag{22}$$

where g_p^k - weight alternative p by criterion k .

As a result, we determine the matrix of weights of alternatives by the criteria:

$$\mathbf{G}=\left(g_p^k\right) \tag{23}$$

Multiplying matrix G by w vector, we get the final column of weights of alternatives to achieve our goal:

$$\omega=G.w \tag{24}$$

or if to paint on elements:

$$\begin{pmatrix}\omega_1\\ \omega_2\\ \vdots\\ \omega_{n_a}\end{pmatrix}=\begin{pmatrix}g_1^1w_1+g_1^2w_2+\ldots+g_1^{n_c}w_{n_c}\\ g_2^1w_1+g_2^2w_2+\ldots+g_2^{n_c}w_{n_c}\\ \vdots\\ g_{n_a}^1w_1+g_{n_a}^2w_2+\ldots+g_{n_a}^{n_c}w_{n_c}\end{pmatrix} \tag{25}$$

The alternatives with the greatest weights ω_p are accepted as alternatives-leaders and are recommended for implementation in production.

The approbation of the mechanism shows that it is necessary to take the necessary measures to improve the efficiency of the use of production capacity at the enterprise Namangan Tukimachi LLC. The proposed method of forming a strategy for increasing the efficiency of using production capacity based on the hierarchy analysis method is universal and can be used in other industries.

5 CONCLUSIONS

In this study, we tried to create a mechanism for determining the optimal management of production capacity in the textile industry. The basis of the mechanism is the formation of the company's strategy, which are defined by goals. AHI is used to select the optimal control. In its original form, the AHI implies the use of the original approach by T. Saati to calculate the relative significance of the signs and the formation of estimates of the relative importance of alternatives in terms of signs, as well as using the majority principle for the final calculation of the weights of alternatives. However, the method does not provide for taking into account the presence of problem situations; on this basis, we used the choice of a Pareto-effective set of alternatives.

And so, the method of analyzing hierarchies in such systems has two rather important advantages: it allows stakeholders to express a subjective view of an enterprise's value system, and the method minimizes subjectivity (including lobbying) in relation to specific alternatives. Indeed, after defining specific criteria using the system, it is rather difficult to imagine a substantially non-objective comparison of alternatives to them. The results are important for decision-making in textile enterprises, as well as for other sectors of the economy.

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