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Algorithms for Making Managerial Decisions in the Digital Economy

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ABSTRACT

For solving the existing problems such as loss of sales and customer dissatisfaction, it is necessary to improve promptly the properties of manufactured products in accordance with the dynamically changing market demands. This requires the development of special methods and models for making managerial decisions in conditions of uncertainty and risk. Such decisions could become an algorithm for artificial intelligence of digital technologies, which determines the relevance of the study. The subject of the study is choosing the most significant decisions in conditions of uncertainty and risk. The goal is to find opportunities for making informed decisions for poorly structured, non-formalized processes when developing new product designs with characteristics that meet the rapidly changing needs of the business environment. The solution uses the method of prioritization with expert assessments, groupings, comparisons. The result of the research is the development of a priority setting model with the identification of existing shortcomings and the proposal of changes and additions that eliminate shortcomings in relation to the problem being solved. The author concluded: the developed model, when used in management decisions, allows us to determine the best functions of the product for their inclusion in the design of the innovative model; to make a rating of the significance of functional properties for the consumer and the manufacturer. The development of a methodology with the elimination of the shortcomings of previous studies is a scientific novelty. The obtained methodology contributes to maximizing the demand and competitiveness of the management model, operational innovative changes in the properties of the product corresponding to the rapidly changing demands of the competitive business environment and can be used in the formation of a knowledge base in neural networks of digital technologies. It solves the problem of responding to dynamic changes in consumer preferences, as well as introducing technological innovations in the production of goods, that entail changes in the company's business processes focused on improving the quality of the final product, which determines the success of strategic business development. The companies' management may apply the results of the research in the development of corporate governance strategies, researchers, university students, etc.

Keywords: custom solutions; innovative projects; strategic investment decision making; prioritization method; compensation for lack of information; uncertainty and risk; non-formalized process; expert method; business environment

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INTRODUCTION

In a digital transformation environment, it is important that economic-mathematical management methods can be used as artificial intelligence algorithms. For this need that the models developed gave prepared management individual solutions, contributing to the success of the business in specific circumstances, taking into account the place, time and circumstances. Production organizations are increasingly faced with the challenge of transition from *equipment orientation* to *individual* solutions, and them starting to come up with these solutions. At the same time, organizations periodically face by serious problems, such as loss of sales and customer dissatisfaction. [1]

At the solution of problems, organizations in different sectors consider either the individual life cycle of the project or individual project management by sector. [1] Based on resilient to business cycles, A.V. Kolobov proposes to apply maturity assessment matrix in the context of stages of development of the company when analyzing the sustainability of the company. [2, p. 21–32] Our proposed priority setting methodology, in addition to maturity assessment, allows to adapt production to the dynamically changing requirements of business environment, so that the level of maturity passes into active growth.

In innovative projects, developers often faced by organizational inertia that hinders innovation processes. This phenomenon has been researched in the literature, which also considers the positive impact of innovation on productivity. [3]

As is known, innovation processes are impossible without strategic investment decision making (SIDM). В открытых источниках встречается четыре различных стиля (или акцента) SIDM: management authority, financial analysis, senior leadership and strategies are based on investment. Thus, the authors from Pakistan, after empirical research on the influence of contextual variables on the styles of strategic investment decisions, came to the conclusion, that high expected profitability is only related to the investment style based on financial analysis and the four styles of SIDM (or accents) listed above. [4]

As a supplement, we offer as key tools to achieve high expected profitability with an investment style, based on financial analysis and four focus areas, performance management. [5]

But it takes fundamental approaches to price management [6] and rational international cooperation on an equal basis of mutual benefit. [7] But in order to achieve high profitability in these conditions, need rapid innovation changes in the properties of the product, responding to the rapidly changing demands of a competitive business environment. [1] To do this, we propose to use a model base on method the assignment of priorities.

There are other important factors that determine the innovation of companies to varying degrees. [8, p. 24–35]. The assignment of priorities model has the advantage of not only identifying essential parameters but also determining their significance quantitatively. To form an initial set of data for the development of a standard management model of innovative development of a company allows practical approbation of proposals made on specific economic entities. In our case, we get an array in the form of an intellectual base that allows us to improve the quality of the products in accordance with the rapidly changing demands of the market.

It is important to take into account the views of stakeholders when determining the significance of parameters and factors. To this end, we propose that their representatives be included in the panel of experts and that the latter's assessments be used in establishing an assignment of priorities model, oriented

towards value creation for interested parties (model considered in [9, p. 2–16]).

MATERIALS AND METHODS

When forming artificial intelligence in digital control [10, p. 1–9; 11, p. 283–297] use deterministic and stochastic methods and models. Where unambiguous decisions are possible (with functional dependencies and full information), the algorithm of calculation and control "falls" in the program of artificial intelligence without any difficulties, forming a knowledge base based on deterministic methods of economic analysis, which is rarely observed in a market economy. In practice, business faces an environment where information is incomplete and management processes are poorly structured or not formalized. This creates uncertainty and associated risk, which is originally inherent for market relations. For these challenges are required methods, compensating for lack of information, and for digitalization management — algorithms using stochastic methods and models.

In the process of generating missing data, experts are engaged to apply heuristic methods (methods of expert evaluations), which forms the database necessary to create a knowledge base of artificial intelligence in digital neural networks. At the digital level, automated expert systems can be used as experts, provided that they have appropriate artificial intelligence algorithms. [10, p. 1–9; 11, p. 283–297] The subject of our research is the creation of such algorithms, and purpose — is to develop a method of forming the functions of the product model, which are in demand by the consumer, with the lowest possible production and then operating costs.

Thus, we solve the problem of functional-cost analysis (FCA) under conditions of uncertainty and risk. In order to reduce costs, the article research the degree of necessity and demand of the proposed functions of the model, their quantitative characteristics and identifies the most economical ways to achieve these functions. In this way we can have an economic effect, which could not be achieved by other methods in decision poorly structured, impossible to formalize tasks, and proposed developments can become an artificial intelligence algorithm for digital neural networks for the specified conditions.

The relevance of the functions can be better determined from statistical consumer surveys. When it is impossible or much difficult to spend time and money on the results of such interviews, and if sufficient information is available from specialists from the managers, practitioners from the economic sphere, directly working in this type of production, the task can be solved with the help of such experts.

Importance of each function is estimated at points. For this we will use the method of prioritization, in which to express expert judgments use the method of pair comparisons. [12] Pairwise comparisons release us from the requirement of transitivity, their logical relationships are not straightforward, but relative and more flexible. It is this fact that allows the method to be used in solving poorly structured tasks that cannot be formalized.

Nontransitive (non-conformity with formal logic in a comparison chain) in a pairwise comparison system arises for different reasons. For example, if the expert has varying degrees of knowledge of the objects being assessed, which means that some of them may be assumed to be inaccurate.

Experts who evaluate multiple objects on a single basis may disagree (especially if each assesses only part of the objects), and then some contradictions may arise.

One expert who evaluates all objects may have a different threshold variation to some

of them. If the assessment of the same objects by different experts on the basis of the established criteria achieved transitive results, then their grouping may not exclude violations of this principle. Therefore, pairwise comparisons are more consistent with the subjective nature of preferences: they are less limited and do not have rigid a priori transitive conditions.

In a transitive comparison system, when comparing a pair of objects with an erroneous result, it should be taken into account when comparing other pairs, which can lead to new errors. If pairwise comparisons are not limited by transitive requirements, the objects are compared independently of the results of other comparisons. Therefore, an error in one of the comparisons will not reduce the credibility of the others, which will reduce the impact of possible incorrect results on the accuracy needed and sufficient to make the right management decision.

Thus, the main advantage of the priority setting method is that it is applicable in all methods of examination results processing: both transitive and nontransitive. The mathematical content of this method is the so-called "leader problem". Usually, the identification of the leader (object with the highest rank) and the allocation of seats among the participating objects is done by summing the scored points; at the same time, the strength of objects participating in the competition, which have not become the leaders of the rating, is not fully taken into account. The method of prioritization takes into account the strength of all participants with the most accurate allocation of seats.

In order to construct a model of ranking of studied objects let's denote them through X_i, where i — sequential number of objects from 1 to n. Then draw up a matrix of paired comparisons $R = |r_{ij}|$, where j — object sequence number X_j, matched against to object X_i.

$$\begin{vmatrix} r_{11} & r_{12} \dots & r_{1j} & \dots & r_{1n} \\ r_{21} & r_{22} \dots & r_{2j} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ r_{i1} & r_{i2} & \dots & r_{ij} & \dots & r_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{n3} \dots & r_{nn} \end{vmatrix},$$

$$\text{where } r_{ij} = \begin{cases} 1{,}5, \ if \ X_i \succ X_j \\ 1, \quad if \ X_i = X_j \\ 0{,}5, \ if \ X_i \prec X_j \end{cases},$$

where $X_i \succ X_j$ means that i-object is more preferable to the analyzed features than j-object, or satisfies the condition of the j- object, or removes the defect indicated by X_j.

$X_i = X_j$ indicates that i and j objects are equivalent on the basis of the reference, are in a critical ratio when object i does not contribute, but does not prevent the realization of condition j of the object X_j, or these conditions i and j are not related and independent of each other.

Condition $X_i \prec X_j$ indicates that object i is less preferable to object j. Or object i cannot fulfil the condition of object j. Either the i-object prevents the implementation of condition j, or eliminates the possibility of remedying the defect j.

The disadvantage of this method is that the comparison X_i and X_j reflects the preferences of the functional characteristics researched, but does not reflect their relevance to the preferences of other characteristics researched. Three numerical estimates from 0.5 to 1.5 answer the question: does or does not match the property characteristic j or is not related to it? But when choosing features it is also important to know how significant the feature. Otherwise, the meaningful and insignificant characteristics will receive the same estimates if both satisfy the condition of the corresponding property j.

Therefore, we recommend, depending on the property of the function under study, to use unclear multiple:

if $X_i \succ X_j$ select an evaluation from 1.5 to 2;

if $X_i \prec X_j$ select an evaluation from 0 to 0.5.

In the process of solution apply multiple calculations k for the object are applied X_i. In the integrated evaluation of the zero value of object X_i use the designation $S_i(0)$. And calculate by using the expression:

$$S_i(0) = \sum_{i=1}^{n} a_{ij}. \quad (1)$$

So, we got the primary iteration to the results evaluation. Move on to the next iteration using a formula called the main management of the priority setting method:

$$S_i^n(k+1) = \sum_{i=1}^{n} a_{ij} S_j^N(k), \quad (2)$$

where $S_j^N(k)$ — normalized integrated value k for object X_i, which expression defined:

$$S_j^N(k) = \frac{S_i(k)}{\sum_{j=1\to n}^{n} S_i(k)}. \quad (3)$$

The solution is terminated on the iteration of the value k, which yields an approximation accuracy value that satisfies a sufficiently small number ξ predefined. In this case, the inequality is satisfied:

$$S_i(k) - S_i(k-1) \le \xi;\ i = 1,2,2\ldots,n. \quad (4)$$

In normal cases it is customary to choose a value of ξ in the range 0.01÷0.001, at which the ranking is considered to be sufficiently accurate.

In the solution, we will arrange to use the following symbols:

$S(k) = \{S_i k\}$ — vector-column of integrated estimates of value k;

$S^N(k) = \{S_i^N k\}$ — vector-column of normalized integrated estimates of value k.

Then the ranking will be done using expressions:

$$P(k) = \begin{Bmatrix} S_1(k) \\ S_2(k) \\ \ldots \\ S_i(k) \\ S_n(k) \end{Bmatrix} \text{ and } S^N(k) = \begin{Bmatrix} S_1^N(k) \\ S_2^N(k) \\ \ldots \\ S_i^N(k) \\ S_n^N(k) \end{Bmatrix}. \quad (5)$$

In this regard get the basic equation of the method of ranking in matrix form:

$$S^N(k+1) = A \cdot S^N(k). \quad (6)$$

CALCULATIONS AND RESULTS

In the example considered by E. A. Prikhodko [12], to solve the problem create a matrix, were placed short-term financial policy objectives on horizontally and vertically. In the solution, a pairwise comparison of tasks of short-term policy is carried out.

This method gives significant results, but it has one major drawback: identical serial numbers vertically and horizontally correspond to the same problem, priority setting therefore does not take into account functionality, weaknesses and options for correcting them.

To eliminate this disadvantage and take these factors into account, we propose a model, where pairwise comparison columns contain objects to be evaluated, and rows contain disadvantages and advantages, which relate to the objects being evaluated for their possession of these advantages and possibilities of overcoming the disadvantages of each of the objects. So, we have two series of digital symbols. And in this method, unlike the

previous one, the number of functionalities in a vertical row may differ from the number of related disadvantages and advantages in a horizontal row.

It should be taken into account that when constructing the model as a key factor of creating market demand, and therefore, and impacts on production, consumers are considered [13, p. 91–101]. Spend rank the quality properties of the product to set their priorities in choosing the construction of models, the most satisfying consumer demand for maximizing the competitiveness of the model for which the functional qualities are selected.

To do this, it is necessary to first study the demand of consumers, which can be done most comprehensively with the methods revealed in the sources [14, p. 1–9; 15; 16, p. 41–53; 17, p. 54–67; 18, p. 43–52].

Example. Using the method of prioritization in the role of experts, to carry out ranking of researches functional characteristics of TV models: determine the "leader" and allocate the seats among the remaining. The following functional characteristics of the X_i TV-model are to be evaluated:

1. Supporting Smart TV.
2. Image transmission 4K (UHD).
3. Power front AC 2×20 Вт.
4. Technology PurColour.
5. Technology Quantum HDR 4x.
6. Android operating system.
7. Technology of displays based on quantum dots — QLED.
8. Technology double-lighting — Dual LED.
9. Active speech enhancer — AVA.
10. Interior regime Ambient+.
11. Mode viewing content from smartphone on TV — Mobile View.
12. Availability Blu-ray player.
13. DST audio format.

Inherent disadvantages and advantages X_j:

1. High price.
2. Dependence on the quality of the Internet.
3. Possibility to create a multimedia center, display on a large screen movies and games from PC, tablet and smartphone.
4 High power consumption.
5 Image fit to interior.
6. Availability of free smart-TV channels.
7. Improved clear lines of images.
8. Ability to install (use) the largest number of applications.
9. Ability to rewind the ether and use to TV archive.
10. Recognition of external noise sources and increase of voice volume on screen, reduction of noise interference.
11. High image update rate.
12. High quality of natural sound transmission.
13. Accurate color reproduction.

Using the matrix, fill out a table of pairwise functional characteristics with inherent disadvantages and advantages of the role of experts (*table 1*).

Use *table 2* to define an integrated zero-order estimate $S(0)$; then normalized integrated zero-order estimate $S^N(0)$; integrated first-order assessment $S(1)$ and first-order normalized integrated assessment $S^N(1)$ and etc. until ξ will reach a value not exceeding 0.0001.

Find integrated zero-order estimate $S_i(0)$ as the sum of results of pairwise comparison of functions and their properties by formula (1):

$$S(0) = 1 + 0.5 + 1 + 1 + 1 + 1 + 1 + 1 + 2 + 1 + 1 + + 1 + 1 = 13.5.$$

The integrated estimates of each subsequent pairwise comparison is found similarly.

Then define the normalized integrated assessment as the ratio of the integrated zero-

Table 1

Pairwise comparison results

Functions X_i	Inherent disadvantages and advantages X_j												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	0.5	1	1	1	1	1	1	2	1	1	1	1
2	1	1	1	1	1	1	1.8	1	1	1	1	1	1
3	1	1	1	0.5	1	1	1	1	1	1	1	1.5	1
4	1	1	1	1	1	1	1.5	1	1	1	1	1	1.5
5	0.5	1	1	1	1	1	1.7	1	1	1	1.5	1	1.5
6	1	0.5	1.5	1	1	1.5	1	1.9	1	1	1	1	1
7	0.5	1	1	0.5	1	1	1.8	1	1	1	1.5	1	1.5
8	0.5	1	1	1	1	1	1	1	1	1	1	1	1.6
9	0.5	1	1	0.5	1	1	1	1	1	1.5	1	1.5	1
10	0.5	1	1	1	1.5	1	1	1	1	1	1	1	1
11	1	0.5	1.5	1	1	1	1	1.5	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1.5	1
13	0.5	1	1	1	1	1	1	1	1	1.5	1	1	1

Source: developed by the author.

order estimate to the sum of the integrated formula estimates (3):

$$S^N(0) = \frac{13.5}{175.8} = 0{,}0768.$$

The normalized estimates of each subsequent pairwise comparison are found similarly.

Define an integrated assessment of the first-order. To do this, we find the sum of the multiplications of pairwise comparison of functions with their properties on the corresponding string and normalized integrated estimation of zero-order on the formula (2):

$$S(1) = 1*0{,}0768 + 0.5*0.0785 + 1*0.0739 + 1*0.0796 + 1*0.808 + 1*0.0819 + 1*0.0785 + 1*0.0745 + 2*0.0739 + 1*0.0739 + 1*0.0768 + 1*0.0768 + 1*0.0739 = 1.0347.$$

The integrated first-order estimate for each subsequent pairwise comparison is found similarly, using all 13 indicators of the corresponding graph. Then we go to the second-order with similar calculations, and then to the third in the same order until then, when the difference between the next and the previous values of the orders k and $(k-1)$ of the integrated estimates is no more than $\xi = 0{,}00010$.

In our case (*table 2*), the difference between the total values of the third and second order of the integrated estimates is 0,0001, which satisfies the condition of the expression (4):

$$13.50723 - 13.50713 = 0{,}00010 \leqslant \xi.$$

Therefore, we will accept this iteration as final. By the size of S (3) we see that the first priority is the installation of item 6. Operating system "Android". And then we will build a rating of priorities on this graph:

Table 2

Calculation of the TV-set functional characteristics' significance

Functions *Xj*	0,00010Inherent disadvantages and advantages X_j													*P*(0)	$P^N(0)$	*P*(1)	$P^N(1)$	*P*(2)	$P^N(2)$	*P*(3)
1	1	0.5	1	1	1	1	1	1	2	1	1	1	1	13.5	0.0768	1.03470	0.0766	1.03448	0.0766	1.03450
2	1	1	1	1	1	1	1.8	1	1	1	1	1	1	13.8	0.0785	1.06280	0.0787	1.06278	0.0787	1.06278
3	1	1	1	0.5	1	1	1	1	1	1	1	1.5	1	13	0.0739	0.99858	0.0739	0.99860	0.0739	0.99860
4	1	1	1	1	1	1	1.5	1	1	1	1	1	1.5	14	0.0796	1.07622	0.0797	1.07620	0.0797	1.07621
5	0.5	1	1	1	1	1	1.7	1	1	1	1.5	1	1.5	14.2	0.0808	1.09192	0.0808	1.09191	0.0808	1.09192
6	1	0.5	1.5	1	1	1.5	1	1.9	1	1	1	1	1	14.4	0.0819	1.10575	0.0819	1.10559	0.0819	1.10559
7	0.5	1	1	0.5	1	1	1.8	1	1	1	1.5	1	1.5	13.8	0.0785	1.05995	0.0785	1.05992	0.0785	1.05993
8	0.5	1	1	1	1	1	1	1	1	1	1	1	1.6	13.1	0.0745	1.00597	0.0745	1.00606	0.0745	1.00607
9	0.5	1	1	0.5	1	1	1	1	1	1.5	1	1.5	1	13	0.0739	0.99716	0.0738	0.99739	0.0738	0.99740
10	0.5	1	1	1	1.5	1	1	1	1	1	1	1	1	13	0.0739	1.00199	0.0742	1.00212	0.0742	1.00213
11	1	0.5	1.5	1	1	1	1	1.5	1	1	1	1	1	13.5	0.0768	1.03498	0.0766	1.03486	0.0766	1.03487
12	1	1	1	1	1	1	1	1	1	1	1	1.5	1	13.5	0.0768	1.03840	0.0769	1.03844	0.0769	1.03844
13	0.5	1	1	1	1	1	1	1	1	1.5	1	1	1	13	0.0739	0.99858	0.0739	0.99879	0.0739	0.99880
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	175.8	1	13.50700	1	13.50713	1	13.50723
Итого / Total	-	-	-	-	-	-	-	-	-	-	-	-	-	175,8	1	13,50700	1	13,50713	1	13,50723

Source: developed by the author.

6. Operating system "Android".
5. Technology Quantum HDR 4x.
4. Technology PurColour.
2. Image transmission 4K (UHD).
7. Technology of displays based on quantum dots QLED.
12. Availability Blu-ray player.
11. Mode viewing content from smartphone on TV — Mobile View.
1. Supporting Smart TV.
8. Technology double-lighting — Dual LED.
10. Interior regime Ambient+.
13. DST audio format.
3. Power front AC 2×20 Вт.
9. Active speech enhancer — AVA.

The resulting model serves the purpose as a methodological development, which can be built into the algorithm of neural network programs of intelligent digital technologies to manage an organization under conditions of uncertainty and risk.

CONCLUSION

During the research process, we developed a model to regulate the functional properties of the product, most relevant to the rapidly changing business environment based on prioritization. We identified the disadvantages of this method and suggested ways to address them:

1) determining the preference of the functional characteristics being studied does not reflect their importance relative to the preferences of other characteristics being studied. This disadvantage has been corrected by introducing in model range of estimates in the form of unclear sets;

2) priority-setting does not take into account functionalities, disadvantages and options for overcoming them, as the same vertical and horizontal sequence numbers correspond to the same problem.

Disadvantage eliminated by the introduction of a second series of numerals, so that the pairwise comparison columns contain the objects to be evaluated, and the rows contain the disadvantages and advantages.

As a result of using the management model, we have identified the best functional characteristics for selecting and incorporating them into the design of TVs, by rating assessment, assign their importance to the consumer and producer, taking into account the qualities that contribute to: increase in demand and competitiveness of the emerging model; operational innovation changes in product properties, corresponding to the rapidly changing requirements of a competitive business environment.

Using the proposed model, an enterprise can achieve an economic effect, which is unattainable by other methods in dealing with poorly structured, cannot be formalized objectives that under conditions of uncertainty and risk. The proposed developments can be built into the algorithm of artificial intelligence programs of digital neural networks for the specified conditions.

The resulting methodology involves its inclusion in digital technologies of automated information and analytical functions of compensation, missing information generation, transition from a database to a knowledge base that fills neural networks with artificial intelligence, providing design of management decisions, innovative sustainable development under conditions of uncertainty and risk.

Further direction of this research may be a more detailed selection and grouping of properties (their disadvantages and advantages) for more accurate characterization and development of innovative design components. And in the conditions of clustering science and production, research can be carried out taking into account the conditions of the network interaction of the market. [19]

Next stage — integration of models into the processes of managerial decision-making at the level of elements of information and analytical applications of the complex IS company/organization achievable in the technical field through computer software.

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