УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ" - ШТИП
ФАКУЛТЕТ ЗА ПРИРОДНИ И ТЕХНИЧКИ НАУКИ

UNIVERSITY GOCE DELCEV - STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

UDC: 622:55:574:658

ISSN: 1857-6966

Природни ресурси и технологии
Natural resources and technology

Број 2
No 2

Година 15
Volume XV

Декември 2021
December 2021

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ПРИРОДНИ РЕСУРСИ И ТЕХНОЛОГИИ
NATURAL RESOURCES AND TECHNOLOGIES
За издавачот
Проф. д-р Зоран Десподов

Редакција и администрација	Address of the editorial office
Универзитет „Гоце Делчев” - Штип	Goce Delcev University - Stip
Факултет за природни и технички науки	Faculty of Natural and Technical Sciences
ул. „Гоце Делчев“ 89, Штип	Goce Delcev 89, Stip
Република Северна Македонија	Republic of North Macedonia

Содржина/Contents

UDC: 519.876.2:675.05
DOI: https://www.doi.org/10.46763/NRT21152075t

DATA PROCESSING USING MATHEMATICAL MODELS IN LEATHER INDUSTRY

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Abstract. In the development of the industry of small and medium enterprises that are involved in one of the most specific activities such as working with leather products, it gives and seeks opportunities for optimizing the basic management activities in the work of a company. Today, many data are constantly generated that require proper processing and access to them, especially when it comes to supply chain management. Standard processing techniques may not meet these requirements. The development of information technology and decision theory has contributed to the emergence of the application of modern-applicable methods and approaches to data processing and analysis. The way of processing data from traditional data processing tools are adapted for data processing and with the help of tools and mathematical methods that enable processing and analysis of big data that depend on several criteria such as time, resources, quality, and distance when it is about delivering work material. The identification and analysis of the problem to be solved, the determination of the possible solutions to the problem, the criteria according to which the possible solutions are evaluated, i.e., the alternatives and the choice of the best possible solution is a decision-making process, i.e., a decision-making process, and because of the decision-making process, the decision arises. It is the choice of the best, from the most possible alternative solutions to the problem such as the problem of delivery of specific material such as leather considering the quality and price.

Keywords: data processing, supply chains, data, decision making, analysis, mathematical methods

ОБРАБОТКА НА ПОДАТОЦИ СО КОРИСТЕЊЕ НА МАТЕМАТИЧКИ МОДЕЛИ ВО КОЖАРСКАТА ИНДУСТРИЈА

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Апстракт. Во развојот на индустријата на малите и средни претпријатија кои се вклучени во една од најспецифичната дејност, како што е работата со кожарски продукти дава, но и бара можности за оптимирање на основните управувачки активности при работа на една компанија. Денес постојано се генерираат голем број на податоци кои бараат соодветна обработка и пристап кон истите, посебно кога станува збор за управувањето со снабдувачките синџири. Стандардните техники за обработка не можат да одговорат на овие барања. Развојот на информатичката технологија и теоријата на одлучување допринесе за појава на примена на модерно-применливи методи и пристапи за обработка и анализа на податоците. Начинот на обработка на податоците од традиционалните алатки за обработка на податоци се адаптираат за процесирањето на податоци и со помош на алатки и математички методи кои овозможуваат обработка и анализа на големи податоци кои зависат од повеќе критериуми, како што се времето, ресурсите, квалитетот и дистанцата кога станува збор за достава на материјал за работа. Идентификацијата и анализата на проблемот кој треба да се реши, одредувањето на можните решенија на проблемот, критериумите според кои се оценуваат можните решенија, т.е. алтернативите и изборот на најдоброто можно решение претставува процес на донесување на одлука, односно процес на одлучување, а како резултат од процесот на одлучување, произлегува одлуката. Таа всушност претставува самиот избор на најдоброто, од повеќето можни алтернативни решенија на проблемот, како што е проблемот за достава на специфичен материјал како што е кожата, земајќи го во предвид квалитетот и цената.

Клучни зборови: процесирање на податоци, снабдувачки синџири, податоци, донесување на одлука, анализа, математички методи

1. Introduction

Logistics in the modern world is becoming a current issue to which more attention is paid. In many countries with developed market economies, the share of logistics activities in the formation of gross national product exceeds 20%, which directly affects all aspects of the economy (inflation, productivity, interest rates, etc.). This is one of the main reasons for the increased interest in this issue. In the field of logistics, you can find several terms such as: materials management, physical distribution, business logistics, logistics management (synonymous with business logistics), supply chain management and others. All these terms explain the same area - logistics. The leather industry is of exceptional importance for the economy of the Republic of Northern

Macedonia according to the realized participation in employment and export, but also import of material goods. Unlike some other economic activities and industries, in the field of leather industry relatively more private entrepreneurial initiatives came to the fore, a solid material basis was created, several foreign business relations were established with foreign partners, which is the basis for future development. The labour-intensive character and the opportunities it provides for more balanced regional development are additional features of this industry. The process of globalization and the growing involvement of the national in the international economy pose a number of challenges for the leather industry, for the national economy, and for the country. Most of the companies in the leather industry in R.N. Macedonia are organized as small and medium enterprises with a total number of employees of 30 - 200. This fact is positive, because it provides great flexibility to companies in terms of changing the product range, production of small batches and short delivery time of the final product. This is a key factor for successful cooperation with foreign partners and for the survival of this branch which is under constant pressure from competition and market laws. Macedonian leather production is mainly export-oriented but lately also on import of repro-materials, mostly on and from the European market. [1,2,4]

2. Research methodology

For correct and optimal choice of procurement of material goods for secondary processing of materials in the leather industry of small and medium enterprises, there is a need for technical-economic analysis with the help of multi-criteria decision-making methods. Multi-criterion optimization is an area where a mathematical model is formed for a particular mathematical problem, considering multiple goals at the same time. It is essential that the most favourable alternative solution be found according to all the criteria considered, which can be expressed in different units of measure, different currencies, different probabilities of occurrence or subjective estimates. The task of multi-criteria decision optimization is in cases where important decisions are considered and made, such as capital investment decisions, which are characterized by a relatively large number of criteria. For effective analysis of decisions and finding an appropriate solution, the criteria are selected and grouped into economic, technical, technological, social and environmental criteria. Models that form a mathematical model for a real problem from the beginning consider multiple criteria simultaneously and develop in the field of multi-criteria optimization. Many criteria in the models of multi-criterion optimization mean not only the realization of modelling, but also increasing the reliability of the obtained results. The disadvantages of multi-criteria optimization are the consideration of several criteria and the way they define weights in the model, which in turn makes this process of mathematical modelling complex. The development of multi-criteria optimization methods started with problem solving step by step, i.e., methods for specific problems were developed. Defining the effects of weights in the model of this process with mathematical modelling makes it complex in today's conditions of development of mathematics as a science. There are a few optimization methods and other quantitative mathematical methods that can be applied to problem solving and decision making in the planning and design processes in industry. [3]

2.1 Methods of decision making and their application

Mathematical-model optimization methods have been developed for solving problems in planning and design in the field of mining, which consists of preparatory work for defining and developing the mathematical model. From this set of modelling methods, from the position of application, the following groups can be distinguished:

- Models of one-criteria optimization are: linear programming, nonlinear programming, dynamic programming, etc.
- Models of multi-criterion optimization are: AHP method, ELECTRA method, PROMETHEE method, VIKOR method and others. These methods belong to the group of multi-attribute decision making methods. Working with them is different depending on how the models are calculated and the input data (alternatives and criteria).

The most characteristic methods of multi-criteria decision optimization are the ELECTRA method group, the PROMETHEE method group and the AHP method.

- ELECTRA method - The ELECTRA method means a set of methods for solving problems from multi-criteria optimization. There are several variants of this method and the most famous are the variants ELECTRA I and ELECTRA II. The ELECTRA II method is used in cases of complete ranking of the set of alternatives and this group of methods enables the ranking of a set of solutions for discrete problems and for various criterion functions.
- PROMETHEE Method - The PROMETHEE method is one of the newer methods in the field of multi-criteria optimization, where there are several variants of this method, as follows: PROMETHEE I, PROMETHEE II, PROMETHEE III, PROMETHEE IV, PROMETHEE VI and PROMET GDSS and PROMETHEE-GAIA. The PROMETHEE method is characterized in the group of methods, where alternatives are ranked based on multiple decision criteria. Multi-criterion optimization with the PROMETHEE I method gives the possibility for a partial order of the alternatives, while PROMETHEE II

gives a complete order. The PROMETHEE III method provides ranking of alternatives at appropriate intervals and finally the PROMETHEE IV method performs multi-criteria optimization, related to a range of alternatives. As in the other methods of multi-criterion optimization, in the PROMETHEE methods it is possible to specifically define the appropriate weights for the criteria.

- AHP Method - The Analytical Hierarchical Process (AHP) method was developed by Thomass Saaty (1980), who is the founder of the method as a professor at the Wharton Business School in Philadelphia and is a tool in decision analysis. The method of analytical hierarchical processes is one of the classic methods of multi-criteria optimization, which solves complex decision-making problems. Based on defined decision criteria, it helps researchers in choosing the most favourable alternative. This method is suitable for use in cases when there is not enough information from the observed alternatives in the decision-making process. [1]

3. Material and method of operation

The decision-making process is often extremely complex due to the presence of competitive and conflicting goals among the available criteria or alternatives. Decision-making practices often deal with weighted alternatives, all of which meet the set of desired goals. The problem is to choose the alternatives that will best meet the overall package of goals.

Analytical hierarchical process (AHP) is based on the concept of balance used to determine the overall relative importance of a set of attributes, activities or criteria and refers to the analysed problem with the decision. This can be achieved by structuring any complex decision-making problem, involving multiple individuals, multiple criteria, and multiple periods at several hierarchical levels, assigning weights in the form of a series of double-piece matrices, and then using Expert decision support system to determine normalized weight. These weights are used to estimate the attributes at the lowest level of the entire hierarchy. The thus understood process of modelling includes four stages:

- Problem structuring,
- Data collection,
- Relative weight assessment and
- Determining the solution to the problem.

The problem structuring stage consists of breaking down a complex problem of decision-making into a series of hierarchies where each level represents a smaller number of managed attributes. Then, they break down into another set of elements that correspond to the next level and in the same order as *Figure 1*. This hierarchical structuring of any problem-solving problem in this way is an effective way to deal with the complexity of real problems and identify significant one’s attributes in order to achieve the overall goal of the problem. Therefore, the method (AHP) possesses and provides exceptional flexibility in assisting decision-making processes. The method (AHP) allows the realization of independence - independence between attributes to disintegrate at different hierarchical levels. [1]

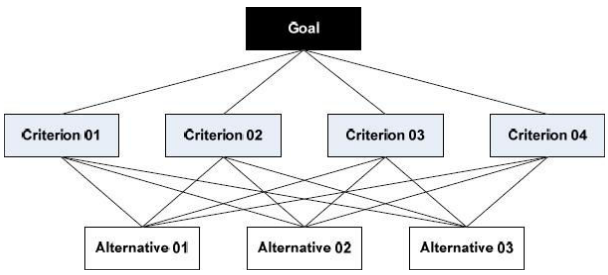

Figure 1. Structuring the problem

The second stage of the method (AHP) begins with data collection and measurement. It is then necessary to assign a relative estimate of pairs of attributes to one hierarchical level, then to the next level, and so on, to the last level. A nine-point scale for weight distribution in *Table 1*, has proven to be extremely reliable in solving real-world problems.

Table 1. Nine-point scale according to Saaty

AHP Scale of Importance for comparison pair (a_{ij})	Numeric Rating	Reciprocal (decimal)
Extreme Importance	9	1/9 (0.111)
Very strong to extremely	8	1/8 (0.125)
Very strong Importance	7	1/7 (0.143)
Strongly to very strong	6	1/6 (0.167)
Strong Importance	5	1/5 (0.200)
Moderately to Strong	4	1/4 (0.250)
Moderate Importance	3	1/3 (0.333)
Equally to Moderately	2	1/2 (0.500)
Equal Importance	1	1 (1.000)

The third stage of the method (AHP) involves the assessment of relative weights. Pair comparison matrices will turn into problems with important values to obtain normalized and unique weight agitators for all attributes at each level of the hierarchy. The assumption is that there are n levels of the hierarchy of attributes $A_1, A_2, \ldots, A_n$ with vector weight $t = (t_1, t_2, \ldots, t_n)$. It is necessary to find t to determine the relative importance of $A_1, A_2, \ldots, A_n$. Approaching the comparison of pairs A_i and A_j of all attributes, as the degree to which A_i dominates over A_j, i.e. we are, i.e., to be able to form a matrix for comparing pairs.

$$A = (a_{ij}) = \begin{pmatrix} t_1/t_1 & t_1/t_2 & \dots & t_1/t_n \\ ::: & ::: & ::: & ::: \\ t_n/t_1 & t_n/t_2 & \dots & t_n/t_n \end{pmatrix}$$

The last stage of the method (AHP) involves finding a composite normalized vector. Because successive hierarchical levels are interconnected, the single composite vector of unique and normalized weight vectors for the entire hierarchy will be determined by multiplying the weight vectors by all subsequent levels. This composite vector will then be used to find the relative priorities of all subjects at the lowest hierarchical level, which allows to achieve the set goals of the overall problem.

The method (AHP) is very successfully used to solve several real-world problems: when choosing an operating system for a local computer network, to study a product / market / distribution when generating and evaluating new production concepts, to predict the real price of products.

4. Research study using the method of Analytical Hierarchical Process (AHP)

The main purpose of this paper is to propose a modern scientific methodology such as (AHP) that will be used in selecting the most favourable producers and supplier of leather material for a company, using the methods for multicriteria decision making as a modern approach uses:

- analyse the problem.
- to identify alternatives (variant solutions).
- selection of criteria and definition of their weights.
- to transform the qualities of the attributes (criteria).
- making a multi-criteria model.
- solving the model and
- Determining the optimal solution.

When making orders, it is necessary to develop a production plan that requires knowledge of the procurement and operation of a production company as well as appropriate material resources to perform an activity most efficiently and cheaply in production and orders "from-to" a certain place and distance. The process of correct selection of material according to the offer from a given bidder where the factor-criterion that has been taken is both the transport and the price of the material which is an important factor in the optimization. This problem is recorded in the routing and planning of routes using various optimization techniques such as network planning, transport problem and linear programming to optimize an activity that in this case requires the most efficient supplier of materials and orders from the place of production. To solve the problem, it is necessary to analyse the technical-economic parameters by making a model for selection of an appropriate manufacturer and supplier of material, according to a multi-criteria decision-making method.

In our case, four alternative hypothetical models of material manufacturers and suppliers are given, which should be used for an industrial process in which chemical preparations with their basic characteristics are used:

Table 2. Nine-point scale according to Saaty

No.	Alternative	Mark
1	Istanbul - manufacturer and supplier	A1
2	Thessaloniki - manufacturer and supplier	A2
3	Belgrade - manufacturer and supplier	A3
4	Sofia - manufacturer and supplier	A4

Defining criteria for multi-criteria decision making:
Criteria 1 - Price of leather material by appropriate quantity,
Criteria 2 - Material performance ("positive" leather properties),
Criteria 3 - Delivery time, (*hours*)
Criteria 4 - Location (distance from production site to industrial plant) (*km*),
Criteria 5 - "Material quality" according to the method (appearance / colour and skin tones).

4.1 Solving a multi-criteria model in selecting the best manufacturer and bidder according to the requirements of a company

The calculation methodology uses the AHP method for multi-criteria decision making described in the previous chapters. The data used for this illustration of problem solving are hypothetical. At the beginning, a decision matrix is formed with quantitative and qualitative assessments of the criteria that were considered as input data of the model, during processing the following matrix is obtained.

Table 3. Real data from the bidders

Alternatives	**Criteria**				
	К1	**К2**	**К3**	**К4**	**К5**
Goal	min	max	min	min	max
A1	3100	1,5	9,10	814	Very High
A2	6250	1,4	2,53	237	High
A3	5910	1,2	4,40	432	Average
A4	4560	1,1	3,45	242	Average

The transformation of qualitative attributes, i.e. in numerical values and they are ranked for each alternative in numerical scale that are presented in the matrix form of the AHP algorithm method that provides means for decomposing parts of the problem in a hierarchy of subproblems that can be more easily understood and subjectively evaluated. Subjective assessments i.e. evaluations are converted to numerical values and they are ranked for each alternative with numerical values from the Saaty scale., which is called a quantified decision matrix represented by the following appearance:

Table 4. Nine-point scale according to Saaty with numerical values

Qualitative assessment	**Very low**	**Low**	**Average**	**High**	**Very High**	**Type of criteria**
Quantitative assessment	1	3	5	7	9	max
	9	7	5	3	1	min

Table 5. Nine-point scale according to Saaty with numerical values presented in the real data from the bidders

Alternatives	**Criteria**				
	К1	**К2**	**К3**	**К4**	**К5**
Goal	min	max	min	min	max
A1	3100	1,5	9,10	814	9
A2	6250	1,4	2,53	237	7
A3	5910	1,2	4,40	432	5
A4	4560	1,1	3,45	242	5

The development of a multi-criteria model with the AHP method is structured in four stages and is processed as follows:

- Stage 1. Structuring the problem
- Stage 2. Data collection
- Stage 3. Assessment of relative weights
- Stage 4. Determining the solution to the problem

After performing all stages, it is obtained from the given parameters that as the best bidder regardless of who the manufacturer is but who meets the important criteria such as price of material by purchase quantity and price for delivery or transport as primary, and as secondary important parameters quality of purchased material for production taking into account that it is the same leather material that is obtained by a specific production method regardless of the industrial plant that will be used by all manufacturers and suppliers, it is obtained that:
„In the last and final stage for determining the solution of the problem, the overall synthesis of the problem for optimal selection of material procurement from certain products of a specific order has been performed in this case chemical material used in a certain industrial plant.“

Table 6. Data before interaction and Criteria weight

Criteria	**Criteria weight**	**A1**	**KxA1**	**A2**	**KxA2**	**A3**	**KxA3**	**A4**	**KxA4**
K1	0,336	0,490		0,338		0,097		0,074	
K2	0,378	0,418		0,383		0,116		0,083	
K3	0,145	0,442		0,392		0,096		0,070	
K4	0,056	0,370		0,455		0,097		0,078	
K5	0,084	0,381		0,459		0,094		0,065	

Table 7. Data interaction and Criteria weight

Criteria	**Criteria weight**	**A1**	**KxA1**	**A2**	**KxA2**	**A3**	**KxA3**	**A4**	**KxA4**
K1	0,336	0,490	0,165	0,338	0,114	0,097	0,033	0,074	0,025
K2	0,378	0,418	0,158	0,383	0,144	0,116	0,044	0,083	0,031
K3	0,145	0,442	0,064	0,392	0,057	0,096	0,014	0,070	0,010
K4	0,056	0,370	0,021	0,455	0,026	0,097	0,005	0,078	0,004
K5	0,084	0,381	0,032	0,459	0,039	0,094	0,008	0,065	0,006
Total			**0,440**		**0,380**		**0,104**		**0,077**

Table 8. Final ranking of the alternatives

	Total	**Rank**
A1	0,440	1
A2	0,380	2
A3	0,104	3
A4	0,077	4

5. Conclusion

This paper presents a process of optimal selection of procurement of leather material for the needs of a small and medium enterprise dealing with primary and secondary production of leather products. The AHP method as a method for multi-criteria evaluation and selection has been used for the research conducted in this paper. The method is first explained theoretically, all the procedures by which it is used in everyday decision-making in the logistics process. The main problem with the application of this method is the definition of decision-making attributes in the second level of the hierarchical structure for the selection of criteria and the assessment of their relative weights. The definition of alternatives is based on the budget and the basic requirements of the end user that would meet the basic criteria for production considered when choosing a suitable supplier of suitable material. After the assessment it is shown that the best supplier is the Istanbul supplier even, although it is the furthest place based on its location, but it is more financial and quality suitable for the enterprise.

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