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Abstract:

In this work, a variant of the method of the multicriteria alternative choice ELECTRE, which allows taking into account uncertainties of expert estimates, was developed and studied. The modified method ELECTRE was tested on a problem solution of the logistics management transportation system "point of departure – point of destination". The suggested approach can increase the effectiveness of logistic management of goods delivery transport systems and reduce delivery time.

Key words: *method ELECTRE, fuzzy sets, neural network, logistics, goods delivery.*

Introduction

Although logistics has deep historical background, it is a rather young science. It developed significantly during World War II when it was applied to solving strategic tasks and organizing a successful cooperation of defense industry, rear supply bases and transport for providing troops. The concepts and methods of logistics began to be also applied in the civilian sector in the following years.

Logistics as a science and as an area of practical knowledge is of a great value nowadays. The activity in the field of logistics includes different areas: management of transport, warehousing, inventory and personnel management, organizational and information support, commercial activity and many others. It is difficult to determine more or less significant areas in the list above because a logistic system can be only a uniform system for delivering materials. A transport system or transport logistics provides such a unity, increasing concurrency of direct participants of logistic processes. The tasks of transport logistics are:

– creation of transport corridors,
– choice of a type of transport,
– choice of a cargo transport route,
– timetable scheduling.

The analysis of this list shows that 1st, 2^{d} and 3^{d} tasks can be solved by means of the graph theory, the methods of network planning, and the combinatorial theory. However, a task of choosing a transport type is a task of a multicriteria alternative choice for which these mathematical methods cannot be used because of their characteristics (Kosko, 1992).

The analysis of various works on transport logistics has shown that mathematical models of a transport type choice are not explained thoroughly. It is enough to use some numerical estimates which are, in most cases, limited to a set of criteria. Such approach does not consider at all uncertainty of expert estimates, different physical and logical meanings of used criteria - for example, cargo delivery speed can be presented by a numerical characteristic, and the cargo safety condition can be presented by a verbal characteristic such as "high, average, low".

It should be noted that, for experts estimating a type of transport, verbal estimates can be more convenient. In this article, a model of a transport type choice in logistic systems is considered, taking into account uncertainty factors.

Problem description

As noted in the introductory section, the task of a choice of a transport type for logistic system creation can be presented as a task of a multicriteria alternative choice where the alternatives are automobile, railway, air, and water (river or sea) means of transport. The following criteria are usually used (Lubentsova, 2008):

– speed of cargo delivery,
– expenses of cargo delivery,

– frequency of departures,

– safety of cargo,

– dependence on climatic conditions,

– reliability of timekeeping,

– ability to transport different freights,

– territorial availability.

It is easy to see that only three criteria can be calculated by numerical estimates for a concrete type of transport, while other criteria can be calculated in a marking system with a scale chosen in advance, or by verbal estimates such as "low, average, high".

Thus, there is an uncertainty in the system of criteria estimates having obviously expressed non statistical nature. That is why the standard task of a multicriteria alternative choice is transformed to a task of the best alternative choice with no statistical uncertainty of criteria estimates.

Different criteria like Wald's, Gurvit's, Bayes-Laplace's and Sevidzh's criteria are usually used for decision making in the conditions of uncertainty. It should be noted that their correct application is caused by certain conditions which are rather far from practice of logistic systems; besides, they cannot work with verbal estimates. The usage of the fuzzy sets theory will be the most suitable in this situation.

The most often used methods of a multicriteria alternative choice are based on the calculation of an integral estimate of alternatives by all sets of criteria. As it was already noted, the criteria of estimation of a transport type have different physical and logical nature; therefore, the correctness of integral convolution demands additional proofs. In these conditions, it is more preferable to use methods in which the choice of the best alternative is based on determining the relations of preference between alternatives, in particular the ELECTRE (Roy, 1996) method. At the same time, the standard ELECTRE method does not assume an uncertainty of criteria estimates.

Decision making procedure

The structure of a choice of a transport type for a logistic system is presented in Fig. 1:
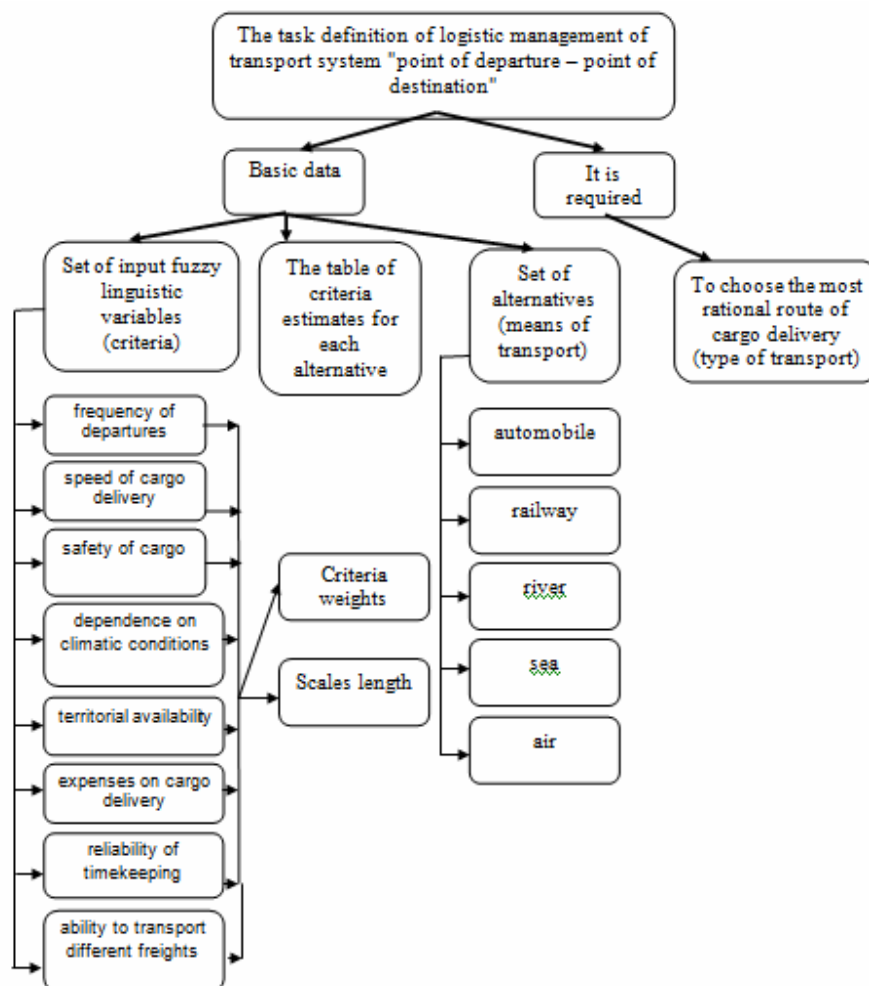
Figure 1 – Structure of a choice of a transport type for a logistic system
Рис. 1 – Изображение выбора вида транспорта в системе логистики
Slika 1 – Slika izbora vrste transporta za logistički sistem

It is necessary to give a set of marks of criteria compliance to each transport type, to define the criterion weight and the length of the corresponding scales. The specified task parameters are estimated in the expert way, so they will be represented as fuzzy numbers.

For this purpose, it is necessary to create a term set of variables and the corresponding verbal-numeric scales (Tab. 1). It can be noted that the numerical values given in Table 1 as well as in other tables have a conditional character. However, this circumstance does not affect the obtained results.

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Table 1 – Verbal-numeric scale of variables
Таблица 1 – Вербально-числовая шкала переменных
Tabela 1 –Verbalno-numerička skala promenljivih

Designation	Linguistic evaluation	Numeric value
speed of cargo delivery	Low	[0, 250]
	Medium	[250, 500]
	High	[500, 750]
safety of cargo	Low	[0, 0.33]
	Medium	[0.33, 0.66]
	High	[0.66, 1]
dependence on climatic conditions	Low	[0, 0.33]
	Medium	[0.33, 0.66]
	High	[0.66, 1]
territorial availability	Low	[0, 0.33]
	Medium	[0.33, 0.66]
	High	[0.66, 1]
expenses of cargo delivery	Low	[0, 250]
	Medium	[250, 500]
	High	[500, 750]
frequency of departures	Low	[0, 33]
	Medium	[33, 66]
	High	[66, 100]
reliability of timekeeping	Low	[0, 0.33]
	Medium	[0.33, 0.66]
	High	[0.66, 1]
ability to transport different freights	Low	[0, 0.33]
	Medium	[0.33, 0.66]
	High	[0.66, 1]

A fuzzy set is determined for each linguistic variable with a membership function set on the corresponding interval, e.g. for the linguistic variable "safety of cargo" = {low, medium, high} = $\{\mu_H(x), \mu_{cp}(x), \mu_B(x), x \in [0,1]\}$. One of the types of a membership function is presented in Fig. 2.
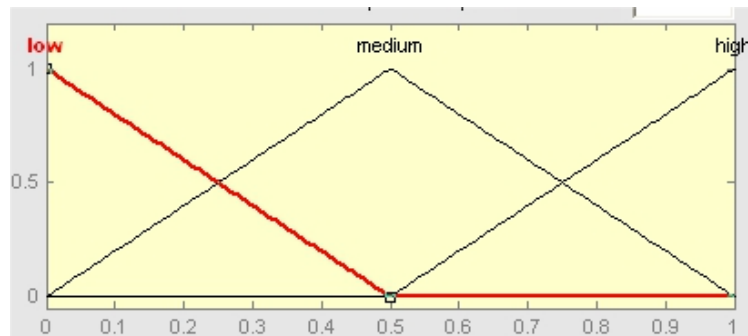

Figure 2 – Type of a membership function
Рис. 2 – Тип функции принадлежности
Slika 2 – Vrsta funkcije pripadnosti

This type of a membership function is chosen only because of the simplicity of graphical presentation. Other types are also possible, but with an obligatory implementation of the rules of a membership functions creation (Malyshev, et al., 1991). An expert determines a corresponding linguistic variable based on concrete criteria for each type of transport.

In the ELECTRE method, it is necessary to set the criterion weight and length of the corresponding scales, except for the estimates of criteria compliance. Defining the criterion weight is a task which always causes many questions (Venttsel, 1972).

The usage of the paired-comparison method with the subsequent calculation of the evector coordinates allows checking of, at least, the correctness of the creation of matrixes by calculating the conformity relation. However, the method is rather time consuming. Besides, as shown in research works (Tutygin, Boxes, 2010), for a large number of criteria, it is rather difficult to provide the established value of the conformity relation. Therefore, despite all shortcomings, expert estimates of values of the criterion weight are still popular and they are also used in the ELECTRE method.

In this research, the expert estimates of scales are presented in the form of fuzzy numbers for the account of uncertainty. The scale length in the ELECTRE method is a particular large-scale coefficient at which various criteria are leveled. A value of the scale length has to be chosen so as to reflect an approximately equal value (importance) of a decision-making criterion, i.e. there is an uncertainty element at the determination of this parameter, as well. For this purpose, scales lengths are also represented by fuzzy numbers.

The usage of estimates in the form of fuzzy numbers allows considering uncertainty of expert estimates, but it also demands to make changes to the algorithm of the ELECTRE method.

There are the sets of alternatives $A = \{ a_i : i = \overline{1, N} \}$ and the sets of criteria $C = \{ c_j : j = \overline{1, M} \}$, the criteria estimates are set by fuzzy numbers:

$$\widetilde{m}_{ij} = \{ \mu_{ij}(x) : x \in S_j, S_j \in Re \}, \tag{1}$$

where $\mu_{ij}(x)$ is a membership function of a fuzzy number;

S_j is a scale on which criteria estimates are set by the criterion c_j.

The weight of criteria is also set as a fuzzy number:

$$\widetilde{w}_j = \{ \mu_{w_j}(y) : y \in S_w \}. \tag{2}$$

In the ELECTRE method, the criteria of agreement and disagreement for structuring alternatives (Roy, 1996) which take into account formulas (1) and (2), are calculated in this way: the criterion of agreement -

$$\widetilde{q}_{ik} = \frac{\Sigma \widetilde{w}'(i \geq k)}{\Sigma_j \widetilde{w}_j}, \qquad (3)$$

where $\Sigma \widetilde{w}'(i \geq k)$ is the sum of criteria weights on which the alternative i is better than the alternative k.

It should be noted that the sum of criteria weights is not equal to 1 in the ELECTRE method; the criterion of disagreement –

$$\widetilde{r}_{i \succ k}(j) = max(\frac{\widetilde{m}_{kj} - \widetilde{m}_{ij}}{\widetilde{L}_j}), \qquad (4)$$

where $\widetilde{m}_{kj}$ is an estimate of the j-criterion by which the alternative k is more preferable than the alternative i;

$\widetilde{L}_j$ is the fuzzy length of the j-criterion scale.

The algorithm of calculations (3) and (4) is determined by a type of fuzzy numbers (Borisov, et al., 2014). The simplest way is the usage of fuzzy numbers in the LR-representation.

The criteria estimates of different transport types represented in a linguistic form (Tab. 1) are defined on the basis of the apriori information taken from (Tutygin, Boxes, 2010). The procedure for the criterion "the frequency of departures" is presented in Fig. 3. Transformations for all other criteria are carried out in the same way.
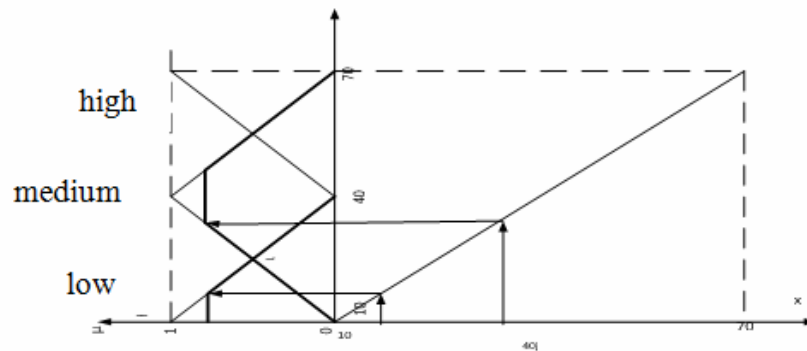

Figure 3 – Transformation of numerical estimates to linguistic estimates
Рис. 3 – Преобразование числовых оценок в лингвистические оценки
Slika 3 – Transformacija numeričkih estimacija u lingvističke estimacije

As a result, there are sets of linguistic estimates values by criteria for different types of transport (Tab. 2). Quantitative data have rather conditional estimates. They can have other values in reality, but it does not influence the algorithms of calculations and decision making.

Table 2 – Table of values estimates
Таблица 2 – Таблица оценок по критериям
Tabela 2 – Tabela vrednosti estimacija

	automobile (A)	railway (B)	river (C)	sea (D)	air (E)
speed of cargo delivery (kmph)	Low (35)	Low (15)	Low (15)	Low (17)	High (500)
safety of cargo (points)	High (0.7)	High (0.8)	Medium (0.5)	Medium (0.5)	High (0.9)
dependence on climatic conditions (points)	Medium (0.6)	Low (0.3)	Medium (0.6)	Medium (0.6)	Medium (0.5)
territorial availability (points)	High (1)	Medium (0.6)	Medium (0.5)	Medium (0.5)	Medium (0.5)
expenses of cargo delivery (rubles/km)	Low (15)	Low (50)	Medium (150)	Medium (200)	High (500)
frequency of departures (times per day)	High (70)	Low (30)	Low (10)	Low (10)	Low (10)
reliability of timekeeping (points)	Low (0.3)	Medium (0.5)	Medium (0.4)	Medium (0.4)	High (0.9)
ability to transport different freights (points)	Medium (0.4)	Medium (0.5)	Medium (0.4)	Medium (0.4)	Medium (0.5)

As it was already noted, the ELECTRE method assumes that experts set criteria weights and scales lengths on them, as well as these procedures, need additional research. Let us suppose that experts have chosen the weights and lengths of the scales presented in Table 3. As it can be seen in the table, the weights of the criteria in the form of LR-fuzzy numbers are somewhat different. The lengths of the scales in the form of LR-fuzzy numbers approximately correspond to the criteria estimates, and for the criteria where estimates are given in the form of points, the length of the scale is approximately equal to 1.

Table 3 – Table of weights and lengths of the criteria scales
Таблица 3 –Таблица весов и длин шкал критериев
Tabela 3 – Tabela težina I dužina kriterijumskih skala

Criteria	Criteria weight	Scales length
speed of cargo delivery	[7, 8, 9]	[450 500 550]
safety of cargo	[6 ,7, 8]	[0.5, 1, 1.5]
dependence on climatic conditions	[4, 5, 6]	[0.5, 1, 1.5]
territorial availability	[5, 6, 7]	[0.5, 1, 1.5]
expenses of cargo delivery	[7, 8, 9]	[450 500 550]
frequency of departures	[5, 6, 7]	[50 100 150]
reliability of timekeeping	[7 ,8, 9]	[0.5, 1, 1.5]
ability to transport different freights	[7 ,8, 9]	[0.5 , 1, 1.5]

It is convenient to use the fuzzy table FuzzyCalc (Chernov, 1998) for calculating formulas (3) and (4).

The results of the calculations of the agreement and disagreement indexes are presented in Figs. 4 and 5.

	A	B	C	D	E	F
1	Расчет индексов согласия:					
2		A	B	C	D	E
3	A	-	▶ 0,505917	▶ 0,867286	▶ 0,867286	▶ 0,361369
4	B	▶ 0,505917	-	▶ 1,01183	▶ 1,01183	▶ 0,596259
5	C	▶ 0,379438	▶ 0,144548	-	▶ 0,867286	▶ 0,361369
6	D	▶ 0,379438	▶ 0,144548	▶ 0,867286	-	▶ 0,361369
7	E	▶ 0,650465	▶ 0,560122	▶ 0,867286	▶ 0,867286	-

Figure 4 – Matrix of agreement indexes
Рис. 4 – Матрица индексов согласия
Slika 4 – Matrica indeksa slaganja

17		A	B	C	D	E
18	A	-	▶ 0,3	▶ 0,1	▶ 0,1	▶ 0,93
19	B	▶ 0,4	-	▶ 0	▶ 0,004	▶ 0,97
20	C	▶ 0,6	▶ 0,3	-	▶ 0,004	▶ 0,97
21	D	▶ 0,6	▶ 0,3	▶ 0,1	-	▶ 0,966
22	E	▶ 0,6	▶ 0,9	▶ 0,7	▶ 0,6	-

Figure 5 – Matrix of disagreement indexes
Рис. 5 – Матрица индексов несогласия
Slika 5 – Matrica indeksa neslaganja

The main phases of the ELECTRE method:
– two indexes (agreement and disagreement) are counted on the basis of the set estimates of two alternatives values. These indexes define agreement and disagreement with a hypothesis that the alternative A dominates the alternative B;

– the levels of agreement and disagreement (to which the counted indexes for each couple of alternatives are compared) are set. If the index of agreement is higher than the set level, and a disagreement index is lower, one of the alternatives dominates another. Otherwise, the alternatives are incomparable;

– the dominated alternatives are removed from the set of alternatives. The remained alternatives form the first base. The alternatives entering the base can be either equivalent or incomparable;

– the "weaker" values of the levels of agreement and disagreement (a lower value of the level of agreement, and a higher level of disagreement) are entered to which the bases with a smaller number of alternatives are allocated;

– the last base includes the best alternatives. The sequence of bases determines the order of alternatives by quality.

The levels of agreement C and disagreement D for our example are C=0.582571 and D=0.309467. The values below the level of agreement C and higher than the level of disagreement D are rejected. The base of the dominating alternatives includes the alternatives A, B, C and D (automobile, railway, river and sea means of transport). On the basis of these data, the preference graph is presented in Fig. 6, showing that the automobile transport is the best one under the given conditions.

Figure 6 – The preference graph
Рис. 6 – Граф предпочтений
Slika 6 – Grafički prikaz najboljeg izbora

A disadvantage of the ELECTRE method is a participation of a decision maker in the formation of bases. A possibility to overcome this disadvantage: the levels of agreement and disagreement form the square tables $N \times N$ with the blank main diagonal $\widetilde{Q} = \left\| \widetilde{q}_{ik} \right\|$, $\widetilde{R} = \left\| \widetilde{r}_{ik} \right\|$ the elements of which are fuzzy numbers.

A fuzzy number is a fuzzy set defined on a real axis; therefore, it is possible to apply a sum operation to fuzzy numbers for structuring alternatives:

$$\widetilde{\alpha}_i = \bigcup_k \widetilde{q}_{ik},$$

(5)

$$\widetilde{\gamma}_i = \bigcup_k \widetilde{r}_{ik}.$$

(6)

The estimates received on formulas (5) and (6) are the integrated values of the agreement and disagreement coefficients by all sets of criteria. Thus, formula (5) characterizes a "soft" approach and formula (6) a "rigid" approach. It is obvious that the most preferable alternative should have the maximum value of $\widetilde{\alpha}_i$ (Fig. 7) and the minimum value of $\widetilde{\gamma}_i$ (Fig. 8). The obtained values of these parameters confirm the result obtained earlier.
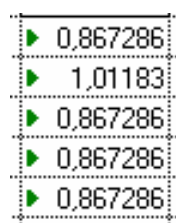
▶	0,867286
▶	1,01183
▶	0,867286
▶	0,867286
▶	0,867286

Figure 7 – Maximum value of $\widetilde{\alpha}_i$

Рис. 7 – Максимальное значение $\widetilde{\alpha}_i$

Slika 7 – Maksimalna vrednost $\widetilde{\alpha}_i$

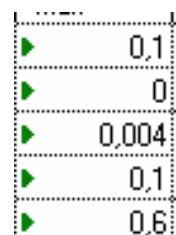| ▶	0,1
▶	0
▶	0,004
▶	0,1
▶	0,6

Figure 8 – Minimum value of $\widetilde{\gamma}_i$

Рис. 8 – Минимальное значение $\widetilde{\gamma}_i$

Slika 8 – Minimalna vrednost $\widetilde{\gamma}_i$

Thus the alternative B unambiguously has the maximum value of $\widetilde{\alpha}_i$ (5), and the two alternatives (B and C) have the minimum of $\widetilde{\gamma}_i$. Although the results do not contradict each other, it is necessary to make additional verification of the obtained decision.

One more solution of the considered task is possible, due to the existence of uncertainty in the basic data and results (Fig. 9). The matrixes of the agreement and disagreement coefficients can be considered as the matrixes of the fuzzy values characterizing uncertainty of a situation, so fuzzy entropy can be used for estimating alternative

decisions (Chernov, 2014). It is determined by the classical formula of Shannon (Deshmukh, Khot, 2011):

$$H_i = -\sum_k \mu_{i,k} log_2 \mu_{i,k} \tag{7}$$

17		A		B		C		D		E		max		entropy
18	A	-	▶	0,3	▶	0,1	▶	0,1	▶	0,93	▶	0,93	▶	1,49026
19	B	▶ 0,4	-		▶	0	▶	0,004	▶	0,97	▶	0,97		IFMLA
20	C	▶ 0,6	▶	0,3	-		▶	0,004	▶	0,97	▶	0,97		IFMLA
21	D	▶ 0,6	▶	0,3	▶	0,1	-		▶	0,966	▶	0,966	▶	1,48077
22	E	▶ 0,6	▶	0,9	▶	0,7	▶	0,6	-		▶	0,9	▶	1,48454
23														

Figure 9 – Entropy calculation
Рис. 9 – Расчет энтропии
Slika 9 – Izračunavanje entropije

Entropy is an estimation of an uncertainty level, so the best decision should have the minimum entropy value. The calculations which are carried out by formula (7) confirm the already obtained results – the best is the alternative B. Thus, three different methods of solving the same task led to the same results, which is in full accordance with the methodology of the stability theory according to which the result of data processing is invariant concerning a method of data processing.

Conclusion

It has been proven that taking into account uncertainty in expert estimates allows making a transport type choice more reasonable, based on the example of the considered problem of a transport type choice for a logistic system. The obtained results give the reason to discuss an opportunity of practical application of the modified ELECTRE method in the conditions of uncertainty of expert estimates. Obtaining the same results by different independent methods confirms their validity.

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ВЫБОР ВИДА ТРАНСПОРТА ДЛЯ ПОСТРОЕНИЯ ЛОГИСТИЧЕСКОЙ СИСТЕМЫ С УЧЕТОМ ФАКТОРОВ НЕОПРЕДЕЛЕННОСТИ

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Резюме:

В работе была разработана и исследована модификация метода многокритериального альтернативного выбора ELECTRE, учитывающая неопределенности экспертных оценок. Разработанный вариант был протестирован на решении задачи логистического управления транспортной системой «пункт отправления – пункт назначения». Предложенный подход позволяет повысить эффективность логистического управления транспортной системы доставки грузов и сократить время доставки.

Введение:

К задачам транспортной логистики относят:

- создание транспортных коридоров;

- выбор вида транспорта;

- выбор маршрута транспортировки грузов;

- составление расписаний.

Анализируя этот перечень можно отметить, что задачи 1,3 и 4 могут решаться с помощью теории графов, методов сетевого планирования, комбинаторики. В тоже время, задача выбора вида транспорта − это задача многокритериального

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альтернативного выбора, для решения которой указанные математические методы не могут использоваться в силу ее специфики. В настоящей статье рассматривается модель выбора вида транспорта в логистических системах с учетом факторов неопределенности
.

Постановка задачи:

Как отмечалось во введении, задача выбора вида транспорта для построения логистической системы может быть представлена как задача многокритериального альтернативного выбора, где в качестве альтернатив выступают: автомобильный, железнодорожный, воздушный, водный (речной или морской) виды транспорта. В этих условиях более предпочтительным является использование методов, в которых выбор наилучшей альтернативы основывается на установлении отношений предпочтения между альтернативами, в частности – метод ELECTRE. В тоже время, стандартный метод ELECTRE не предполагает нечеткость оценок критериального соответствия.

Метод решения:

В настоящем исследовании для учета неопределенности экспертных оценок весов, которые представляются в виде нечетких чисел. Использование оценок в виде нечетких чисел позволяет учесть неопределенность экспертных оценок, но при этом требуется внести изменения в алгоритм реализации метода ELECTRE. Три различных варианта решения одной и той же задачи были продемонстрированы в данной статье и привели к совпадающим результатам, полностью соответствует методологии теории устойчивости, согласно которой результат обработки данных инвариантный относительно метода обработки соответствует реальности.

Заключение:

На примере рассмотренной задачи выбора вида транспорта для логистической системы доказано, что учет неопределенности в экспертных оценках позволяет сделать выбор вида транспорта более обоснованным. Полученные результаты дают основание говорить о возможности практического применения модифицированного метода ELECTRE в условиях неопределенности экспертных оценок. Совпадение результатов, полученных при проведении различных и независимых методов подтверждает их реальность.

Ключевые слова: *метод ELECTRE, нечеткие множества, нейронная сеть, логистика, доставка грузов.*

IZBOR NAČINA TRANSPORTA PRI STVARANJU LOGISTIČKOG SISTEMA S FAKTOROM NESIGURNOSTI

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Sažetak:

Ovaj rad predstavlja razvijanje varijante metoda višekriterijum- skog izbora alternativa pod nazivom ELECTRE koji uzima u obzir nesi- gurnosti ekspertskih procena. Modifikovan metod ELECTRE testiran je na rešavanju problema logističkog upravljanja transportnim sistemom po principu „od vrata do vrata". Predloženi pristup može da poveća efi- kasnost logističkog upravljanja transportnim sistemima za isporuku ro- be, kao i da smanji vreme isporuke.
Neki od zadataka logistike transporta su sledeći:
– stvaranje transportnih koridora,
– izbor vrste transporta,
– izbor rute kargo transporta i
– planiranje vremena transporta.

Uvod

Analiza liste pokazuje da se tri zadatka mogu rešiti pomoću teori- je grafova, metoda planiranja mreže, kao i teorijom kombinatorike. Me- đutim, zadatak izbora vrste transporta je zadatak iz oblasti višekriteri- jumskog odlučivanja o izboru alternativa zbog čijih karakteristika nije moguće koristiti matematičke metode. U članku se razmatra model iz- bora vrste transporta u logističkim sistemima koji uzima u obzir faktore nesigurnosti.

Opis problema

Kao što je pomenuto u uvodu, izbor vrste transporta pri kreiranju logističkog sistema može da se predstavi kao zadatak višekriterijum- skog izbora između alternativa koje mogu biti transport: motornim vo- zilom, železnicom, vazdušnim ili vodenim (rečnim ili morskim) sred- stvima.U takvim uslovima poželjno je korišćenje metoda u kojima je izbor najbolje alternative zasnovan na određivanju odnosa preferen- cija između alternativa, a naročito metoda ELECTRE. Pri tome, stan- dardni oblik metoda ELECTRE ne uzima u obzir nesigurnost procene kriterijuma.

Postupak odlučivanja

U ovom istraživanju ekspertske procene skala predstavljene su u obliku fazi brojeva kako bi se nesigurnosti uzele u obzir. Korišćenje procena u obliku fazi brojeva omogućava razmatranje nesigurnosti ekspertskih procena, ali zahteva i unošenje promena u algoritam metoda ELECTRE. U radu su predstavljena tri različita načina za rešavanje istog zadatka. Sva tri su dovela do istog rešenja, što je potpuno u skladu s metodologijom teorije stabilnosti po kojoj je rezultat obrade podataka invarijantan u odnosu na metod obrade podataka.

Zaključak

Na primeru rešavanja problema izbora vrste transporta pri kreiranju logističkog sistema dokazano je da uzimanje u obzir nesigurnosti ekspertskih procena doprinosi celishodnijem izboru vrste transporta. Dobijeni rezultati ukazuju na mogućnost primene modifikovanog metoda ELECTRE u uslovima nesigurnosti ekspertskih procena. Isti rezultati, dobijeni različitim metodama, potvrđuju njihovu valjanost.

Ključne reči: *metod ELECTRE, fazi skupovi, neuronska mreža, logistika, isporuka robe*